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(54) **Control of dampers for vehicle suspension**

(57) In a vehicle damping system a damping element provided between a wheel of the vehicle and the vehicle structure comprises a working cylinder (5) for receiving damping fluid and a piston (8) which divides the cylinder (5) into an upper chamber (6) and a lower chamber (7). The chambers (6) and (7) are connected together through an electronically controlled damping valve 19 controlled by an electronic circuit in response to signals from a sensor. The sensor may measure damping force, velocity, acceleration, temperature or frequency. Alternatively, as shown, piston travel is sensed by a capacitor 29 within the cylinder and this signal is used to control the valve 19.

FIG.3

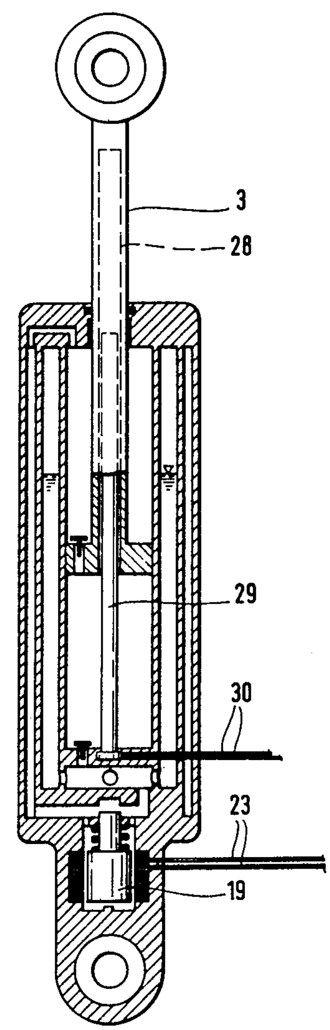

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FIG. 1

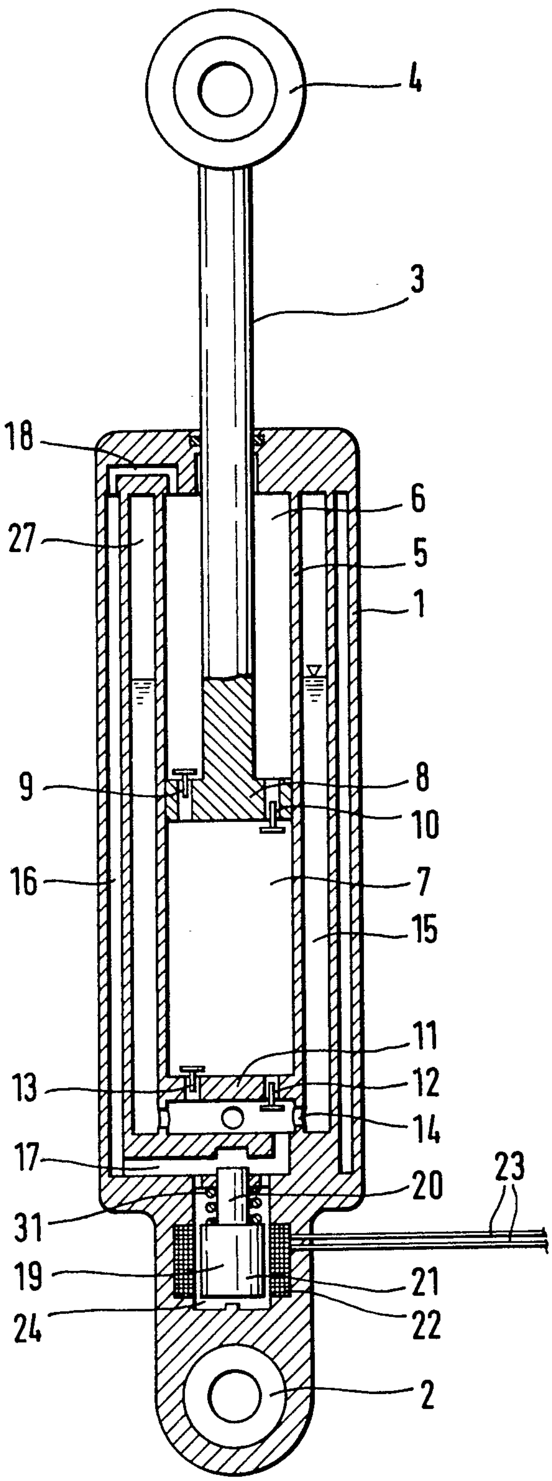


FIG. 2

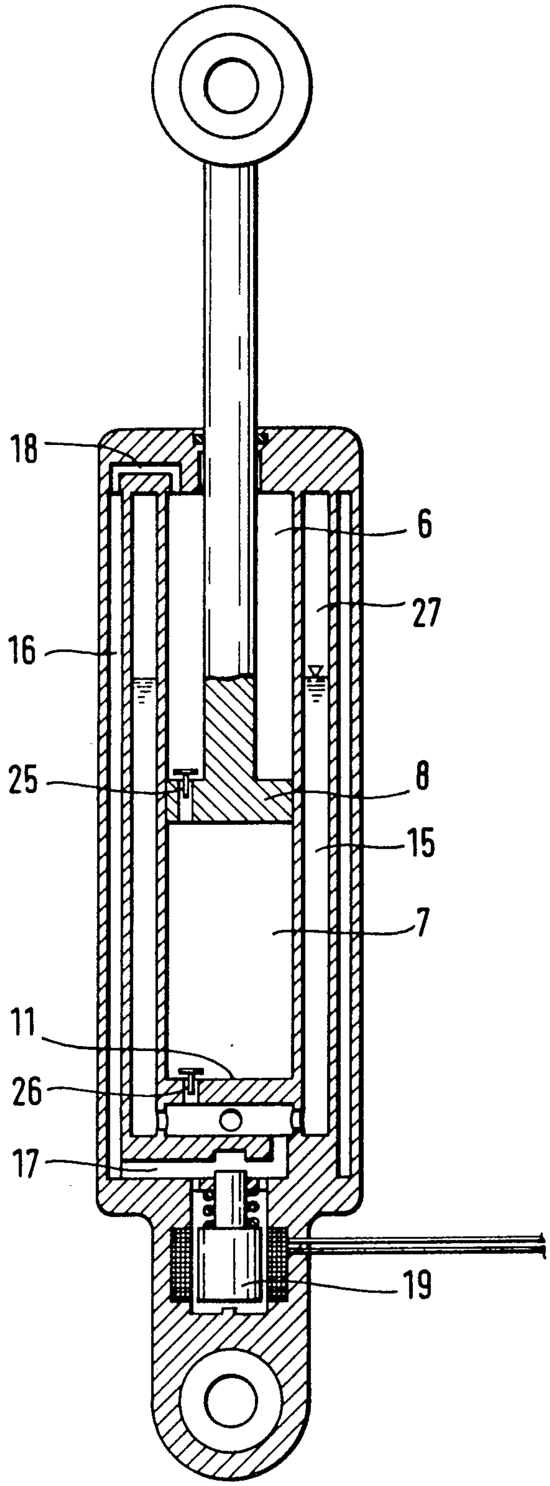


FIG.3

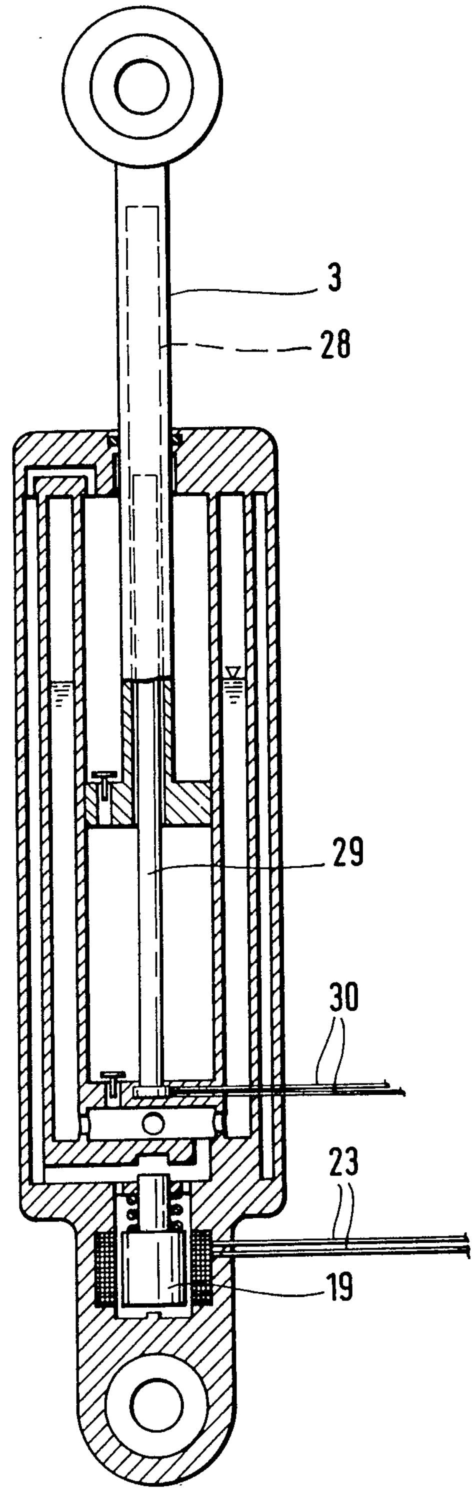
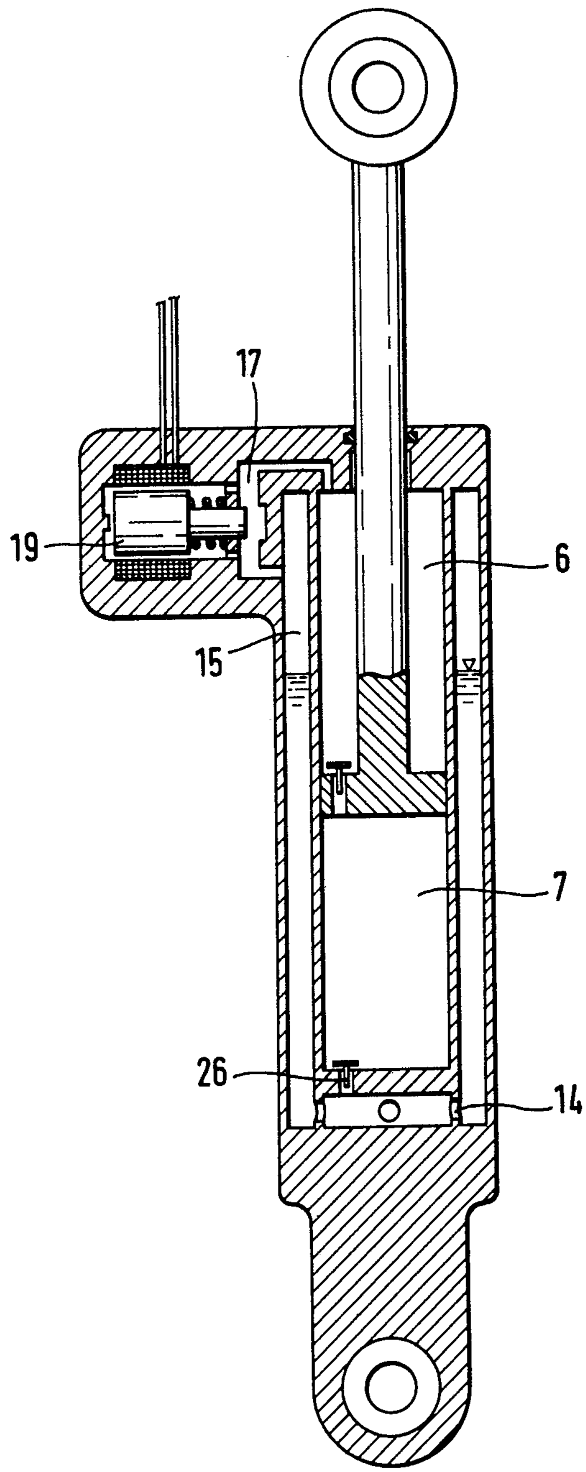


FIG. 4



SPECIFICATION

A vehicle vibration damping system

The invention relates to a vehicle vibration damping system in which at least one damping element is provided in the region of a vehicle wheel and the vehicle structure, the damping element comprising a working cylinder for receiving damping fluid and divided by a piston into two partial chambers, the two partial chambers being connected together through at least one damping valve.

Telescopic hydraulic vibration damping elements are known (e.g. DE-PS 26 55 705, DE-PS 27 44 301), in which a working cylinder is divided by a piston into two partial chambers, the damping piston having damping valves of a mechanical contruction. Such a conventional vibration damping element has the drawback that its damping characteristic is fixed for a certain type of vehicle and is a compromise of differing vehicle conditions. Such vibration damping of a vehicle by telescopic vibration damping elements is, in its operative condition correspondingly severely limited by the fixed damping characteristic, and furthermore different conditions of loading can have an adverse effect on the system.

Furthermore a method of active vibration damping is known (e.g. DE-OS 27 38 455) in which the damping characteristic can be varied. However there is the drawback here that fluid losses must be made up again by means of an external pump. Such a system requires an additional remotely fed hydraulic system needing an input of external energy and is accordingly very expensive. Not all types of vehicles have or indeed permit the provision of such an additional hydraulic system. Moreover on failure of this external pump the safety of the vehicle is no longer ensured as the overall system is put out of action.

It is, therefore, the aim of the invention to provide a vehicle damping system with a variable damping characteristic in which, without the input of external energy, the ride comfort, vehicle safety and ride behaviour can be optimised during operation of the vehicle.

According to the invention there is provided a vehicle vibration damping system for a vehicle in which at least one damping element is provided in the region of a vehicle wheel and the vehicle structure, the damping element comprising a working cylinder for receiving damping fluid and divided by a piston into two partial chambers, the two partial chambers being connected together through at least one electronically controlled damping valve.

In the damping system of the invention the damping characteristic can be varied electronically to suit the prevailing road and driving conditions. Mechanical valves which are preferably also present to serve for the basic damping ensure safety in the event of failure of the electronics. It is furthermore of advantage that by such eletronic control manufacturing tolerances, variations due to wear and variations with temperature in the damping system can be compensated.

Preferably, the electronically controlled damping valve is controlled by an electronic circuit in response to at least one sensor which senses the magnitude of the movement between the vehicle wheel and the vehicle structure. Additional sensors may be provided for sensing variations in other parameters. In this manner the damping characteristic of the damping valve may be vaired to take account of the loading condition and driving condition of the vehicle as well as the speed and/or the ambient temperature.

It is possible in a convenient form of the damping system for the data from the front axle to be used as control signals for the rear axle. Moreover, a control system can be provided for several quantities by having a corresponding number of sensors.

Preferably, the electronically controlled valve is disposed outside the working cylinder of the damping element. In this arrangement the damping element may be of a modular construction, or a basic design of damping element can be equipped subsequently with an electronically controlled valve. Thus a simple construction of the overall damping system is possible.

In a preferred embodiment the electronically controlled valve cooperates with throttling valves and/or base valves provided in the working cylinder. With this kind of cooperation an orthodox damping system may be made variable by the addition of an electronically controlled valve.

In a further embodiment the electronically controlled valve is disposed in the region of the piston. Here also the damping valve is of such a form that it is possible electronically to control the damping cross-sectional area.

The sensor which senses the magnitude of the movement between the vehicle wheel and the vehicle structure may comprise a piston travel sensor disposed inside the working cylinder. This results in a compact system. Preferably, the dimensions of the damping element are fully employed in an advantageous manner, if the piston travel sensor is in the form of a tubular capacitor for producing the corresponding masuring signals. The piston rod of the damping piston may have a hollow interior which is arranged to receive such a sensor.

Preferably, the electronically controlled damping valve is controlled by an electronic circuit in response to signals from at least one sensor which measures at least one of the following parameters: damping force; travel; velocity; acceleration; temperature; or frequency.

Conveniently, the electronically controlled valve comprises a proportional valve.

Some preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:–

Figure 1 is a cross-sectional view of a damping element including an electronically controlled damping valve;

Figure 2 is a cross-sectional view of a two-tube damping element similar to that of Fig. 1 but in which the damping fluid circulates only in one direction;

Figure 3 is a cross-sectional view of a two-tube damping element similar to that of Fig. 2 but with a sensor incorporated into the hollow piston rod; and

Figure 4 is a cross-sectional view of a two-tube damping element similar to that of Fig. 2, in which the electronically controlled valve is disposed to one side of the longitudinal axis of the damping element.

The diagrammatic illustration of a damping element shown in Fig. 1 comprises a housing 1 which is connected to a wheel-guiding member (not shown) through an attachment device 2, and a piston rod 3 which is secured to the vehicle structure by the attachment device 4. A working cylinder 5 within the housing 1 has an upper working chamber 6 and a lower working chamber 7; the chambers being separated from one another by a damping piston 8 on the piston rod 3.

The damping piston 8 is provided with a construction phase damping valve 9 and an extension phase damping valve 10. In the base 11 of the cylinder there is a further contraction phase damping valve 12 and a non-return valve 13. Fluid displaced by the piston rod 3 is forced into a compensating chamber 15 through a bore 14.

An annular chamber 16 disposed outside the compensating chamber 15 is connected through passages 17 and 18 to the upper working chamber 6 and to the compensating chamber 15, the fluid flow path into the lower working chamber 7 being provided from the compensating chamber 15 through the bore 14 and the non-return valve 13. An electronically controlled damping valve 19 is disposed in the passage 17 and has an armature spindle 20 which, according to its position, either closes off the passage 17 or provides a variable path for fluid to get past. The damping valve 19 comprises in detail the armature spindle 20, an armature 21, a coil 22, a spring 31 and terminals 23. The armature is located in a chamber 24 which can be filled with the damping fluid.

The damping valve 19 is controlled through the terminals 23 by an electronic circuit in response to signals received from a sensor or sensors, so that, according to the position of the armature spindle 20 in the passage 17, a variable damping characteristic can be obtained.

The compensating chamber 15 can be filled in its upper region 27 with a gaseous medium, and this medium can be at atmospheric pressure or put under pressure according to the requirements and aims.

Fig. 2 shows an embodiment similar to that of Fig. 1 but the damping piston 8 has only a non-return valve 25 and the base 11 likewise is only provided with one non-return valve 26, so that the damping medium can only circulate in one direction. This direction is from the upper working chamber 6, through the passage 18 and the annular chamber 16, the passage 17 to the damping vave 19 and then into the lower working chamber 7. In this damping element the circulation of the damping medium is important as the actual control of the damping depends solely on the damping valve 19. The compensating chamber 15 can, in its upper region 27, be filled with a gaseous medium, and this medium can be at atmospheric pressure or can be under pressure according to requirements and aims.

Fig. 3 shows an embodiment similar to that of Fig. 2 but with the difference that the piston rod 3 has a hollow interior 28 which serves to receive a sensor 29. This sensor 29, through the terminals 30, transmits signals to the electronic circuit which depend upon the corresponding parameter measured by the sensor, and then the damping valve 19 is controlled by signals from the electronic circuit through the terminals 23. The sensor 29 may comprise a tubular capacitor in which the tubular components form a capacitive half-bridge.

Fig. 4 shows an embodiment similar to that of Fig. 2, but with the difference that the damping valve 19 is arranged to one side of the longitudinal axis of the damping element. Here the connection from the upper working chamber 6 into the compensating chamber 15 is through the passage 17 and the communication from the compensating chamber 15 into the lower working chamber 7 is through the bore 14 and the non-return valve 26. The damping valve 19 itself is identical in construction with those already shown in the previous embodiments.

CLAIMS

1. A vehicle vibration damping system for a vehicle in which at least one damping element is provided in the region of a vehicle wheel and the vehicle structure, the damping element comprising a working cylinder for receiving damping fluid and divided by a piston into two partial chambers, the two partial chambers being connected together through at least one electronically controlled damping valve.

2. A vibration damping system according to Claim 1, in which the electronically con-

trolled damping valve is controlled by an electronic circuit in response to signals from at least one sensor which senses the magnitude of the movement between the vehicle wheel and the vehicle structure.

3. A vibration damping system according to Claim 1 or Claim 2, in which the electronically controlled valve is disposed outside the working cylinder of the damping element.

4. A vibration damping system according to Claim 3, in which a throttling valve or valves and/or a base valve or valves are provided in the working cylinder of the damping element and the electronically controlled valve cooperates with the throttling valve or valves and the base valve or valves in the working cylinder.

5. A vibration damping system according to Claim 1 or Claim 2, in which the electronically controlled valve is disposed in the region of the piston.

6. A vibration damping system according to Claim 2, in which the sensor comprises a piston travel sensor disposed inside the working cylinder.

7. A vibration damping system according to any of the preceding claims in which the electronically controlled damping valve is controlled by an electronic circuit in response to signals from at least one sensor which measures at least one of the following parameters: damping force; travel; velocity; acceleration; temperature or frequency.

8. A vibration damping system according to any of the preceding claims in which the electronically controlled damping valve comprises a proportional valve.

9. A vibration damping system substantially as described herein with reference to Fig. 1 of the accompanying drawings.

10. A vibration damping system substantially as described herein with reference to Fig. 2 of the accompanying drawings.

11. A vibration damping system substantially as described herein with reference to Fig. 3 of the accompanying drawings.

12. A vibration damping system substantially as described herein with reference to Fig. 4 of the accompanying drawings.

CLAIMS

Amendments to the claims have been filed, and have the following effect:–

Claims 1, 3 & 4 above have been deleted or textually amended.

New or textually amended claims have been filed as follows:–

1. A vehicle vibration damping system for a vehicle in which at least one damping element is provided in the region of a vehicle wheel and the vehicle structure, the damping element comprising a working cylinder for receiving damping fluid and divided by a piston into two partial chambers, the two partial chambers being connected together through at least one mechanical damping valve provided in the working cylinder and through at least one electronically controlled damping valve disposed in a bypass passage which extends in parallel from the upper partial chamber to the lower partial chamber, the electronically controlled valve being arranged to regulate the cross-sectional area of the bypass passage in such a manner that the damping is influenced in both the extension and contraction phases, in co-operation with the mechanical valve or valves in the working cylinder.

3. A vibration damping system according to Claim 1 or Claim 2, in which the bypass passage and the electronically controlled valve are disposed outside the working cylinder of the damping element.

4. A vibration damping system according to Claim 3, in which a mechanical throttling valve or mechanical throttling valves and a mechanical base valve or mechanical base valves are provided in the working cylinder of the damping element, the bypass passage leads from the upper partial chamber into a compensating chamber which is connected to the lower partial chamber through the base valve or valves, and the electronically controlled valve cooperates with the throttling valve or valves and the base valve or valves in the working cylinder.

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