(12) UK Patent Application (19) GB (11) 2 273 473 (13) A

(43) Date of A Publication 22.06.1994

(21) Application No 9324291.5

(22) Date of Filing 25.11.1993

(30) Priority Data
(31) 4240614 (32) 03.12.1992 (33) DE

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(51) INT CL[5]
B60G 17/015

(52) UK CL (Edition M)
B7D DCT

(56) Documents Cited
GB 2255752 A **GB 2220624 A** **GB 2220176 A**
GB 2214473 A **EP 0246772 A1** **EP 0221486 A2**

(58) Field of Search
UK CL (Edition M) **B7D DCA DCT**
INT CL[5] **B60G 17/015**
Online database: EDOC

(54) **System for vehicle suspension control and/or regulation**

(57) A system for regulation and/or control of a regulable and/or controllable vehicle suspension comprises actuators (13) which are arranged between the vehicle structure and the wheels and which are acted on by signals (F) for the exertion of forces in dependence on the state of travel of the vehicle. The system incorporates means (12) which limits the temporal changes of the signals (F) and thus of the forces to be exerted, whereby high-frequency peaks in the changes in force may be inhibited so as to improve travel comfort, reduce shocks and jolts perceivable in the vehicle and, when adjustable shock absorbers are used, reduce switching noises.

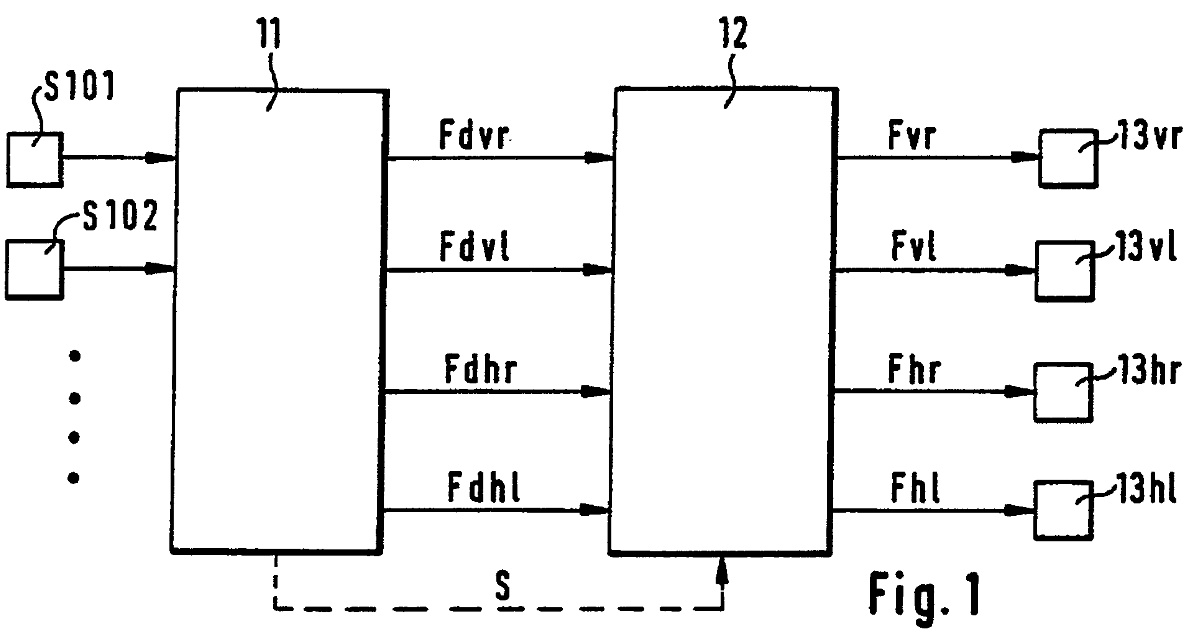

Fig. 1

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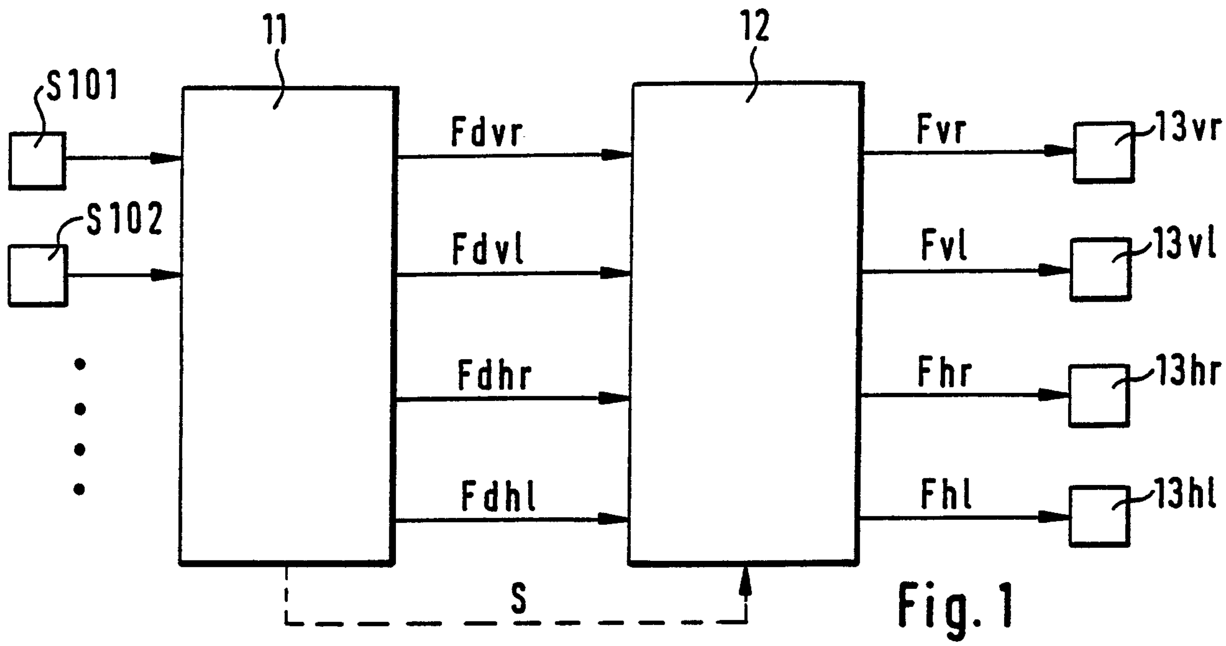
11
12
S101
S102
Fdvr
Fdvl
Fdhr
Fdhl
Fvr
Fvl
Fhr
Fhl
13vr
13vl
13hr
13hl
S

Fig. 1

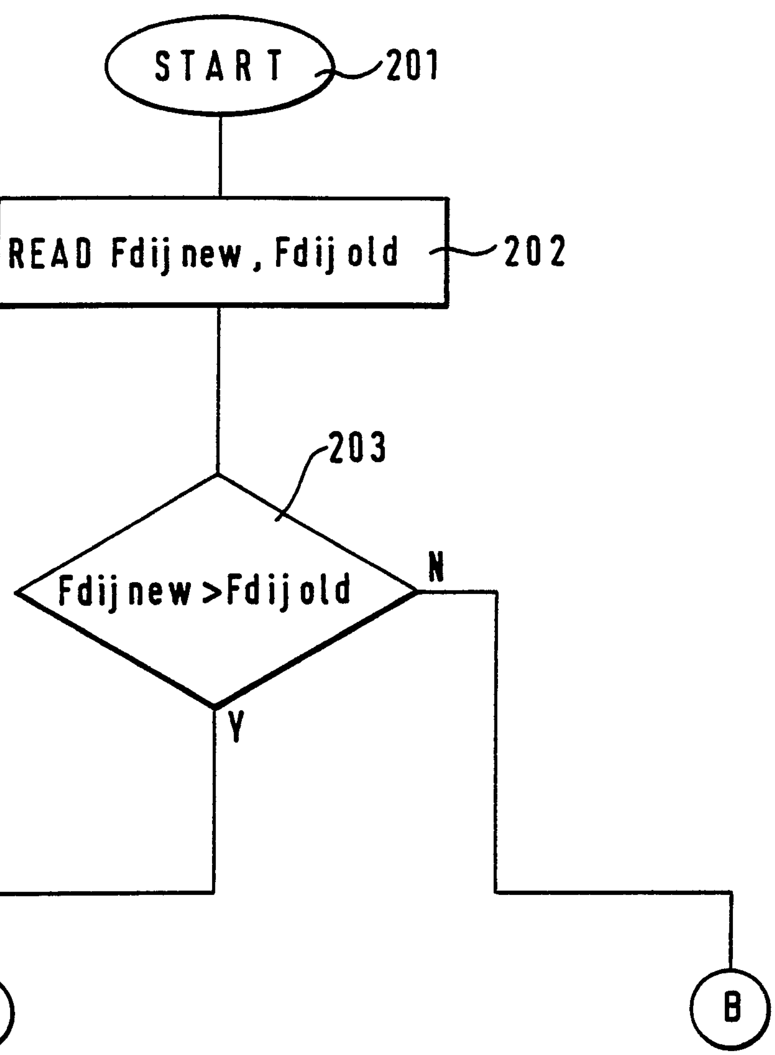
START
201
READ Fdij new , Fdij old
202
203
Fdij new > Fdij old
N
Y
A
B

Fig. 2a

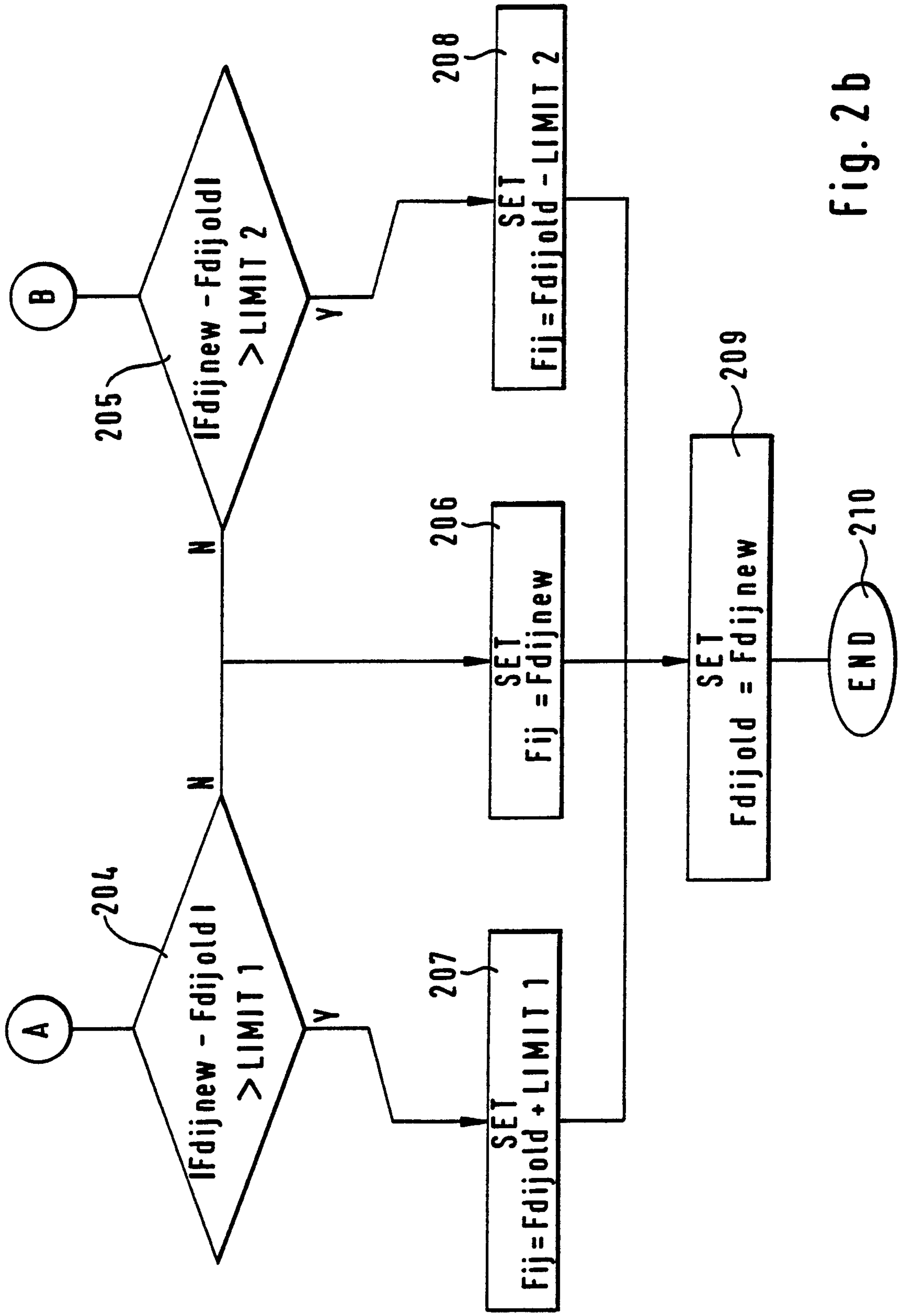
A
B
IFdijnew - FdijoldI
>LIMIT 1
204
IFdijnew - FdijoldI
>LIMIT 2
205
Y
N
N
Y
SET
Fij=Fdijold + LIMIT 1
207
SET
Fij = Fdijnew
206
SET
Fij = Fdijold - LIMIT 2
208
SET
Fdijold = Fdijnew
209
END
210

Fig. 2b

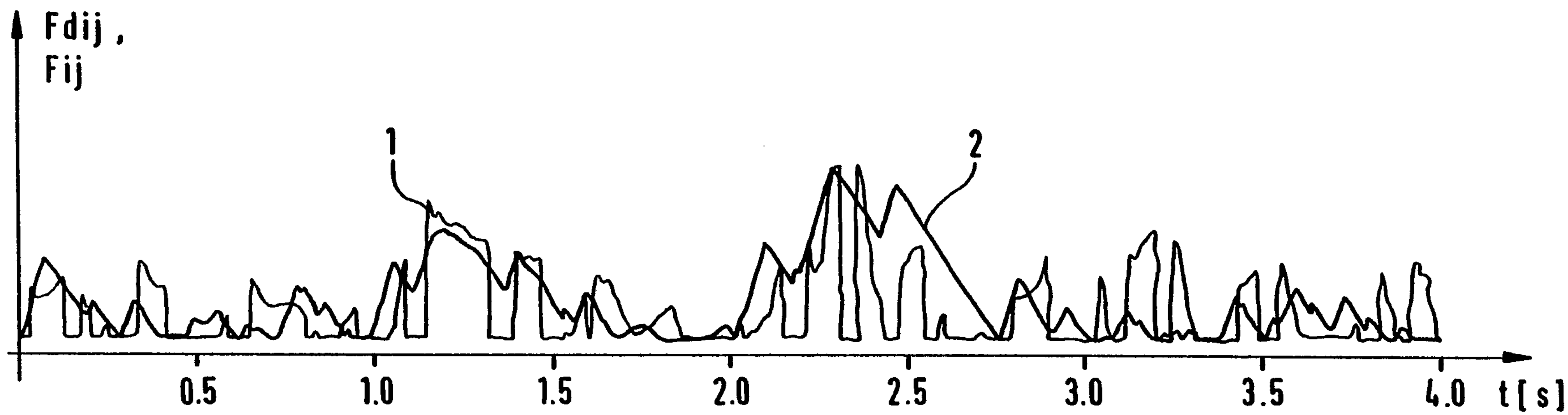

Fig. 3

SYSTEM FOR VEHICLE SUSPENSION CONTROL AND/OR REGULATION

The present invention relates to a system for at least one of control and regulation of a vehicle suspension.

An efficient suspension system between the wheel units and the vehicle structure is essential for refinement of the chassis of a motor vehicle. In conventional suspension systems designed to be passive, the springing and/or damping characteristics are fixedly set as a compromise between travel comfort and travel safety. Thereagainst, in a fully active system desired forces can be exerted between the wheels and the vehicle structure. In the case of a semi-active system, the suspension system in general consists of a spring arrangement which has a fixed spring characteristic and is connected in parallel with damping equipment with an adjustable damping characteristic. Such a shock absorber with an adjustable damping characteristic can be realised, for example, in such a manner that the shock absorber piston is equipped with a throttle valve having a variable throughflow cross-section.

An efficient method for the control or regulation of an adjustable suspension system is of great significance. For such control or regulation, switching signals for the adjustable suspension systems are generally supplied on the basis of sensor signal data giving information about the state of travel of the vehicle.

Such a chassis-regulating system is described in the SAE Article "Modular concept for suspension control" by Decker, Schramm and Kallenbach, SAE 905124.

There remains scope, however, for further improvement in the operation of adjustable suspension systems.

According to the present invention there is provided a system for at least one of control and regulation of a vehicle suspension, comprising force-exerting actuators positionable between the vehicle structure and vehicle wheels and responsive to signals to cause the vehicle suspension to be influenced in dependence on the state of travel of the vehicle and limiting means to limit temporal changes in the signals.

Such a system serves for the regulation and/or control of a regulable and/or controllable suspension of a motor vehicle, by way of actuators which are arranged between the vehicle structure and the wheels and which are acted on by signals for the exertion of forces between the vehicle structure and the wheels in dependence on the state of travel. The limiting means limits the temporal changes of these signals, whereby the temporal changes of the forces to be exerted between the vehicle structure and the wheels are limited. Advantageously, high-frequency peaks in the changes in force are inhibited. This improves travel comfort, reduces shocks and jolts perceivable in the vehicle and, on the case of use of adjustable shock absorbers, reduces switching noises without impairing the vehicle behaviour or travel comfort. Moreover, a reduction in costs may be possible in the design of the system components, since lower demands are placed on dynamic behaviour of the components (shock absorbers, sensors, electronic control device) in the system.

In an advantageous refinement of the system the limitations are carried out differently by the limiting means in accordance with the sign of the temporal changes of the signals or the forces to be exerted. The switchings of the actuators, thus the changes in force, which adjust the suspension system in the direction "hard" in that case are advantageously limited less than the changes in force which adjust the suspension system in the direction "soft". It can thus be provided that changes in force which are effected in the direction of travel safety are limited less than those in the direction of travel comfort. This has the advantage that the system operates with a bias towards safety of travel.

In a further advantageous refinement, the limitations are carried out in dependence on the detected state of the travel. Thus, the safety-oriented temporal force changes can be limited far less in the case of travel states critical for travel safety (for example, high longitudinal and/or transverse accelerations of the vehicle, violent steering movements) than the temporal changes oriented towards travel comfort. For this purpose, comparison means, by which the temporal changes of the force to be exerted are compared with at least one threshold value, can be provided for the limitation.

In a preferred embodiment it is provided that the temporal changes are compared with a first threshold in the presence of a positive force gradient and the temporal changes are compared with a second threshold in the presence of a negative force gradient, wherein the first threshold is chosen to be greater than the second threshold. The temporal changes in the forces to be exerted are then limited if one of the two thresholds is exceeded. The threshold values can be fixed values, and/or can be dependent on magnitudes influencing the state of travel, such as longitudinal speed of the vehicle and/or longitudinal and/or transverse acceleration of the vehicle and/or steering angle and/or wheel speed and/or magnitudes derived therefrom. Thus, the temporal changes in the signals or the forces to be exerted can be limited less in situations critical for the travel safety than in situations not critical for the travel safety. If so desired no limitation at all can take place in situations critical for travel safety.

In the case of semi-active suspension, the actuators can be shock absorbers which are adjustable in their damping behaviour for the exertion of controllable forces between the vehicle structure and the wheels. In the case of shock absorbers, noticeable switching noises can arise in the case of large changes in force. From the aspect of travel safety, the changes in force for which the damping characteristics of the shock absorbers are set to be harder can be limited less than the changes in force for which the damping characteristics of the shock absorbers are set to be softer.

An embodiment of the present invention will now be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 is a block schematic diagram of a system embodying the invention;

Figs. 2a and 2b are parts of a flow chart illustrating stages of operation of limiting means in the system of Fig. 1; and

Fig. 3 is a diagram showing the temporal courses of signals for the switching of a shock absorber by way of a system embodying the invention and a prior art system.

Referring now to the drawings there is shown in Fig. 1 a system for controlling or regulating a motor vehicle suspension, the system comprising sensors S101, S102, etc., which supply input signals for processing means 11 which processes these input signals into shock absorber force target signals Fdij. The index i denotes whether the suspension unit is at the front (i = v) or rear (i = h) of the vehicle and the index j whether the suspension unit is at the righthand (j = r) or lefthand (j = l) side of the vehicle. The designation Fdvr thus signifies the shock absorber target force for the front righthand suspension unit. The target forces Fdij are fed to means 12 for limitation of the temporal changes in such forces. Switching signals Fij for actuators 13ij, in particular the shock absorbers are present at the output of the means 12. In addition, a signal S dependent on the state of travel can be fed to the means 12 for limitation of the temporal changes in force.

The control target forces for the actuators are computed in the means 11 in dependence on the state of travel ascertained by the sensors. For this purpose, the relative movements between the vehicle structure and the wheels, and/or movements of the structure in the form of structure acceleration and/or the instantaneous steering angle and/or the instantaneous wheel speeds are detected by, for example, sensors. From these data, switching signals for the actuators can now be computed in the means 11 in a manner known from the state of the art, for example, by the so-called sky-hook regulating principle in which forces proportional to the sensed absolute structure speed are exerted by the suspension systems. There is thus obtained inertial damping of the structure movements. In addition, it is known to damp the wheel movements in order to counteract the dynamic wheel load fluctuations. Whilst the quietening of the vehicle structure has primarily the consequence of advantages in travel comfort, an increase in the travel safety is also achieved by a minimisation of the dynamic wheel load fluctuations.

In this embodiment, the actuators are constructed as shock absorbers which are adjustable in their damping behaviour.

The detailed function of the means 12 for limitation of the temporal changes in force is described in the following with reference to the flow diagram of the Figs. 2a and 2b.

In the Fig. 2a, the actual value of the force Fdijnew (shock absorber target force) to be exerted and the previously ascertained value Fdijold for the shock absorber force are read in in a step 202 after a start step 201. In a step 203, the new value Fdijnew is compared with the previously ascertained value Fdijold. If the new value to be exerted is higher than the previously ascertained value, a positive force gradient thus being present, the magnitude of the change of the target forces is compared with a threshold value LIMIT 1 in a step 204 as shown in Fig. 2b. In the case of a negative force gradient, thus when the actual new value Fdijnew is lower than the previously ascertained value Fdijold, the magnitude of the difference is compared with a second threshold value LIMIT 2 in a step 205.

If it is established on the steps 204 and 205 that the shock absorber force changes in the means 11 are smaller than the respective threshold values LIMIT 1 and LIMIT 2, then the new value Fdijnew is passed on in the step 206 to the respective shock absorber 13ij and a corresponding force is exerted between the respective wheel and the vehicle structure. If it is ascertained in the steps 204 or 205 that the temporal changes in force are greater than the respective threshold values, then the shock absorber target force Fij = Fdijold + LIMIT 1 is set in the case of a positive force gradient in a step 207 and the shock absorber target force Fij = Fdijold - LIMIT 2 is set in the case of a negative force gradient in a step 208. The force value Fdijnew ascertained as actual in step 202 is then set as previously ascertained Fdijold in the step 209 in order, after an end step 210, to be entered as previously ascertained value in step 202 of the subsequent program run.

The threshold values LIMIT 1 and LIMIT 2 can either assume fixed values or be chosen in dependence on the detected state of travel. For this purpose, it is indicated in the Fig. 1 that the travel state signal S is to be fed to the means 12. With advantage, the threshold values LIMIT 1 and LIMIT 2 are respectively dependent on magnitudes which influence the state of travel. Such magnitudes are, for example, the longitudinal speed of the vheicle, the steering angle, the rotational wheel speeds or magnitudes derived therefrom. For preference, the first threshold LIMIT 1 is chosen to be greater than the second threshold LIMIT 2. This has the consequence that the positive changes in force, which generally signify adjustments oriented towards travel safety, are limited less than negative changes in force, in which the suspension systems are adjusted to be "softer".

The effect of the limitation in change of force is to be seen in Fig. 3. For this purpose, the unlimited shock absorber target force Fdij (thinly drawn line 1) and the limited shock absorber target force Fij (thickly drawn line 2) are entered as a function of time t. It can be clearly seen that far greater jumps in force arise without the force change limitation (line 1) than with the force change limitation (line 2).

CLAIMS

1. A system for at least one of control and regulation of a vehicle suspension, comprising force-exerting actuators positionable between the vehicle structure and vehicle wheels and responsive to signals to cause the vehicle suspension to be influenced in dependence on the state of travel of the vehicle and limiting means to limit temporal changes in the signals.

2. A system as claimed in claim 1, the limiting means being arranged to vary the limitation of such changes in dependence on whether the changes are positive or negative.

3. A system as claimed in claim 1 or claim 2, the limiting means being arranged to effect limitation of such changes in dependence on the instantaneous state of travel of the vehicle.

4. A system as claimed in any one of the preceding claims, the limiting means being arranged to compare such changes with at least one threshold value and to carry out limitation of the changes in dependence on the comparison result.

5. A system as claimed in any one of the preceding claims, the limiting means being arranged to impose a lesser limitation on temporal changes in signals which cause the actuators to exert greater forces representing a positive force gradient than on temporal changes in signals which cause the actuators to exert smaller forces representing a negative force gradient.

6. A system as claimed in claim 5, the limiting means being arranged to compare such changes with a first threshold value in the presence of a positive force gradient and with a second threshold value lower than the first threshold value in the presence of a negative force gradient and to carry out limitation of the changes if either threshold value is exceeded.

7. A system as claimed in claim 4 or claim 6, wherein the or each threshold value is a fixed value.

8. A system as claimed in claim 4 or claim 6, wherein the or each threshold value is dependent on at least one magnitude related to the state of travel of the vehicle.

9. A system as claimed in claim 8, wherein the magnitude or magnitudes is or are selected from the group consisting of longitudinal speed of the vehicle, longitudinal acceleration of the vehicle, transverse acceleration of the vehicle, angle of the vehicle steering, rotational speed of the vehicle wheels and magnitudes derived therefrom.

10. A system as claimed in any one of the preceding claims, the limiting means being arranged to limit such changes less in circumstances predetermined to be critical for the travel safety of the vehicle than in circumstances predetermined not to be critical for the travel safety of the vehicle.

11. A system as claimed in any one of the foregoing claims, wherein the actuators comprise shock absorbers with adjustable damping characteristics.

12. A system as claimed in claim 11, the limiting means being arranged to so limit such changes that a lesser limitation is effected in the case of resetting the damping characteristics to harder than in the case of resetting the damping characteristics to softer.

13. A system substantially as hereinbefore described with reference to the accompanying drawings.

14. A road vehicle provided with a system as claimed in any the of the preceding claims.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9324291.5

Relevant Technical Fields

(i) UK Cl (Ed.M) B7D (DCA, DCT)

(ii) Int Cl (Ed.5) B60G 17/015

Search Examiner
COLIN THOMPSON

Date of completion of Search
21 JANUARY 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASE: EDOC

Documents considered relevant following a search in respect of Claims :-
1-14

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2255752 A	(ROBERT BOSCH GMBH)	1,10,11
X	GB 2220624 A	(ATSUGI MOTOR PARTS CO LTD)	1,2,11
X	GB 2220176 A	(FUJI JUKOGYO K K)	1
X	GB 2214473 A	(MITSUBISHI JIDOSHA K K K)	1
X	EP 0246772 A1	(GAYDON TECHNOLOGY LTD)	1,11
X	EP 0221486 A2	(TOYOTA JIDOSHA K K)	1,11

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