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(54) **RELEASEABLE SPRING-LOADED BUMPER ASSEMBLY**

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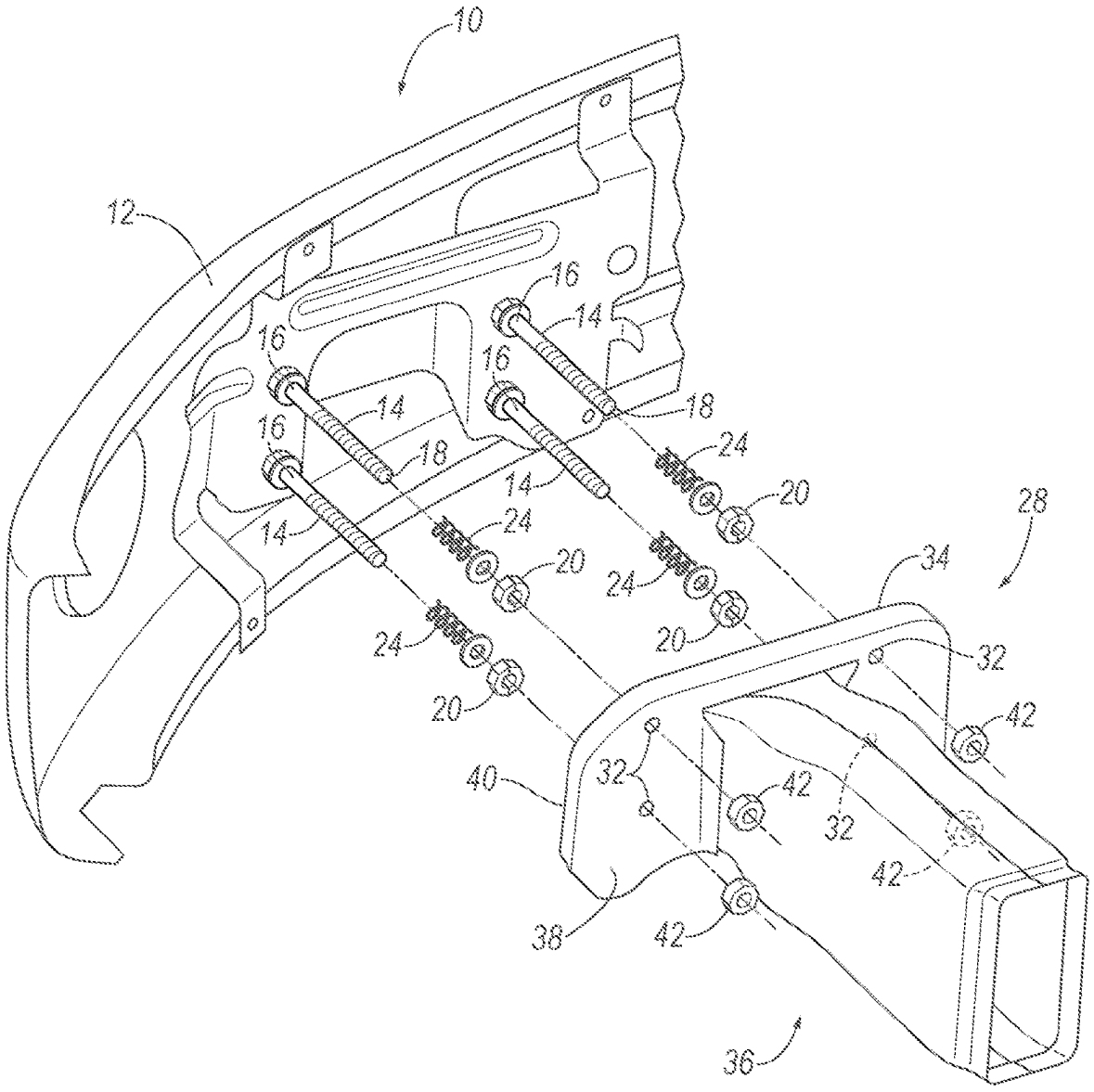
(57) **ABSTRACT**

A vehicle-bumper assembly includes a vehicle bumper and a rod having a first end fixed to the vehicle bumper and a second end spaced from the first end along an elongated axis of the rod. A collar is fixed to the rod between the first end of the rod and the second end of the rod, the collar including a pyrotechnically-activated release releasable from the rod. A spring is retained on the rod between the collar and the vehicle bumper.



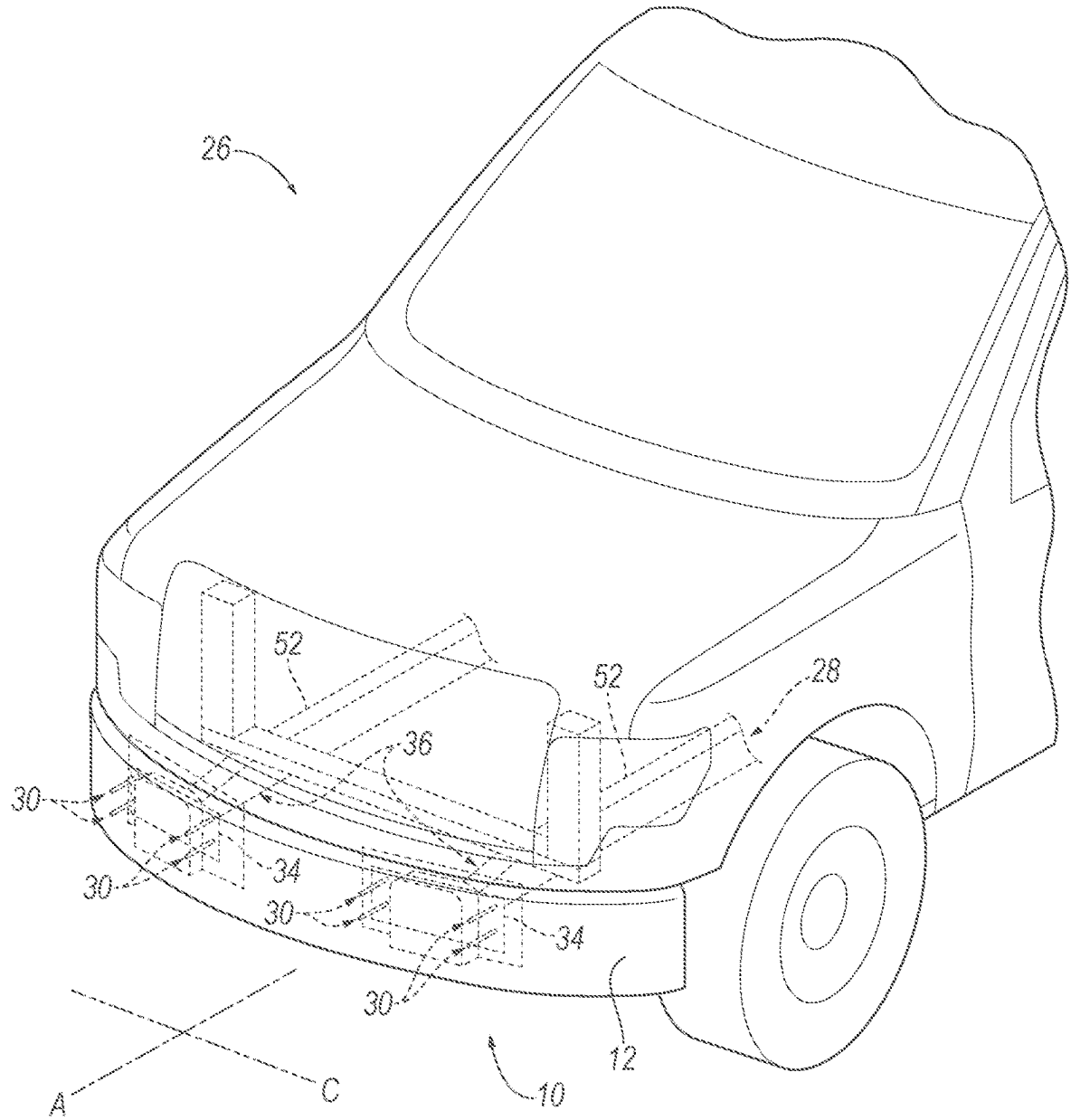


FIG. 1

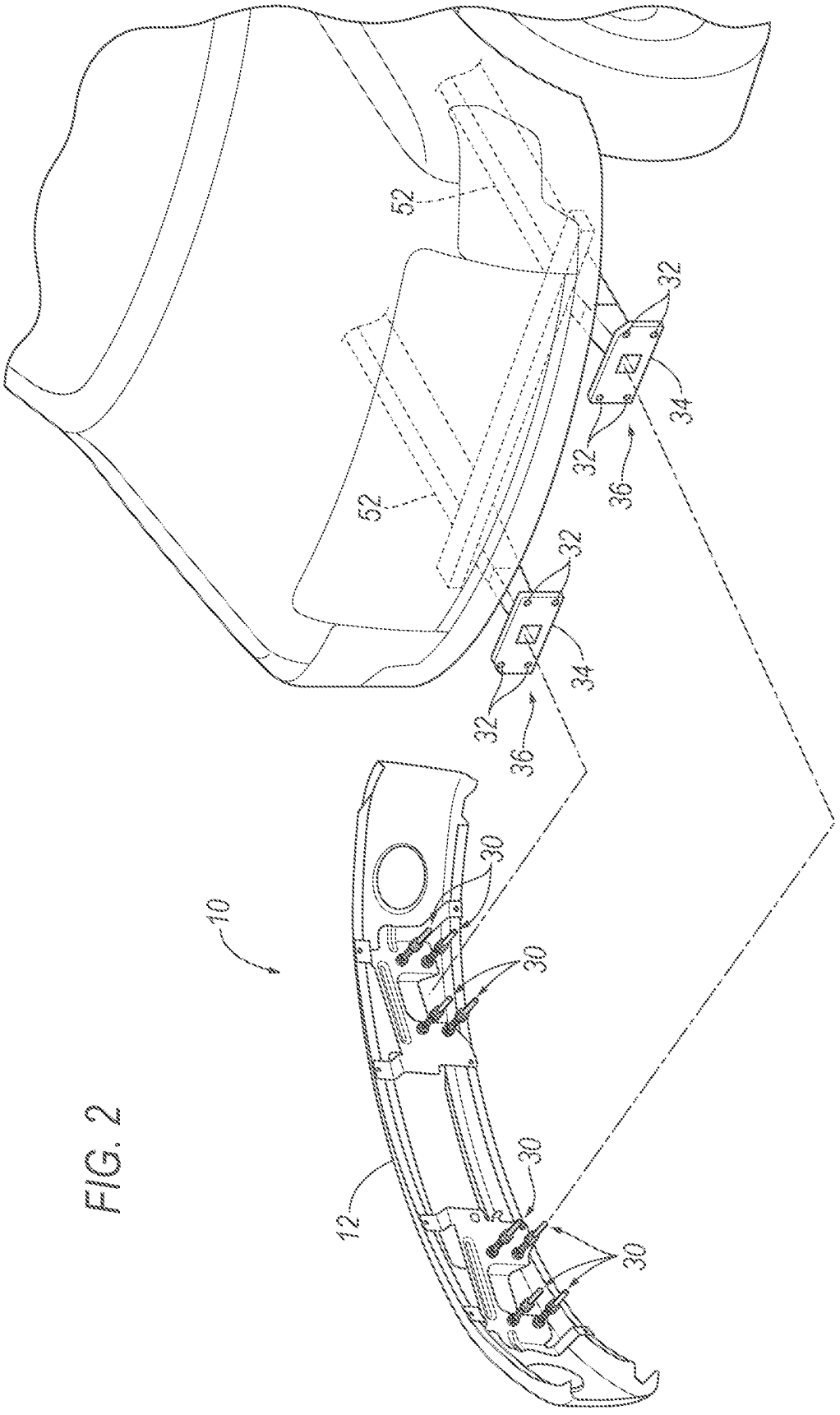


FIG. 2

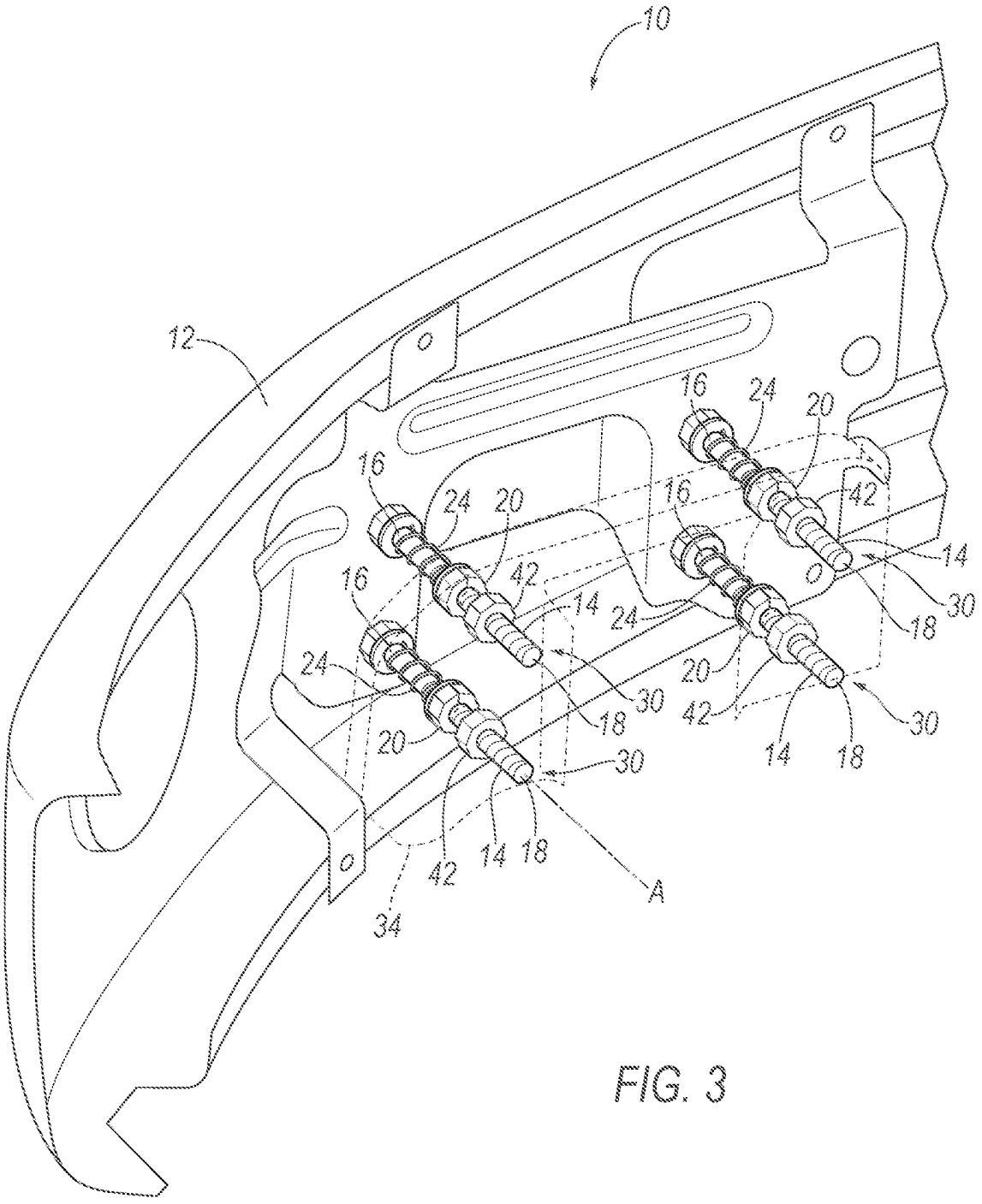


FIG. 3

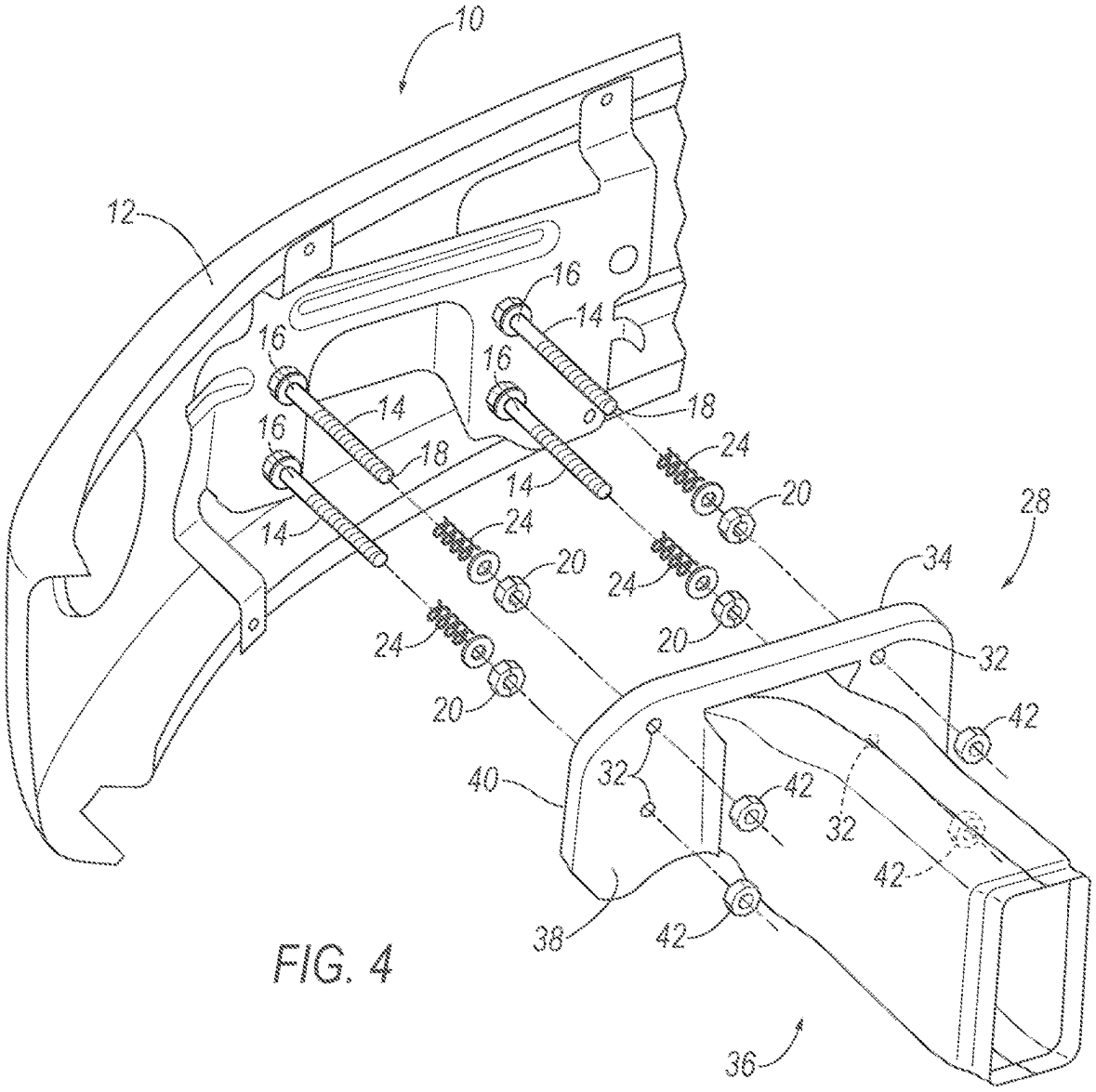


FIG. 4

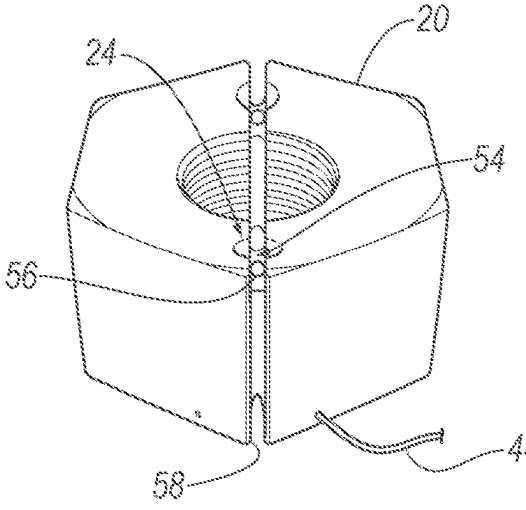


FIG. 5

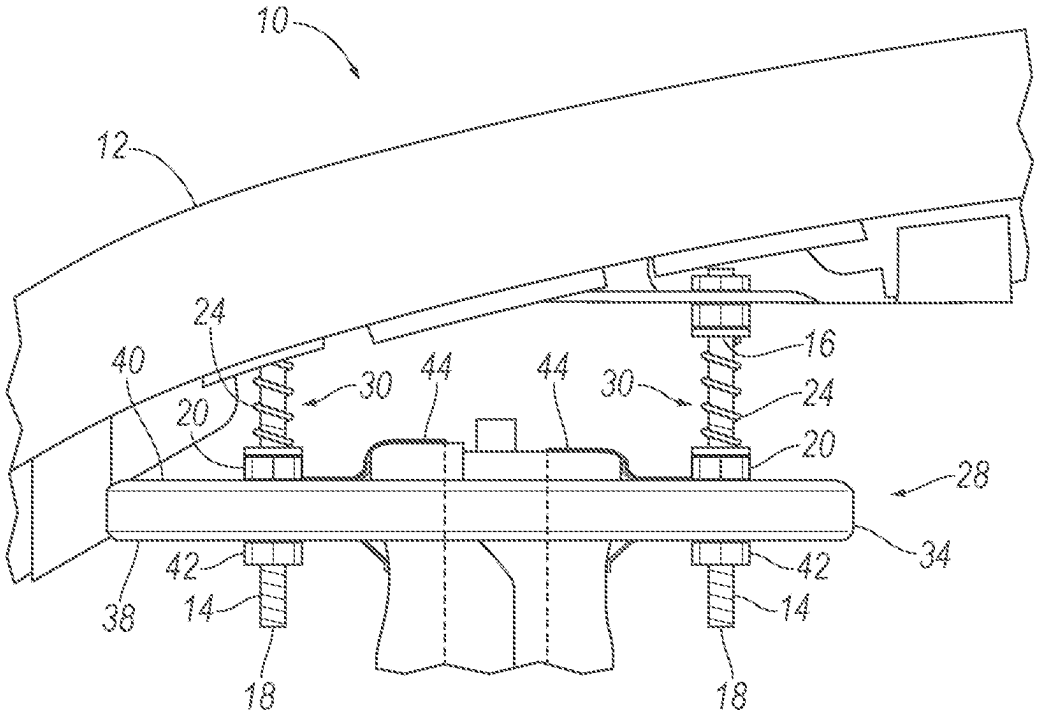

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FIG. 6A

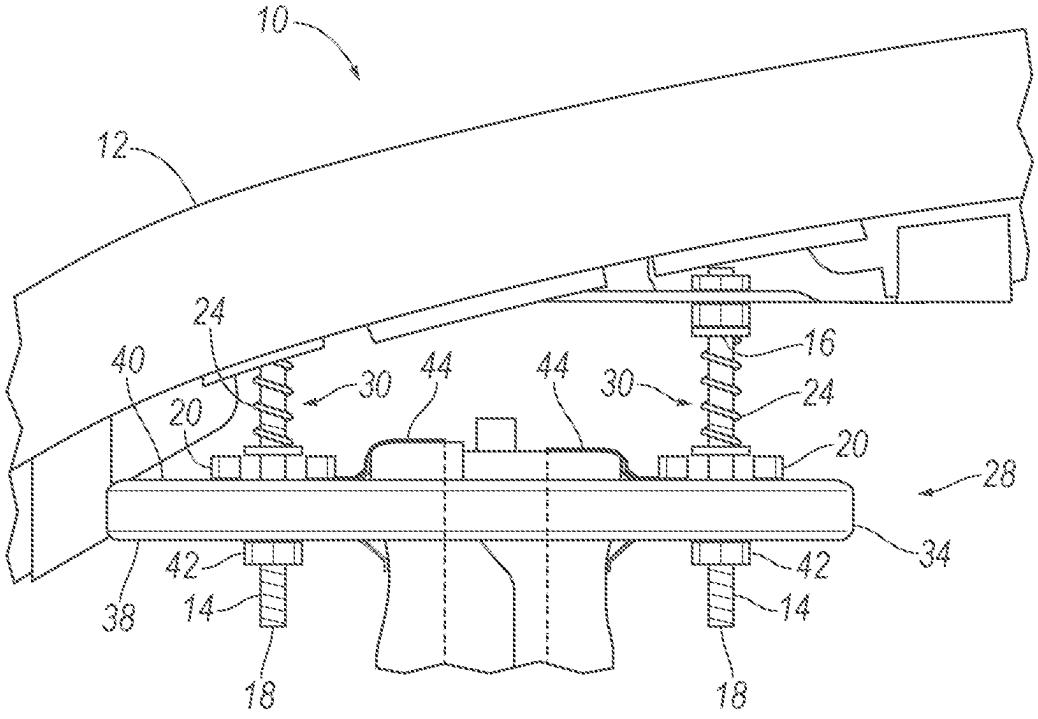
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FIG. 6B

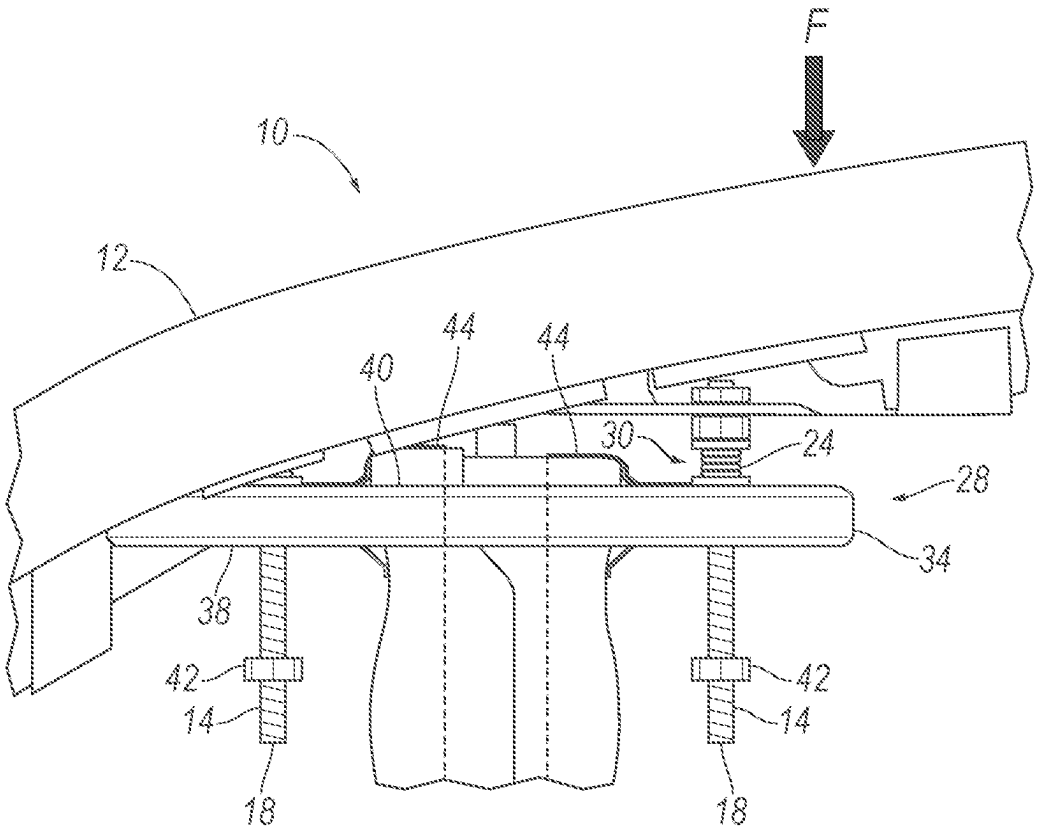
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FIG. 6C

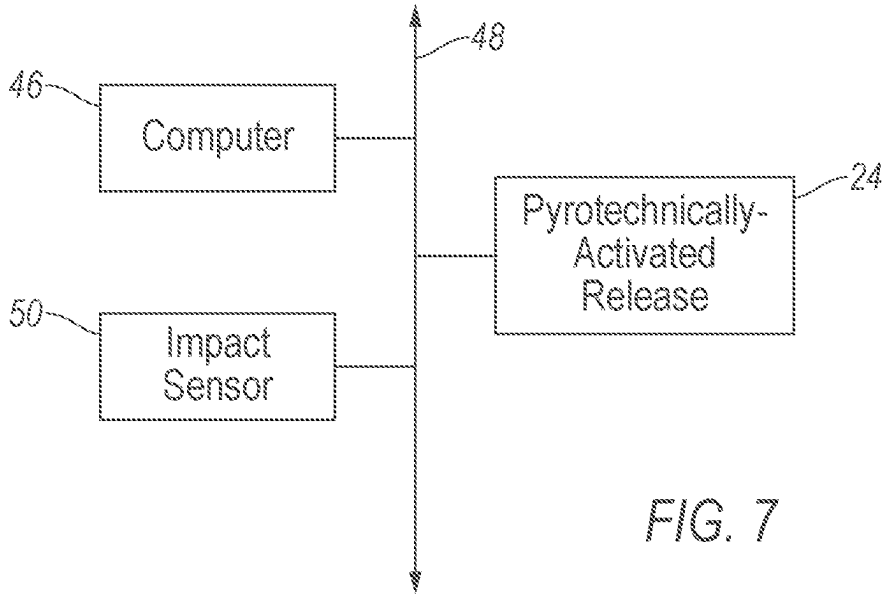
48
46
Computer
24
Pyrotechnically-Activated Release
50
Impact Sensor

FIG. 7

RELEASEABLE SPRING-LOADED BUMPER ASSEMBLY

BACKGROUND

[0001] The Global Technology Regulation (GTR) and the New Car Assessment Program (NCAP) specify leg-injury criteria for pedestrian protection. The regulations are aimed at reducing the impact force to the legs of a pedestrian by a vehicle bumper during certain vehicle-pedestrian impacts.

[0002] Some vehicles, such as light duty trucks and sport utility vehicles (SUVs), for example, may have a bumper height that could lead to an uneven impact on the femur and/or tibia of the pedestrian by the vehicle bumper during certain vehicle-pedestrian impacts. For example, light duty trucks may have bumper heights to provide ground clearance to clear speed bumps, curbs, parking blocks, inclined driveway ramps, hills, rough roads, etc. Some vehicles with such bumper heights also have off-road capabilities that preclude having any components below the bumper. As such, a design for the vehicle front-end is investigated for pedestrian leg impact energy management while addressing ground clearance requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a perspective view of a vehicle including a bumper assembly with an energy-absorbing system in broken lines.

[0004] FIG. **2** the perspective view of FIG. **1** with the bumper assembly removed from a frame of the vehicle.

[0005] FIG. **3** is a rear view of a portion of the bumper assembly and a portion of the vehicle frame with the bumper assembly exploded from the vehicle frame.

[0006] FIG. **4** is an exploded view of the bumper assembly.

[0007] FIG. **5** is a perspective view of a collar of the bumper assembly.

[0008] FIG. **6**A is a top view of the bumper assembly and frame of the vehicle in a design state.

[0009] FIG. **6**B is the top view of FIG. **6**A with the collar released from a rod in a retractable state absent vehicle-impact force on the bumper assembly.

[0010] FIG. **6**C is the top view of FIG. **6**B during certain vehicle impacts.

[0011] FIG. **7** is a schematic of a system of the vehicle.

DETAILED DESCRIPTION

[0012] A vehicle includes a vehicle frame and a vehicle bumper. A rod is elongated along an axis. The rod is fixed relative to the vehicle bumper and slidably engaged with vehicle frame. A spring is between the vehicle bumper and the vehicle frame. A collar is fixed relative to the rod and extends radially from the rod. The collar includes a pyrotechnically-activated release releasable from the rod.

[0013] The collar may be between the vehicle bumper and the vehicle frame.

[0014] The collar may be between the spring and the vehicle frame.

[0015] The vehicle may include a retainer protruding radially outwardly from the rod, the vehicle frame being between the retainer and the spring. The vehicle frame may include a flange between the retainer and the spring. The flange may include a hole that slidably receives the rod, the retainer having an outer diameter larger than an outer diameter of the hole. The flange may be between the retainer and the collar, and the spring may be between the collar and the vehicle bumper. The retainer and the collar may abut the flange. The vehicle frame may include a crush can, the flange being fixed to the crush can. The wiring may extend from the collar along the crush can.

[0016] The vehicle frame may include a hole that slidably receives the rod.

[0017] The rod may support the vehicle bumper on the vehicle frame.

[0018] The spring may be on the rod.

[0019] The rod may include a first portion extending from the vehicle frame to the vehicle bumper, the coil spring having a free length shorter than or equal to than the first portion of the rod.

[0020] An assembly includes a vehicle bumper and a rod having a first end fixed to the vehicle bumper and a second end spaced from the first end along an elongated axis of the rod. A collar is fixed to the rod between the first end of the rod and the second end of the rod, the collar including a pyrotechnically-activated release releasable from the rod. A coil spring is retained on the rod between the collar and the vehicle bumper.

[0021] The assembly may include a retainer fixable to the second end of the rod, the retainer protruding radially outwardly from rod at second end.

[0022] The rod may be configured to extend through a hole in a vehicle frame with the vehicle frame being between the collar and the retainer.

[0023] The assembly may include a vehicle frame defining a hole, the rod extending through the vehicle frame with the vehicle frame being between the collar and the retainer.

[0024] With reference to the Figures, wherein like numerals indicate like parts throughout the several views, a bumper assembly **10** includes a vehicle bumper **12** and a rod **14** having a first end **16** fixed to the vehicle bumper **12** and a second end **18** spaced from the first end **16** along an elongated axis A of the rod **14**. A collar **20** is fixed to the rod **14** between the first end **16** of the rod **14** and the second end **18** of the rod **14**. The collar **20** includes a pyrotechnically-activated release **22** releasable from the rod **14**. A spring **24** is retained on the rod **14** between the collar **20** and the vehicle bumper **12**.

[0025] The vehicle **26** includes a vehicle frame **28** and a vehicle bumper **12**. The rod **14** is fixed relative to the vehicle bumper **12** and is slidably engaged with vehicle frame **28**. The spring **24** is between the vehicle bumper **12** and the vehicle frame **28**. The collar **20** is fixed relative to the rod **14** and extends radially from the rod **14**. The collar **20** includes a pyrotechnically-activated release **22** releasable from the rod **14**.

[0026] When the collar **20** is engaged with the rod **14**, the collar **20**, being fixed to the rod **14**, prevents movement of the rod **14** relative to the vehicle frame **28**. When the collar **20** is disengaged with the rod **14** by activation of the pyrotechnically-activated release **22**, as described below, the rod **14** is free to move relative to the vehicle frame **28** along the axis A of the rod **14**. Specifically, in the event of certain vehicle impacts in which the bumper **12** impacts an object, e.g., a crash test leg form as described further below, the pyrotechnically-activated release **22** is activated to release the collar **20** from the rod **14**, which allows the bumper **12** to move vehicle rearward relative to the vehicle frame **28** against the force of the spring **24**. When the collar **20** is

disengaged from the rod **14**, force against the bumper **12**, e.g., during certain vehicle impacts, of sufficient magnitude to compress the spring **24** will move the bumper **12** and the rod **14** vehicle rearward relative to the vehicle frame **28**, as shown in the progression between FIGS. **6**A-C. For example, during certain impacts with a leg form, the bumper **12** and rod **14** move vehicle rearward against the force of the spring **24** to absorb energy from the impact and reduce energy delivered from the bumper **12** to the leg form. The spring **24** may provide for gradual absorption of the impact energy during certain vehicle impacts.

[0027] As described further below, the bumper assembly **10** includes an energy-absorber assembly **30** between the vehicle frame **28** and the bumper **12**. The energy-absorber assembly **30** includes the rod **14**, the spring **24**, the collar **20**, and a retainer **42**. The energy-absorber assembly **30** supports the bumper **12** on the vehicle frame **28** and allows the bumper **12** to release from the design state to the retractable state in response to detection of certain vehicle impacts. As set forth below, the bumper assembly **10** may include a plurality of energy-absorber assemblies **30** that, in combination with each other, support the bumper **12** on the vehicle frame **28**.

[0028] The bumper **12**, as an example, may impact the knee of a pedestrian impact test leg form during a standardized test. The leg form may be a flexible pedestrian leg impactor (Flex-PLI) leg form. Example regulations that can use the leg form include Global Technical Regulation (GTR), ECE R127 and Korean Motor Vehicle Safety Standards (KMVSS). Example new car assessment programs that can use the leg form include EuroNCAP, CNCAP, and ANCAP.

[0029] The vehicle **26** may be any suitable type of automobile, e.g., a passenger or commercial automobile such as a sedan, a coupe, a truck, a sport utility vehicle, a crossover vehicle, a van, a minivan, a taxi, a bus, etc. The vehicle **26**, as an example, may have a relatively high ride height. With reference to FIG. **1**, the vehicle **26** defines a vehicle-longitudinal axis extending between a front end (not numbered) and a rear end (not numbered) of the vehicle **26**. The vehicle **26** defines a vehicle-lateral axis extending cross-vehicle **26** from one side to the other side of the vehicle **26**. The vehicle **26** defines a vertical axis. The vehicle-longitudinal axis, the vehicle-lateral axis, and the vertical axis are perpendicular relative to each other.

[0030] With reference to FIG. **1**, the vehicle **26** includes the vehicle frame **28** and a vehicle **26** body (not numbered). The vehicle **26** body and the vehicle frame **28** may have a body-on-frame construction (also referred to as a cab-on-frame construction) in which the vehicle **26** body and vehicle frame **28** are separate components, i.e., are modular, and the vehicle **26** body is supported on and affixed to the vehicle frame **28**. In the example shown in the Figures, the vehicle **26** has a body-on-frame construction. As another example, the vehicle **26** body and the vehicle frame **28** may be of a unibody construction in which the vehicle frame **28** is unitary with the vehicle **26** body (including frame rails **52**, pillars, roof rails, etc.). In other examples, the vehicle frame **28** and vehicle **26** body may have any suitable construction. The vehicle frame **28** and vehicle **26** body may be of any suitable material, for example, steel, aluminum, and/or fiber-reinforced plastic, etc.

[0031] The vehicle **26** body includes body panels (not numbered). The body panels may include structural panels, e.g., rockers, pillars, roof rails, etc. The body panels may include exterior panels. The exterior panels may present a class-A surface, e.g., a finished surface exposed to view by a customer and free of unaesthetic blemishes and defects. The body panels include, e.g., a roof panels, doors, fenders, hood, decklid, etc. The vehicle **26** body may define a passenger cabin to house occupants, if any, of the vehicle **26**.

[0032] The vehicle frame **28** includes frame rails **52** and may include cross beams. The frame rails **52** are elongated along the vehicle-longitudinal axis. The frame rails **52** are spaced from each other cross-vehicle **26**, i.e., along the vehicle-lateral axis. The cross beams of the vehicle frame **28** extend from one frame rail **52** to the other frame rail **52** transverse to the vehicle-longitudinal axis.

[0033] With continued reference to FIG. **1**, the vehicle frame **28** includes two frame rails **52**. The frame rails **52** may define the cross-vehicle **26** boundaries of the vehicle frame **28**. The frame rails **52** may be elongated along the vehicle-longitudinal axis A from a rear end of the vehicle **26** to a front end of the vehicle **26**. For example, the frame rails **52** may extend along substantially the entire length of the vehicle **26**. In other examples, the frame rails **52** may be segmented and extend under portions of the vehicle **26**, e.g., at least extending from below a passenger compartment of the vehicle **26** to the front end of the vehicle **26**. In some examples, each frame rail **52** may be unitary from the rear end of the vehicle **26** to the front end of the vehicle **26**. In other examples, the frame rails **52** may include segments fixed to each other (e.g., by welding, threaded fastener, etc.) and in combination extending from a rear end of the vehicle **26** to the front end of the vehicle **26**.

[0034] As set forth above, the vehicle frame **28** may have a body-on-frame construction in which the vehicle **26** body is supported on and affixed to the vehicle frame **28**. In such an example, the frame rails **52** may include cab mount brackets (not shown) on which the vehicle **26** body is supported and affixed. The cab mount brackets are fixed to the frame rails **52**, e.g., welded to the frame rails **52**. The cab mount brackets may extend outboard from the frame rail **52**. The cab mount bracket may be cantilevered from the frame rail **52**. The cab mount brackets are configured to support the vehicle **26** body in a body-on-frame configuration. For example, the cab mount bracket may include a post or a hole that receives a hole or a post, respectively, of the vehicle **26** body to connect the vehicle **26** body to the vehicle frame **28**. Specifically, the vehicle **26** body may be fixed to the cab mount bracket. During assembly of the vehicle **26**, the vehicle **26** body is set on the vehicle frame **28** with fastening features of the vehicle **26** body aligned with the cab mount brackets for engagement with the cab mount brackets.

[0035] The vehicle frame **28** may include suspension and steering attachment points (not shown) that support suspension and steering components of the vehicle **26**. As one example, the suspension and steering attachment points may be suspension towers. Suspension and steering components of the vehicle **26** are connected to the vehicle frame **28**, at least in part, at the suspension towers. The suspension and steering components include suspension shocks, suspension struts, steering arms, steering knuckles, vehicle wheels, etc.

[0036] The frame rails **52** and crossbeams may be extruded, roll-formed, etc. The frame rails **52** and crossbeams of the vehicle frame **28** may be of any suitable material, e.g., suitable types of steel, aluminum, and/or fiber-reinforced plastic, etc. The frame rails **52** and cross-

beams may be hollow. The frame rails **52** and crossbeams may be rectangular in cross-section (e.g., a hollow rectangular cuboid), round in cross section, e.g., a hollow, round such as a hollow cylinder), etc.

[0037] With reference to FIGS. **1** and **2**, the vehicle frame **28** includes frame-rail ends **36** extending vehicle-forward of the frame rails **52**, respectively. In other words, the vehicle frame **28** includes two frame-rail ends **36** with one frame-rail end **36** extending vehicle-forward of one of the frame rails **52** and the other frame-rail end **36** extending vehicle-forward of the other frame rail **52**.

[0038] In some examples, including the example shown in the Figures, the frame-rail ends **36** may be of the type referred to in industry as crush cans. In such examples, the frame-rail ends **36** may be designed to deform relative to the frame rail **52** during certain frontal-vehicle impacts. Specifically, the frame-rail ends **36** deform vehicle-rearward to allow rearward movement of the bumper assembly **10** relative to the frame rails **52** to absorb energy during certain vehicle impacts. The frame-rail ends **36** may include features that direct deformation of the frame-rail end **36** toward the frame rail **52** during frontal impact of the bumper **12**. These features may include wall geometry, wall thickness, dimples, cutouts, etc.

[0039] The frame-rail end **36** is fixed to the respective frame rail **52**. For example, the frame-rail end **36** may be fixed to the respective frame rail **52** by welding, fastening, etc. In the example shown in the Figures, the frame-rail end **36** is a component of the vehicle frame **28** that has a body-on-frame architecture, as described above. In other examples, the vehicle frame **28** may be of another architecture, e.g., a unibody architecture. In such examples, the frame rail **52** is a component of the vehicle frame **28** that has a unibody architecture and the frame-rail end **36** is connected to such frame rail **52**.

[0040] The frame-rail end **36** is elongated along the vehicle-longitudinal axis. For example, the frame-rail end **36** may be coaxial with the frame rail **52** at the connection of the frame-rail end **36** and the frame rail **52**. The frame rail **52** has a vehicle-forward end and the frame-rail end **36** extends vehicle-forward from the vehicle-forward end of the frame rail **52**. Specifically, the frame-rail end **36** has a vehicle-rearward end at the frame rail **52** and a vehicle-forward end proximate the bumper **12**. The frame-rail end **36** may be extruded, roll-formed, etc. The frame-rail end **36** may be of any suitable material, e.g., suitable types of steel, aluminum, and/or fiber-reinforced plastic, etc. The frame-rail end **36** may be hollow. The frame rails **52** and crossbeams may be rectangular in cross-section (e.g., a hollow rectangular cuboid), round in cross section, e.g., a hollow, round such as a hollow cylinder), etc.

[0041] With reference to FIG. **1**, the vehicle **26** has a front-end structure. The front-end structure includes a grill and the bumper assembly **10**. The grill is above the bumper assembly **10**. The grill may be a component of the vehicle **26** body and may be supported on other components of the vehicle **26** body.

[0042] The bumper **12** extends transversely to the frame rails **52**. With reference to FIG. **1**, the bumper **12** is elongated along the vehicle-lateral axis. The bumper **12** may be of any suitable material such as metal (steel, aluminum, etc.), fiber-reinforced plastic, etc.

[0043] The bumper **12** has a vehicle-forward face **40** and a vehicle-rearward face **38**. The vehicle-forward face **40** may be a class-A surface, i.e., a surface specifically manufactured to have a high-quality, finished aesthetic appearance free of blemishes. As an example, the vehicle-forward face **40** may be chromed. The mounting bracket of the bumper assembly **10** is on the vehicle-rearward face **38** of the bumper **12**, as shown in the example in the Figures. The mounting bracket is fixed to and moves as a unit with the bumper **12**.

[0044] In the example shown in the Figures, the bumper assembly **10** includes eight energy-absorber assemblies **30**, specifically four energy-absorber assemblies **30** between each frame-rail end **36** and the bumper **12**. In other examples, the bumper assembly **10** may include any suitable number of energy-absorber assemblies **30**, i.e., one or more. Common numerals are used in the Figures to identify common features among the energy-absorber assemblies **30**.

[0045] The energy-absorber assembly **30** of the bumper assembly **10** is between the vehicle frame **28** and the bumper **12** and is connected to the vehicle frame **28** and the bumper **12**. In the example shown in the Figures, the rod **14** extends from the vehicle frame **28** to the bumper **12**. As an example, the vehicle frame **28** includes a hole **32** that slidably receives the rod **14**. In the example shown in the Figures, the vehicle frame **28** includes a flange **34** is fixed to the rest of the vehicle frame **28**, e.g., the frame-rail end **36** in the example shown in the Figures, and the flange **34** includes the hole **32** that slidably receives the rod **14**. In examples in which the frame-rail end **36** is a crush can, the flange **34** is fixed to the crush can. In such examples, the collar **20** is between the flange **34** and the spring **24**. In the example shown in the Figures, the collar **20** abuts the flange **34** vehicle-forward of the flange **34** in the design state. The flange **34** includes a vehicle-rearward face **38** and a vehicle-forward face **40**, and the collar **20** abuts the vehicle-forward face **40** in the design state in the example shown in the Figures.

[0046] The bumper assembly **10** is supported by the vehicle frame **28**, i.e., the weight of the bumper assembly **10** is borne by the vehicle frame **28**. Specifically, the rod **14** supports the bumper **12** on the vehicle frame **28**. In other words, the weight of the bumper **12** is borne by the rod **14** and the weight of the rod **14** and the bumper **12** is borne by the vehicle frame **28** through the connection of the rod **14** to the vehicle frame **28**. The bumper assembly **10** may be a front bumper assembly, as shown in the example in the Figures. In other words, the bumper assembly **10** may be at a front of the vehicle **26** and, in such examples, the bumper **12** is operable for certain frontal collisions of the vehicle **26**.

[0047] In the retractable state, the bumper **12** and the rod **14** are movable along the axis A of the rod **14** relative to the vehicle frame **28** against the force of the spring **24** during certain vehicle impacts. The vehicle frame **28** movably receives the rod **14**. For example, as shown in the example in the Figures, the rod **14** slides in the hole **32** axially along the axis A of the rod **14** and the bumper **12** moves relative to the vehicle frame **28** in the retractable state when force on the bumper **12** is sufficient to compress the spring **24**. In such examples, the hole **32** is designed, i.e., sized, shaped, and oriented, to allow for movement of the rod **14** along the vehicle-longitudinal axis. In other examples, the vehicle frame **28**, e.g., the frame-rail end **36**, may include any suitable track, channel, etc., that slidably receives the rod **14** for movement of the rod **14** along the axis A.

[0048] The rod **14** is elongated along the axis A of the rod **14**. In other words, the longest dimension of the rod **14** is

along the axis A. The rod **14** may be, for example, cylindrical, as shown in the example in the Figures. The rod **14** may be, for example, metal or any other suitable material. The rod **14**, or the rods **14** in examples including more than one rod **14**, has sufficient rigidity to support the bumper **12** on the vehicle frame **28** and sufficient rigidity to transfer linear movement of the bumper **12** relative to the vehicle frame **28** in the retractable state. In the example shown in the Figures, the rods **14**, e.g., the eight rods **14**, are designed to, in combination, support the bumper **12** on the vehicle frame **28**.

[0049] The rod **14** is fixable relative to the bumper **12**. When the bumper assembly **10** is assembled to the vehicle frame **28**, the rod **14** is fixed to the bumper **12**. The rod **14** may be fixed to the bumper **12** prior to assembly of the bumper assembly **10** to the vehicle frame **28**. The rod **14** may be fixed to the bumper **12** by mechanical attachment that requires removal by a service technician with the use of a tool and/or destruction such as cutting, e.g., cutting material and/or welded joints, etc. In the example shown in the Figures, the rod **14** is threadedly engaged with a weld nut on the bumper **12**. The rod **14** may be fixed to the bumper **12**, e.g., the weld nut, with additional features such as welding, pinning, a counter-nut, etc.

[0050] The rod **14** is slidably engaged with the vehicle frame **28**. In the example shown in the Figures, the hole **32** and the rod **14** are sized and shaped so that the rod **14** is free to slide vehicle forward and vehicle rearward along the axis A when forces act axially on the rod **14**. The rod **14** is moveable axially relative to the vehicle frame **28** vehicle-rearward toward the vehicle frame **28** when the collar **20** is disengaged with the rod **14** and force is applied to the bumper **12** sufficient to compress the spring **24**. After compression of the spring **24**, in the event the force on the bumper **12** decreases to a level at which the spring **24** resiliently decompresses, the spring **24** expands and moves the bumper **12** vehicle-forward away from the vehicle frame **28**, during which movement the rod **14** moves axially relative to the vehicle frame **28**.

[0051] As set forth above, the rod **14** has a first end **16** and a second end **18** spaced from the first end **16** along the axis A of the rod **14**. The first end **16** is fixable to the vehicle bumper **12**. In the example shown in the Figures, the rod **14** includes threads at the first end **16** and the vehicle bumper **12** includes a threaded hole **32**, e.g., in a weld nut, designed to threadedly receive the threads of the rod **14**.

[0052] When the bumper assembly **10** is assembled to the vehicle frame **28** in the design state, a first portion of the rod **14** extends from the collar **20** to the bumper **12**, e.g., the weld nut. For example, the first portion of the rod **14** terminates at the collar **20** and at the bumper **12** when the bumper assembly **10** is in the design state. The second end **18** of the rod **14** is retained to the vehicle frame **28** by the collar **20** in the design state and by the retainer **42** in the retractable state.

[0053] The collar **20** is between the vehicle bumper **12** and the vehicle frame **28**. The collar **20** is between the spring **24** and the vehicle frame **28**, and the spring **24** is between the collar **20** and the vehicle bumper **12**. In some examples, including the example shown in the Figures, a washer (not numbered) may be between the spring **24** and the collar **20**. The vehicle frame **28**, e.g., the flange **34**, is between the retainer **42** and the spring **24**.

[0054] The collar **20** and the retainer **42** limit axial movement of the rod **14** when the collar **20** is engaged with the rod **14** in the design state. The collar **20**, being vehicle-forward of the flange **34**, prevents vehicle-rearward movement of the rod **14** relative to the vehicle frame **28**. The retainer **42**, being vehicle rearward of the flange **34**, prevents vehicle-forward movement of the rod **14** relative to the vehicle frame **28**. In the example shown in the Figures, the collar **20** abuts the vehicle-forward face **40** of the flange **34** and the retainer **42** abuts the vehicle-rearward face **38** of the flange **34**.

[0055] The collar **20** is fixed relative to the rod **14** when the bumper assembly **10** is in the design state. In the example shown in the Figures, the collar **20** is connected directly to the rod **14** between the first end **16** of the rod **14** and the second end **18** of the rod **14**. The collar **20** is fixed to the rod **14** in that the collar **20** is immovable axially along the rod **14** absent intentional release of the collar **20**, e.g., destruction by activation of the pyrotechnically-activated release **22**, or by removal by a service technician with the use of a tool and/or destruction such as cutting, e.g., cutting material and/or welded joints, etc., by the service technician. In the example shown in the Figures, the rod **14** has external threads and the collar **20** has internal threads threadedly engaged with the external threads of the rod **14** to axially fix the collar **20** relative to the rod **14**. In such an example, additional engagement may be achieved by adhesive, bond, welding, etc., at the threads. In other examples, the collar **20** may be fixed to the rod **14** in any suitable fashion including one or a combination of threads, pinning, engagement of grooves, adhesive, bonding, welding, etc.

[0056] The collar **20** extends radially from the rod **14**. In the example shown in the Figures, the collar **20** has the shape of a threaded nut. In such an example, the collar **20** extends endlessly around the circumference of the rod **14**. In other examples, the collar **20** may extend along less than the entire circumference of the rod **14**. The collar **20** is larger than the hole **32** such that the collar **20** abuts the vehicle frame **28**, e.g., the flange **34**, to maintain the position of the rod **14** relative to the vehicle frame **28** in the design state. The collar **20** has an outer dimension, i.e., taken radially outward from the rod **14**, that is larger than the outer dimension of the hole **32** such that the collar **20** abuts the vehicle frame **28** in the design state to maintain the rod **14** and the bumper **12** in the design state.

[0057] The collar **20** is releasable from the rod **14** and, when the collar **20** is released from the rod **14**, the energy-absorber assembly **30** changes from the design state to the retractable state. As set forth above, the collar **20** is fixed to the rod **14** absent intentional release and the collar **20** is releasable from the rod **14** and thus is releasably fixed to the rod **14**.

[0058] The collar **20** may include a pyrotechnically-activated release **22** releasable from the rod **14**. The pyrotechnically-activated release **22** includes a pyrotechnic charge **56** that releases the collar **20** from the rod **14** when activated. The activation of the pyrotechnically-activated release **22** releases the collar **20** from the rod **14** by destroying at least the connection between the collar **20** and the rod **14**. The collar **20** may be a pyrotechnic fastener, and more specifically a pyrotechnic-separation nut. In some instances of such examples the pyrotechnic fastener, e.g., the pyrotechnic-separation nut, may be of a type known in the art. As one example, the pyrotechnically-activated release **22** includes a

pocket **54** that receives the pyrotechnic charge **56** so that activation of the pyrotechnic charge **56** breaks the collar **20** to release the collar **20** from the rod **14**. The pyrotechnically-activated release **22** may include a seam **58** in the collar **20** at or near the pyrotechnic charge **56**. The seam **58** may be a weakened area at which separation is encouraged during activation of the pyrotechnic charge **56**.

[0059] The pyrotechnic charge **56** may be combustible to produce a gas. The pyrotechnic charge **56** may be a solid mixture of substances that, when ignited, react to produce the gas. For example, the pyrotechnic charge **56** may be sodium azide (NaNO3), potassium nitrate (KNO3), and silicon dioxide (SiO2), which react to form nitrogen gas (N2).

[0060] The vehicle **26** may include a communication cable **44** connecting the pyrotechnically-activated release **22** to a control module that controls activation of the pyrotechnically-activated release **22**. In the example shown in the Figures, the communication cable **44** extends along the frame-rail end **36**, e.g., the crush can, along the flange **34** to the pyrotechnically-activated release **22**. The control module commands activation of the pyrotechnically-activated release **22** through the communication cable **44**. The communication cable **44**, for example, may include an electric wire through which an electrical impulse may be transmitted to the pyrotechnically-activated release **22** to activate the pyrotechnically-activated release **22**.

[0061] The spring **24** is operatively engaged with the vehicle frame **28** and the bumper **12** to exert force the bumper **12** vehicle-forward away from the vehicle frame **28** along the axis A. In the example shown in the Figures, the spring **24** abuts the bumper **12** and abuts the collar **20** in the design state. In the retractable state, the spring **24** abuts the bumper **12** and abuts the vehicle frame **28**, specifically the flange **34**. In some examples, the spring **24** may be relaxed in the design state. In such examples, the coil spring **24** has a free length shorter than or equal to than the first portion of the rod **14**. In other examples, the spring **24** may be compressed along the axis A of the rod **14** between the vehicle bumper **12** and the vehicle frame **28** in the design state.

[0062] In the retractable state, the spring **24** may be compressed between the bumper **12** and the vehicle frame **28** as the bumper **12** moves vehicle-rearward relative to the vehicle frame **28** after release of the collar **20** based on certain vehicle impacts. In such instances, the spring **24** is compressed as the bumper **12** moves vehicle-rearward toward the vehicle frame **28**. When in the design state, the collar **20** may be released from the rod **14** based on pre-impact detection of certain vehicle impacts, as described further below.

[0063] The spring **24**, as an example, may be a coil spring **24**. In the example shown in the Figures, the spring **24** is a coil spring **24** on the rod **14** between the bumper **12** and the vehicle frame **28**, i.e., the coils of the coil spring **24** helically extend around the rod **14** along the axis A. In such an example, the spring **24** has an inner diameter sized to be received by the rod **14**. The inner diameter of the spring **24** is larger than the outer diameter of the rod **14**. The spring **24** may be metal.

[0064] In the example shown in the Figures, the bumper assembly **10**, specifically the energy-absorber assembly **30**, includes the retainer **42** fixed to the rod **14** to retain the rod **14** to the vehicle frame **28**, e.g., in the hole **32**, in both the design state and the retractable state. The flange **34** is between the collar **20** and the retainer **42**. The retainer **42** is spaced from the collar **20** along the axis A with the flange **34** therebetween.

[0065] The retainer **42** is sized to retain the rod **14** in the hole **32**. The retainer **42** protrudes radially outwardly from rod **14**, e.g., at second end **18**. The retainer **42** has an outer dimension, i.e., taken radially outward from the rod **14**, that is larger than the outer dimension of the hole **32** such that the retainer **42** abuts the vehicle frame **28** in the design state and the retractable state.

[0066] The retainer **42** is fixable to the rod **14**, e.g., the second end **18** of the rod **14**. Specifically, when assembled in the design state, the retainer **42** is fixed to the rod **14**. The retainer **42** is fixed to the rod **14** along the axis A of the rod **14**, e.g., by threaded engagement, adhesive, welding, unitary formation, etc. The retainer **42** may be fixed to the distal end of the rod **14**.

[0067] In the example shown in the Figures, the rod **14** has external threads and the retainer **42** has internal threads threadedly engaged with the external threads of the rod **14** to axially fix the collar **20** relative to the rod **14**. In such an example, additional engagement may be achieved by adhesive, bond, welding, etc., at the threads. In other examples, the retainer **42** may be fixed to the rod **14** in any suitable fashion including one or a combination of threads, pinning, engagement of grooves, adhesive, bonding, welding, etc. In the example shown in the Figures, the retainer **42** is a threaded nut that engages the same external threads in the rod **14** that the collar **20** engages.

[0068] With reference to FIG. **7**, the vehicle **26** includes the vehicle computer **46** including a processor and a memory. The computer **46** may be a body control module. The memory includes one or more forms of computer **46** readable media, and stores instructions executable by the computer **46** for performing various operations, including as disclosed herein and including, for example, the process described below. For example, the computer **46** may be a generic computer **46** with a processor and memory as described above and/or may include an electronic control unit ECU or controller for a specific function or set of functions, and/or a dedicated electronic circuit including an ASIC (application specific integrated circuit) that is manufactured for a particular operation, e.g., an ASIC for processing sensor data and/or communicating the sensor data. In another example, the computer **46** may include an FPGA (Field-Programmable Gate Array) which is an integrated circuit manufactured to be configurable by a user. Typically, a hardware description language such as VHDL (Very High-Speed Integrated Circuit Hardware Description Language) is used in electronic design automation to describe digital and mixed-signal systems such as FPGA and ASIC. For example, an ASIC is manufactured based on VHDL programming provided pre-manufacturing, whereas logical components inside an FPGA may be configured based on VHDL programming, e.g., stored in a memory electrically connected to the FPGA circuit. In some examples, a combination of processor(s), ASIC(s), and/or FPGA circuits may be included in the computer **46**. The memory may be of any type, e.g., hard disk drives, solid state drives, servers, or any volatile or non-volatile media. The memory may store the collected data sent from the sensors. The memory may be a separate device from the computer **46**, and the computer **46** may retrieve information stored by the memory via a vehicle

communication network **48**, e.g., over a CAN bus, a wireless network, etc. Alternatively or additionally, the memory may be part of the computer **46**, e.g., as a memory of the computer **46**.

[0069] As shown in FIG. **7**, the computer **46** is generally arranged for communications on the vehicle communication network **48** that may include a bus in the vehicle **26** such as a controller area network CAN or the like, and/or other wired and/or wireless mechanisms. Alternatively or additionally, in cases where the computer **46** includes a plurality of devices, the vehicle communication network **48** may be used for communications between devices represented as the computer **46** in this disclosure. Further, as mentioned below, various controllers and/or sensors may provide data to the computer **46** via the vehicle communication network **48**.

[0070] The vehicle **26** may include at least one impact sensor **50** for sensing certain vehicle impacts (e.g., impacts of a certain magnitude, direction, etc.), and the computer **46** in communication with the impact sensor **50** and the pyrotechnically-activated release **22**. The computer **46** may activate the pyrotechnically-activated release **22**, e.g., provide an impulse to the pyrotechnic charge **56** of the pyrotechnically-activated release **22** when the impact sensor **50** senses certain vehicle impacts. The impact sensor **50** may be configured to sense certain vehicle impacts prior to impact, i.e., pre-impact sensing. The impact sensor **50** may be in communication with the computer **46**. The impact sensor **50** is configured to detect certain vehicle impacts. In other words, a "certain vehicle impact" is an impact of the type and/or magnitude for which inflation of the airbag is designed i.e., "certain" indicates the type and/or magnitude of the impact. The type and/or magnitude of such "certain vehicle impacts" may be pre-stored in the computer **46**, e.g., a restraints control module and/or a body control module. The impact sensor **50** may be of any suitable type, for example, post contact sensors such as accelerometers, pressure sensors, and contact switches; and pre-impact sensors such as radar, LIDAR, and vision sensing systems. The vision sensing systems may include one or more cameras, CCD image sensors, CMOS image sensors, etc. The impact sensor **50** may be located at numerous points in or on the vehicle **26**.

[0071] The computer **46** stores instructions to control components of the vehicle **26** according to the process described below. Use of "in response to," "based on," and "upon determining" herein indicates a causal relationship, not merely a temporal relationship. The computer **46** stores instructions to, in response to detection of certain vehicle impacts (e.g., pre-impact detection of a certain imminent impacts), command activation of the pyrotechnically-activated release **22**. Specifically, the computer **46** commands an electrical impulse to the pyrotechnic charge **56** to release the collar **20** from the rod **14**, as described above. In examples including more than one pyrotechnically-activated release **22**, the computer **46** may simultaneously command activation of each pyrotechnically-activated release **22**. When the collars **20** release the rods **14**, the energy-absorbing assemblies are in the retractable state such that the springs **24** can compress to during impact with the vehicle bumper **12**, as described above. In examples in which the release of the collars **20** from the rods **14** is based on pre-impact detection, the certain vehicle impacts are detected before impact and the collars **20** are released from the rods **14** prior to impact. In such examples, during certain vehicle impacts of sufficient magnitude to compress the spring **24**, the impact can move the bumper **12** and the rods **14** vehicle rearward relative to the vehicle frame **28**. For example, during certain impacts with a leg form, the bumper **12** and rods **14** move vehicle rearward against the force of the springs **24** to absorb energy from the impact and reduce energy delivered from the bumper **12** to the leg form, as described above.

[0072] The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

What is claimed is:

1. A vehicle comprising:

a vehicle frame;

a vehicle bumper;

a rod elongated along an axis, the rod being fixed relative to the vehicle bumper and slidably engaged with vehicle frame;

a spring between the vehicle bumper and the vehicle frame; and

a collar fixed relative to the rod and extending radially from the rod, the collar including a pyrotechnically-activated release releasable from the rod.

2. The vehicle of claim **1**, wherein the collar is between the vehicle bumper and the vehicle frame.

3. The vehicle of claim **1**, wherein the collar is between the spring and the vehicle frame.

4. The vehicle of claim **1**, further comprising a retainer protruding radially outwardly from the rod, the vehicle frame being between the retainer and the spring.

5. The vehicle of claim **4**, wherein the vehicle frame includes a flange between the retainer and the spring.

6. The vehicle of claim **5**, wherein the flange includes a hole that slidably receives the rod, the retainer having an outer diameter larger than an outer diameter of the hole.

7. The vehicle of claim **5**, wherein the flange is between the retainer and the collar, and the spring is between the collar and the vehicle bumper.

8. The vehicle of claim **5**, wherein the retainer and the collar abut the flange.

9. The vehicle of claim **5**, wherein the vehicle frame includes a crush can, the flange being fixed to the crush can.

10. The vehicle of claim **9**, wherein the wiring extends from the collar along the crush can.

11. The vehicle of claim **1**, wherein the vehicle frame includes a hole that slidably receives the rod.

12. The vehicle of claim **1**, wherein the rod supports the vehicle bumper on the vehicle frame.

13. The vehicle of claim **1**, wherein the spring is on the rod.

14. The vehicle of claim **1**, wherein the rod includes a first portion extending from the vehicle frame to the vehicle bumper, the spring having a free length shorter than or equal to than the first portion of the rod.

15. An assembly comprising:

a vehicle bumper;

a rod having a first end fixed to the vehicle bumper and a second end spaced from the first end along an elongated axis of the rod;

a collar fixed to the rod between the first end of the rod and the second end of the rod, the collar including a pyrotechnically-activated release releasable from the rod; and

a coil spring retained on the rod between the collar and the vehicle bumper.

16. The assembly of claim **15**, further comprising a retainer fixable to the second end of the rod, the retainer protruding radially outwardly from rod at second end.

17. The assembly of claim **16**, wherein the rod is configured to extend through a hole in a vehicle frame with the vehicle frame being between the collar and the retainer.

18. The assembly of claim **16**, further comprising a vehicle frame defining a hole, the rod extending through the vehicle frame with the vehicle frame being between the collar and the retainer.

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