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(54) **REMOTELY OPERATED BYPASS FOR A SUSPENSION DAMPER**

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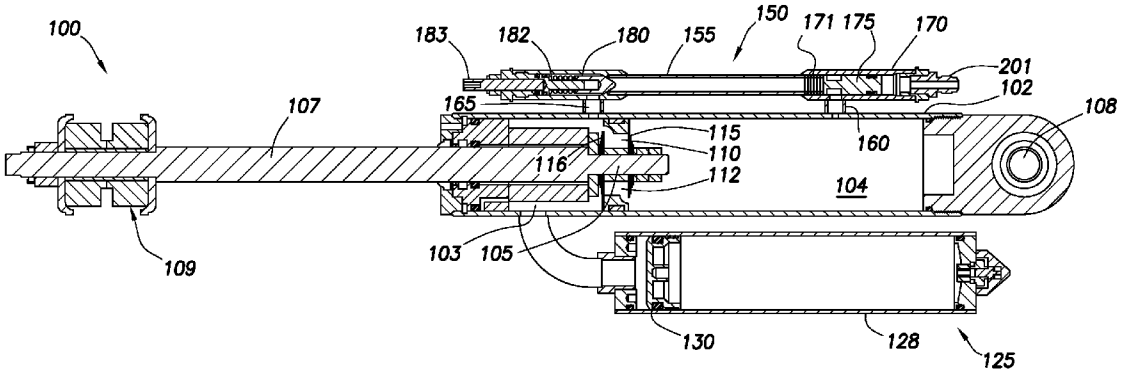
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(57) **ABSTRACT**

A damper assembly with a bypass for a vehicle comprises a pressure cylinder with a piston and piston rod for limiting the flow rate of damping fluid as it passes from a first to a second side of said piston. A bypass provides fluid pathway between the first and second sides of the piston separately from the flow rate limitation. In one aspect, the bypass is remotely controllable from a passenger compartment of the vehicle. In another aspect, the bypass is remotely controllable based upon one or more variable parameters associated with the vehicle.



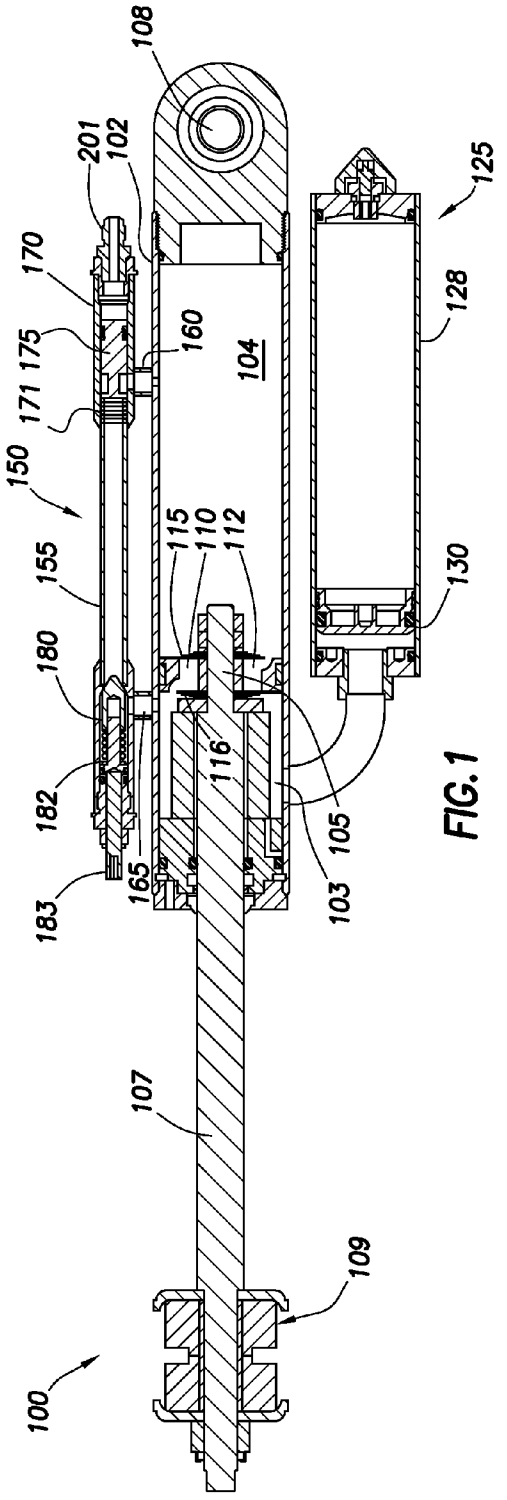

108
201
102
125
170
128
160
104
175
171
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155
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182
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165
103
183
107
109
100

FIG.1

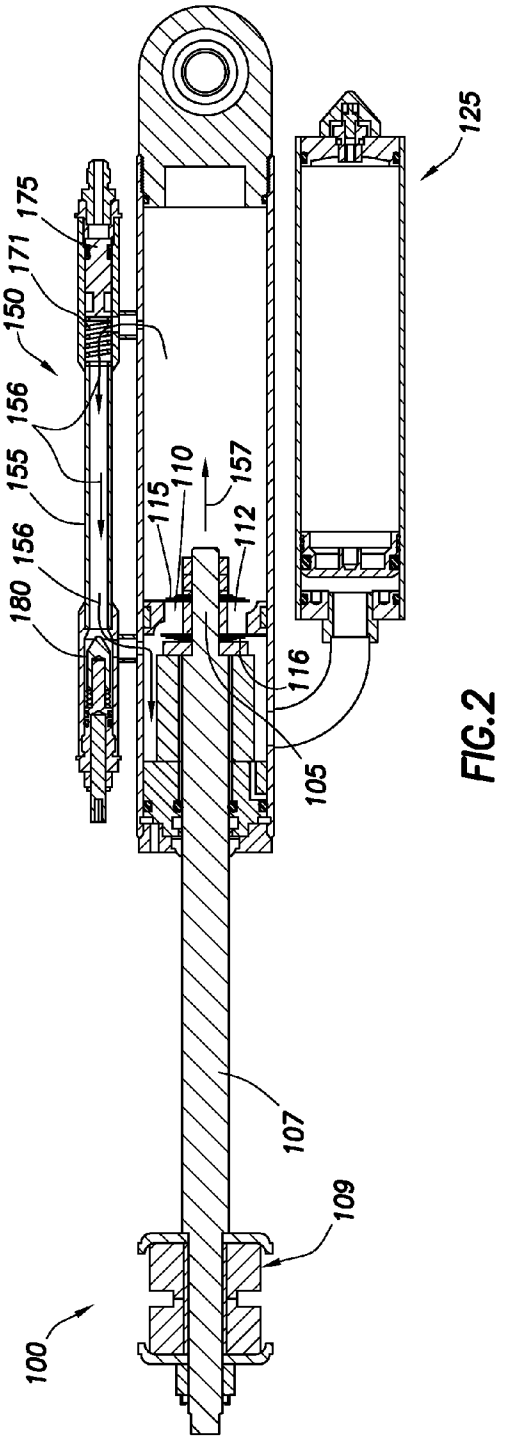
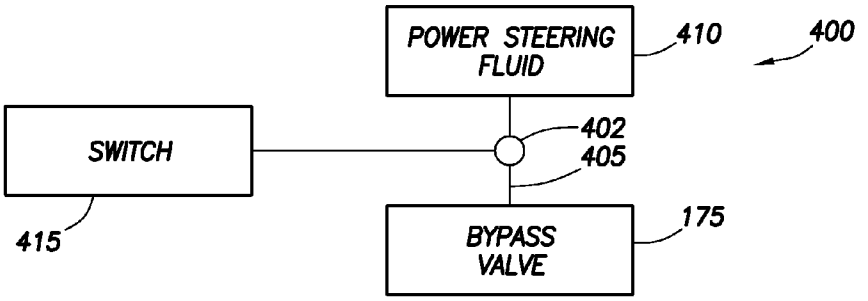

125
175
171
150
156
155
157
110
115
112
180
116
105
107
109
100

FIG.2

FIG.3



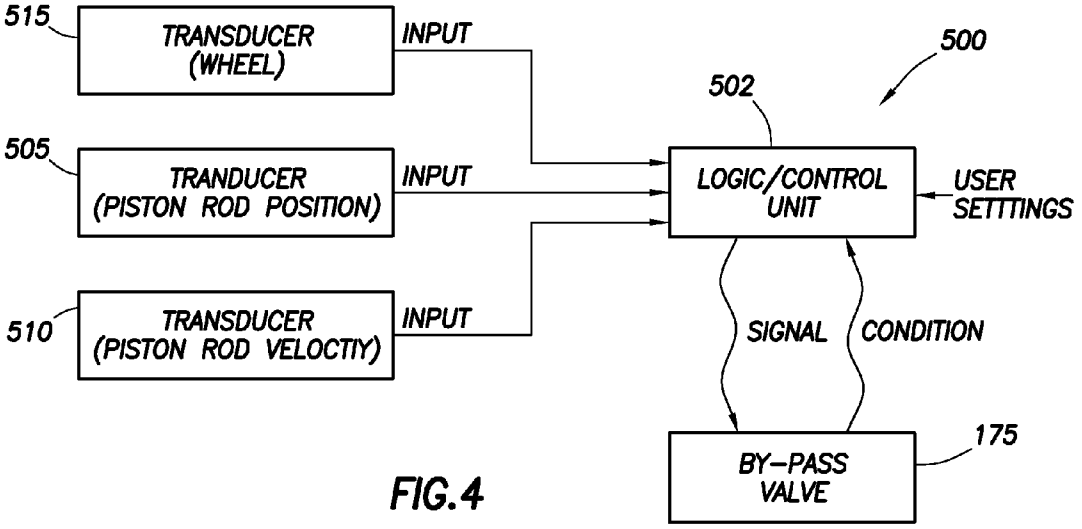


FIG.4

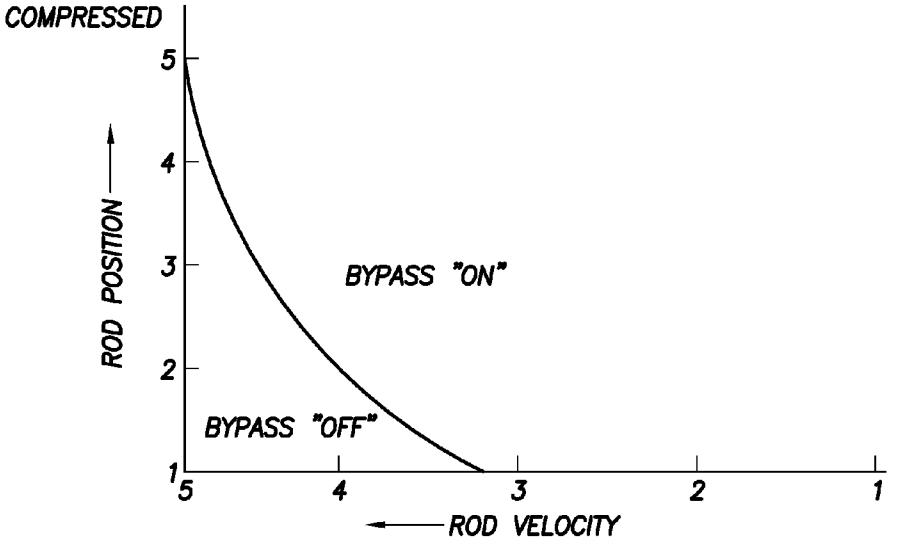


FIG.5

REMOTELY OPERATED BYPASS FOR A SUSPENSION DAMPER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. provisional patent application Ser. No. 61/143,152, filed Jan. 7, 2009, which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] Embodiments of the present invention generally relate to a damper assembly for a vehicle. More specifically, the invention relates to a remotely operated bypass device used in conjunction with a vehicle damper.

[0003] Vehicle suspension systems typically include a spring component or components and a dampening component or components. Typically, mechanical springs, like helical springs are used with some type of viscous fluid-based dampening mechanism and the two are mounted functionally in parallel.

SUMMARY OF THE INVENTION

[0004] The present invention generally comprises a damper assembly having a bypass. In one aspect, the assembly comprises a cylinder with a piston and piston rod for limiting the flow rate of damping fluid as it passes from a first to a second portion of said cylinder. A bypass provides fluid pathway between the first and second portions of the cylinder and may be independent of, or in conjunction with, the aforementioned flow rate limitation. In one aspect, the bypass is remotely controllable from a passenger compartment of the vehicle. In another aspect, the bypass is remotely controllable based upon one or more variable parameters associated with the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] So that the manner in which the above recited features can be understood in detail, a more particular description may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0006] FIG. **1** is a section view showing a suspension damping unit with a remotely operable bypass, the bypass in a closed position.

[0007] FIG. **2** is a section view showing the suspension damping unit of FIG. **1** with the bypass in an open position.

[0008] FIG. **3** is a schematic diagram showing a control arrangement for a remotely operated bypass.

[0009] FIG. **4** is a schematic diagram showing another control arrangement for a remotely operated bypass.

[0010] FIG. **5** is a graph showing possible operational characteristics of the arrangement of FIG. **4**.

DETAILED DESCRIPTION

[0011] As used herein, the terms "down" "up" "downward" upward" "lower" "upper" and other directional references are relative and are used for reference only. FIGS. **1** and **2** are section views of a suspension damping unit **100**. The damper includes a cylinder portion **102** with a rod **107** and a piston **105**. Typically, the fluid meters, from one side to the other side of piston **105**, by passing through flow paths **110**, **112** formed in the piston **105**. In the embodiment shown, shims **115**, **116** are used to partially obstruct the flow paths **110**, **112** in each direction. By selecting shims **115**, **116** having certain desired stiffness characteristics, the dampening effects can be increased or decreased and dampening rates can be different between the compression and rebound strokes of the piston **105**. For example, shims **115** are configured to meter rebound flow from the rebound portion **103** of the cylinder **102** to the compression portion **104** of the cylinder **102**. Shims **116**, on the other hand, are configured to meter compression flow from the compression portion of the cylinder to the rebound portion. In one embodiment, shims **116** are not included on the rebound portion side leaving the piston essentially "locked out" in the compression stroke without some means of flow bypass. Note that piston apertures (not shown) may be included in planes other than those shown (e.g. other than apertures used by paths **110** and **112**) and further that such apertures may, or may not, be subject to the shims **115**, **116** as shown (because for example, the shims **115**, **116** may be clover-shaped or have some other non-circular shape).

[0012] A reservoir **125** is in fluid communication with the damper cylinder **102** for receiving and supplying damping fluid as the piston rod **107** moves in and out of the cylinder. The reservoir includes a cylinder portion **128** in fluid communication with the damper cylinder **102**. The reservoir also includes a floating piston **130** with a volume of gas on a backside ("blind end" side) of it, the gas being compressible as the reservoir cylinder **128** fills with fluid due to movement of the damper rod **107** and piston **105** into the damper cylinder **102**. Certain features of reservoir type dampers are shown and described in U.S. Pat. No. 7,374,028, which is incorporated herein, in its entirety, by reference. The upper portion of the rod **107** is supplied with a bushing set **109** for connecting to a portion of a vehicle wheel suspension linkage. In another embodiment, not shown, the upper portion of the rod **107** (opposite the piston) may be supplied with an eyelet to be mounted to one part of the vehicle, while the lower part of the housing shown with an eyelet **108** is attached to another portion of the vehicle, such as the frame, that moves independently of the first part. A spring member (not shown) is usually mounted to act between the same portions of the vehicle as the damper. As the rod **107** and piston **105** move into cylinder **102** (during compression), the damping fluid slows the movement of the two portions of the vehicle relative to each other due to the incompressible fluid moving through the shimmed paths **110**, **112** (past shims **116**) provided in the piston **105** and/or through the metered bypass **150**, as will be described herein. As the rod **107** and piston **105** move out of the cylinder **102** (during extension or "rebound") fluid meters again through shimmed paths **110** and **112** and the flow rate and corresponding rebound rate is controlled by the shims **115**.

[0013] In one embodiment as shown in the Figures, a bypass assembly **150** is designed to permit damping fluid to travel from a first side of the piston to the other side without traversing shimmed flow paths **110**, **112** that may otherwise be traversed in a compression stroke of the damper. In FIG. **1**, the bypass **150** is shown in a closed position (e.g. a valve **170** obstructs fluid passage through entry way **160**) and in FIG. **2** the bypass is shown in an open position (e.g. valve **170** is open and fluid may flow through passage **160**). In FIG. **2**, the piston

is shown moving downward in a compression stroke, the movement shown by arrow **157**. The bypass includes a cylindrical body **155** that communicates with the damper cylinder **102** through entry **160** and exit **165** pathways. In FIG. **2**, with the bypass open, the flow of fluid through the bypass is shown by arrow **156**. In one embodiment an entry valve **170** is located at the entry pathway **160** with a valve member **175** sealingly disposed and axially movable within the valve body. A needle-type check valve **180**, allowing flow in direction **156** and checking flow in the opposite direction, is located proximate exit pathway **165**. The needle valve sets flow resistance through the bypass **150** during compression and restricts fluid from entering the bypass cylinder **150** during a rebound stroke of the damper piston **105**. In one embodiment the needle valve **180** is spring loaded and biased closed. The initial compression force of the biasing spring **182** is adjusted via adjuster **183** thereby allowing a user to preset the needle valve opening pressure and hence the compression damping fluid flow rate (hence damping rate) through the bypass. The biasing force of the needle valve spring **182** is overcome by fluid pressure in the cylinder **155** causing the needle valve **180** to open during a compression stroke.

[0014] The entry pathway **160** and entry valve **170** in the embodiments shown in FIGS. **1** and **2**, are located towards a lower end of the damper cylinder **102**. In one embodiment, as selected by design, the bypass will not operate after the piston **105** passes the entry pathway **160** near the end of a compression stroke. This "position sensitive" feature ensures increased dampening will be in effect near the end of the compression stoke to help prevent the piston from approaching a "bottomed out" position (e.g. impact) in the cylinder **102**. In some instances, multiple bypasses are used with a single damper and the entry pathways for each may be staggered axially along the length of the damper cylinder in order to provide an ever-increasing amount of dampening (and less bypass) as the piston moves through its compression stroke and towards the bottom of the damping cylinder. Certain bypass damper features are described and shown in U.S. Pat. Nos. 6,296,092 and 6,415,895, each of which are incorporated herein, in its entirety, by reference.

[0015] In one embodiment the bypass **150**, as shown in FIGS. **1** and **2**, includes a fluid (e.g. hydraulic or pneumatic) fitting **201** disposed at an end of the entry valve body **170**. The fluid fitting **201** is intended to carry a control signal in the form of fluid pressure to the valve member **175** in order to move the valve **170** from an open to a closed position. In one embodiment, valve member **175** is biased open by an annular spring **171** located between an upper end of the valve member **175** and the lower axial end face of tube **155**.

[0016] In one example, the valve **170** is moved to a closed position and the bypass feature disabled by remote control from a simple operator-actuated switch located in the passenger compartment of the vehicle. In one embodiment, fluid pressure for controlling (e.g. closing) the valve **170** is provided by the vehicle's own source of pressurized hydraulic fluid created by, for example, the vehicle power steering system. In one embodiment, pneumatic pressure is used to control (e,g, close) the valve **170** where the pneumatic pressure is generated by an on-board compressor and accumulator system and conducted to the valve **170** via a fluid conduit. In one embodiment, a linear electric motor (e.g. solenoid), or other suitable electric actuator, is used to move valve member **175** axially within valve body. A shaft of the electric actuator (not shown) may be fixed to the valve member **175** such that axial movement of the shaft causes axial movement of the valve member **175**. In one embodiment, the electric actuator is configured to "push" the valve member **175** to a closed position and to "pull" the valve member **175** to an open position depending on the direction of the current switched through the actuator. In one embodiment, the valve **170** is spring biased, for example, to an open position as previously described herein, and the actuator, being switched by a potentiometer or other suitable current or voltage modulator, moves the valve member **175** against the biasing spring to a closed position or to some position of desired partial closure (depending on the operation of the switch). Such partial closure increases the compression stiffness of the damper but does not provide the more rigid dampening of complete bypass closure. In such electrical embodiments, the solenoid is wired (e.g. via electrical conduit) into the vehicle electrical system and switched to move the valve **170** as described herein.

[0017] FIG. **3** is a schematic diagram illustrating a sample circuit **400** used to provide remote control of a bypass valve using a vehicle's power steering fluid (although any suitable fluid pressure source may be substituted for reservoir **410** as could an electrical current source in the case of an electrically actuated valve member **175**). As illustrated, a fluid pathway **405** having a switch-operated valve **402** therein runs from a fluid (or current) reservoir **410** that is kept pressurized by, in one embodiment, a power steering pump (not shown) to a bypass valve **170** that is operable, for example, by a user selectable dash board switch **415**. The valve **402** permits fluid to travel to the bypass valve **170**, thereby urging it to a closed position. When the switch **415** is in the "off" position, working pressure within the damper, and/or a biasing member such as a spring **171** (as described herein in relation to FIGS. **1** & **2**) or annular atmospheric chamber (not shown), returns the bypass to its normally-open position. Hydraulically actuated valving for use with additional components is shown and described in U.S. Pat. No. 6,073,536 and that patent is incorporated by reference herein in its entirety. While FIG. **3** is simplified and involves control of a single bypass valve, it will be understood that the valve **402** could be plumbed to simultaneously provide a signal to two or more bypass valves operable with two or more vehicle dampers and/or with a single damper having multiple bypass channels and multiple corresponding valves (e.g. **175**). Additional switches could permit individual operation of separate damper bypass valves in individual bypass channels, whether on separate dampers or on the same multiple bypass damper, depending upon an operator's needs. While the example of FIG. **3** uses fluid power for operating the bypass valve, a variety of means are available for remotely controlling a valve. For instance, a source of electrical power from a 12 volt battery could be used to operate a solenoid member, thereby shifting valve member **175** in bypass valve **170** between open and closed positions. The signal can be either via a physical conductor or an RF signal (or other wireless such as Bluetooth, WiFi, ANT) from a transmitter operated by the switch **415** to a receiver operable on the bypass valve **175**.

[0018] A remotely operable bypass like the one described above is particularly useful with an on/off road vehicle. These vehicles can have as much as 20" of shock absorber travel to permit them to negotiate rough, uneven terrain at speed with usable shock absorbing function. In off-road applications, compliant dampening is necessary as the vehicle relies on its long travel suspension when encountering off-road obstacles.

Operating a vehicle with very compliant, long travel suspension on a smooth road at higher speeds can be problematic due to the springiness/sponginess of the suspension. Such compliance can cause reduced handling characteristics and even loss of control. Such control issues can be pronounced when cornering at high speed as a compliant, long travel vehicle may tend to roll excessively. Similarly, such a vehicle may pitch and yaw excessively during braking and acceleration. With the remotely operated bypass "lock out" described herein, dampening characteristics of a shock absorber can be completely changed from a compliantly dampened "springy" arrangement to a highly dampened and "stiffer" system ideal for higher speeds on a smooth road. In one embodiment where compression flow through the piston is completely blocked, closure of the bypass **150** results in substantial "lock out" of the suspension (the suspension is rendered essentially rigid). In one embodiment where some compression flow is allowed through the piston (e.g. ports **110**, **112** and shims **116**), closure of the bypass **150** results in a stiffer but still functional compression damper. In one embodiment, the needle valve **180** is tuned (using adjuster **183**), and the shims **116** sized, to optimize damping when the bypass **150** is open and when bypass **150** is closed based on total anticipated driving conditions. In one embodiment the needle valve adjuster **183** is connected to a rotary electrical actuator so that adjustment of the needle valve4 **180** may be performed remotely as disclosed herein referencing the bypass valve **170**.

[0019] In addition to, or in lieu of, the simple, switch operated remote arrangement of FIG. **3**, the remote bypass can be operated automatically based upon one or more driving conditions. FIG. **4** shows a schematic diagram of a remote control system **500** based upon any or all of vehicle speed, damper rod speed, and damper rod position. One embodiment of FIG. **4** is designed to automatically increase dampening in a shock absorber in the event a damper rod reaches a certain velocity in its travel towards the bottom end of a damper at a predetermined speed of the vehicle. In one embodiment the system adds dampening (and control) in the event of rapid operation (e.g. high rod velocity) of the damper to avoid a bottoming out of the damper rod as well as a loss of control that can accompany rapid compression of a shock absorber with a relative long amount of travel. In one embodiment the system adds dampening (e.g. closes or throttles down the bypass) in the event that the rod velocity in compression is relatively low, but the rod progresses past a certain point in the travel. Such configuration aids in stabilizing the vehicle against excessive low rate suspension movement events such as cornering roll, braking and acceleration yaw and pitch and "g-out."

[0020] FIG. **4** illustrates, for example, a system including three variables: rod speed, rod position and vehicle speed. Any or all of the variables shown may be considered by processor **502** in controlling the valve **175**. Any other suitable vehicle operation variable may be used in addition to or in lieu of the variables **515**, **505**, **510** such as for example piton rod compression strain, eyelet strain, vehicle mounted accelerometer data or any other suitable vehicle or component performance data. In one embodiment, a suitable proximity sensor or linear coil transducer or other electro-magnetic transducer is incorporated in the dampening cylinder to provide a sensor to monitor the position and/or speed of the piston (and suitable magnetic tag) with respect to the cylinder. In one embodiment, the magnetic transducer includes a waveguide and a magnet, such as a doughnut (toroidal) magnet that is joined to the cylinder and oriented such that the magnetic field generated by the magnet passes through the piston rod and the waveguide. Electric pulses are applied to the waveguide from a pulse generator that provides a stream of electric pulses, each of which is also provided to a signal processing circuit for timing purposes. When the electric pulse is applied to the waveguide a magnetic field is formed surrounding the waveguide. Interaction of this field with the magnetic field from the magnet causes a torsional strain wave pulse to be launched in the waveguide in both directions away from the magnet. A coil assembly and sensing tape is joined to the waveguide. The strain wave causes a dynamic effect in the permeability of the sensing tape which is biased with a permanent magnetic field by the magnet. The dynamic effect in the magnetic field of the coil assembly due to the strain wave pulse, results in an output signal from the coil assembly that is provided to the signal processing circuit along signal lines. By comparing the time of application of a particular electric pulse and a time of return of a sonic torsional strain wave pulse back along the waveguide, the signal processing circuit can calculate a distance of the magnet from the coil assembly or the relative velocity between the waveguide and the magnet. The signal processing circuit provides an output signal, either digital or analog, proportional to the calculated distance and/or velocity. Such a transducer-operated arrangement for measuring rod speed and velocity is described in U.S. Pat. No. 5,952,823 and that patent is incorporated by reference herein in its entirety.

[0021] While a transducer assembly located at the damper measures rod speed and location, a separate wheel speed transducer for sensing the rotational speed of a wheel about an axle includes housing fixed to the axle and containing therein, for example, two permanent magnets. In one embodiment the magnets are arranged such that an elongated pole piece commonly abuts first surfaces of each of the magnets, such surfaces being of like polarity. Two inductive coils having flux-conductive cores axially passing therethrough abut each of the magnets on second surfaces thereof, the second surfaces of the magnets again being of like polarity with respect to each other and of opposite polarity with respect to the first surfaces. Wheel speed transducers are described in U.S. Pat. No. 3,986,118 which is incorporated herein by reference in its entirety.

[0022] In one embodiment, as illustrated in FIG. **4**, a logic unit **502** with user-definable settings receives inputs from the rod speed **510** and location **505** transducers as well as the wheel speed transducer **515**. The logic unit is user-programmable and depending on the needs of the operator, the unit records the variables and then if certain criteria are met, the logic circuit sends its own signal to the bypass to either close or open (or optionally throttle) the bypass valve **175**. Thereafter, the condition of the bypass valve is relayed back to the logic unit **502**.

[0023] FIG. **5** is a graph that illustrates a possible operation of one embodiment of the bypass assembly **500** of FIG. **4**. The graph assumes a constant vehicle speed. For a given vehicle speed, rod position is shown on a y axis and rod velocity is shown on an x axis. The graph illustrates the possible on/off conditions of the bypass at combinations of relative rod position and relative rod velocity. For example, it may be desired that the bypass is operable (bypass "on") unless the rod is near its compressed position and/or the rod velocity is relatively high (such as is exemplified in FIG. **5**). The on/off configurations of FIG. **5** are by way of example only and any other

suitable on/off logic based on the variable shown or other suitable variables may be used. In one embodiment it is desirable that the damper become relatively stiff at relatively low rod velocities and low rod compressive strain (corresponding for example to vehicle roll, pitch or yaw) but remains compliant in other positions. In one embodiment the piston rod **107** includes a "blow off" (overpressure relief valve typically allowing overpressure flow from the compression side to the rebound side) valve positioned in a channel coaxially disposed though the rod **107** and communicating one side of the piston (and cylinder) with the other side of the piston (and cylinder) independently of the apertures **110**,**112** and the bypass **150**.

[0024] In one embodiment, the logic shown in FIG. **4** assumes a single damper but the logic circuit is usable with any number of dampers or groups of dampers. For instance, the dampers on one side of the vehicle can be acted upon while the vehicles other dampers remain unaffected.

[0025] While the examples illustrated relate to manual operation and automated operation based upon specific parameters, the remotely operated bypass can be used in a variety of ways with many different driving and road variables. In one example, the bypass is controlled based upon vehicle speed in conjunction with the angular location of the vehicle's steering wheel. In this manner, by sensing the steering wheel turn severity (angle of rotation), additional dampening can be applied to one damper or one set of dampers on one side of the vehicle (suitable for example to mitigate cornering roll) in the event of a sharp turn at a relatively high speed. In another example, a transducer, such as an accelerometer measures other aspects of the vehicle's suspension system, like axle force and/or moments applied to various parts of the vehicle, like steering tie rods, and directs change to the bypass valve positioning in response thereto. In another example, the bypass can be controlled at least in part by a pressure transducer measuring pressure in a vehicle tire and adding dampening characteristics to some or all of the wheels in the event of, for example, an increased or decreased pressure reading. In still another example, a parameter might include a gyroscopic mechanism that monitors vehicle trajectory and identifies a "spin-out" or other loss of control condition and adds and/or reduces dampening to some or all of the vehicle's dampers in the event of a loss of control to help the operator of the vehicle to regain control.

[0026] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. A vehicle suspension damper comprising:
- a cylinder and a piston assembly comprising a piston and piston rod;
- working fluid within said cylinder;
- a passageway through said piston allowing and limiting a flow rate of the working fluid through the piston in at least one direction;
- a bypass having a fluid pathway between the first and second sides of the piston; and
- a remotely controllable valve for limiting the flow of fluid through the bypass.

2. The damper of claim **1**, further including a control system for moving the valve between an open and closed position form a remote location, the control system comprising:
- a switch for operating the valve; and
- a conduit providing communication between the switch and valve.

3. The damper of claim **2**, wherein the switch is a manually operable switch having at least two positions.

4. The damper of claim **2**, wherein the switch is located in a passenger compartment of the vehicle.

5. The damper of claim **2**, wherein the conduit is a fluid conduit for carrying control fluid and the system includes a source of control fluid.

6. The damper of claim **2**, wherein the conduit is an electrical conduit for carrying a control signal.

7. The damper of claim **2**, wherein the valve is solenoid actuated, the solenoid electrically connected to the conduit.

8. The damper of claim **2**, wherein the conduit is a waveform for carrying an RF signal.

9. The damper of claim **2**, wherein the control system further includes a power source.

10. The damper of claim **1**, wherein the valve is disposed adjacent the bypass and includes valve member having a first position obstructing a flow path between the cylinder and bypass and a second position allowing flow through the flow path.

11. The damper of claim **1**, wherein the at least one direction comprises two directions.

12. The damper of claim **2**, wherein the signaling apparatus is a transducer for measuring rod position within a damper cylinder.

13. The damper of claim **1**, further comprising a second valve for limiting flow through the bypass.

14. The damper of claim **2**, wherein the switch comprises a load transducer for sensing piston rod force.

15. The damper of claim **2**, wherein the switch comprises a transducer arranged to measure an angle associated with the steering wheel of the vehicle.

16. The damper of claim **1**, further comprising a one way valve arranged to control flow through the piston.

17. A remotely controllable shock absorber system for a vehicle comprising:
- at least two dampers associated with at least two wheels of the vehicle, each damper comprising:
- a cylinder with a piston for movement therein, the piston metering fluid in at least one direction there though;
- a bypass for bypassing fluid around the piston to decrease a dampening effect in the damper,
- a remotely actuatable valve for opening and closing the bypass to the flow of fluid; and the shock absorber system further including a switch associated with each damper, the switch arranged to cause at least one valve to operate based upon at least one characteristic of the vehicle.

18. The remotely controllable shock absorber system of claim **17**, wherein the dynamic characteristic is at least two of vehicle speed, vehicle trajectory angular acceleration, damper rod velocity, and rod location in a damper cylinder.

19. The remotely controllable shock absorber system of claim **17**, further comprising a second valve for limiting fluid flow through the damper.

20. The remotely controllable shock absorber system of claim **19**, wherein the second valve is remotely controllable.

21. The remotely controllable shock absorber system of claim **20** wherein the second valve controls fluid flow through the bypass.

* * * * *