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F2S

(54) An adjustable hydraulic damper

(57) In a two-tube adjustable hydraulic damper an axially displaceable annular piston (23) supports a coil spring (8) which surrounds and is coaxial with the cover tube (6) of the damper. The piston (23) is exposed to the pressure of damping fluid within a lifting cylinder (9) and thereby lifts the vehicle. A simple electrically controlled adjustment of the load-supporting capacity and a load-dependent adjustment of the damping acting in parallel with the damping in extension and contraction is achieved by providing an annular connecting passage (10) which connects the upper working chamber (4) with the compensating chamber (7), the annular passage (10) being in communication with the lifting cylinder (9) through an opening (11), an a valve (13) being provided for closing off a port (12) which leads from the passage (10) into the compensating chamber (7). The valve (13) can be electronically controlled.

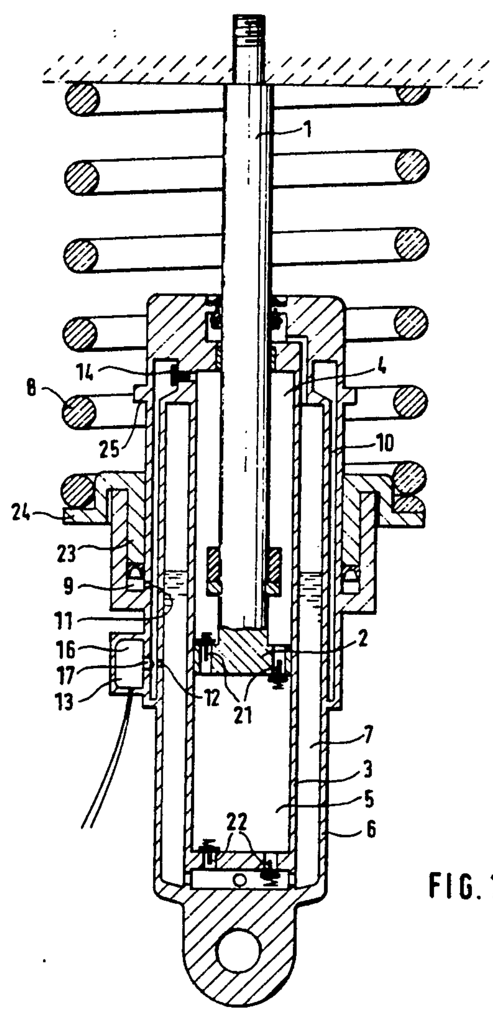

FIG.1

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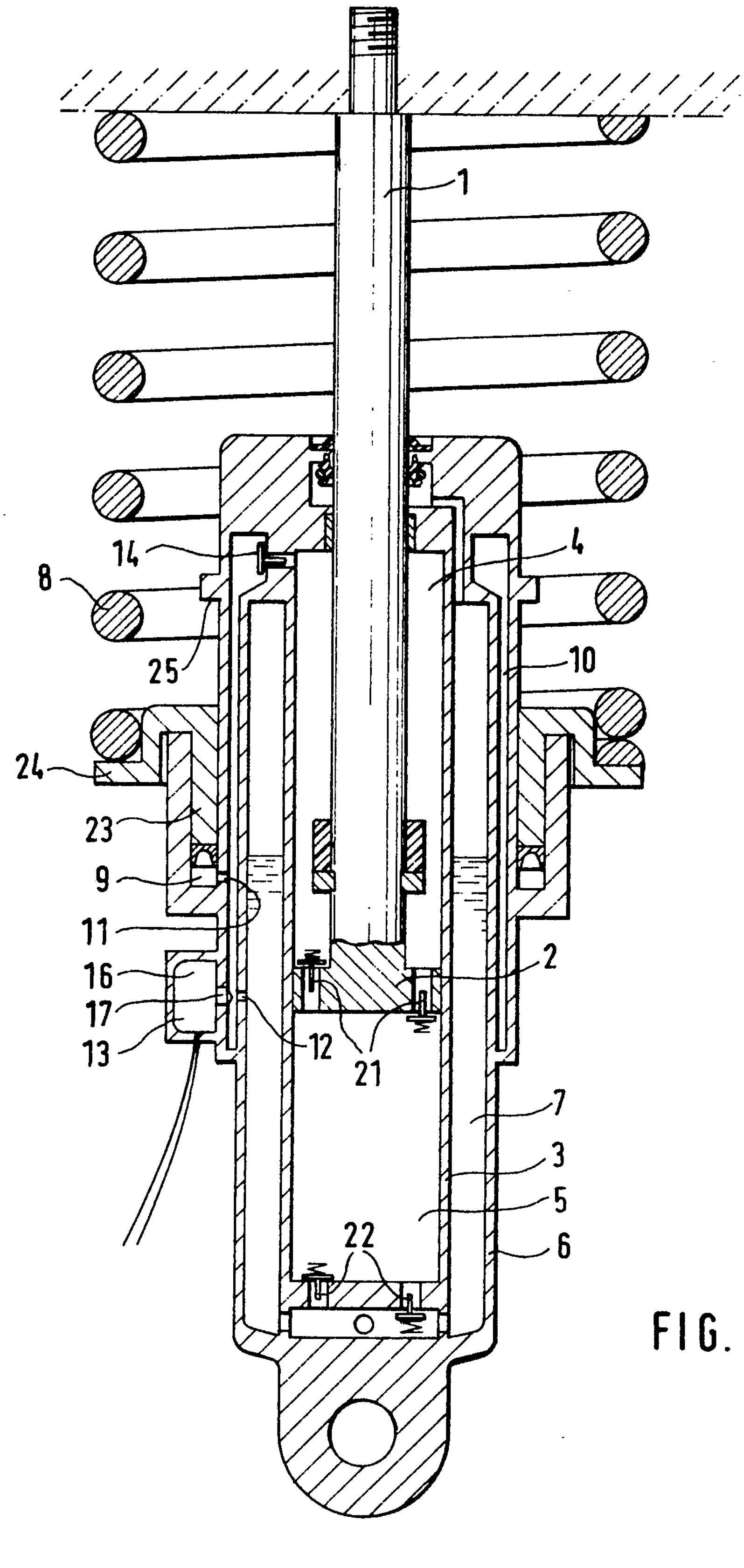

FIG. 1

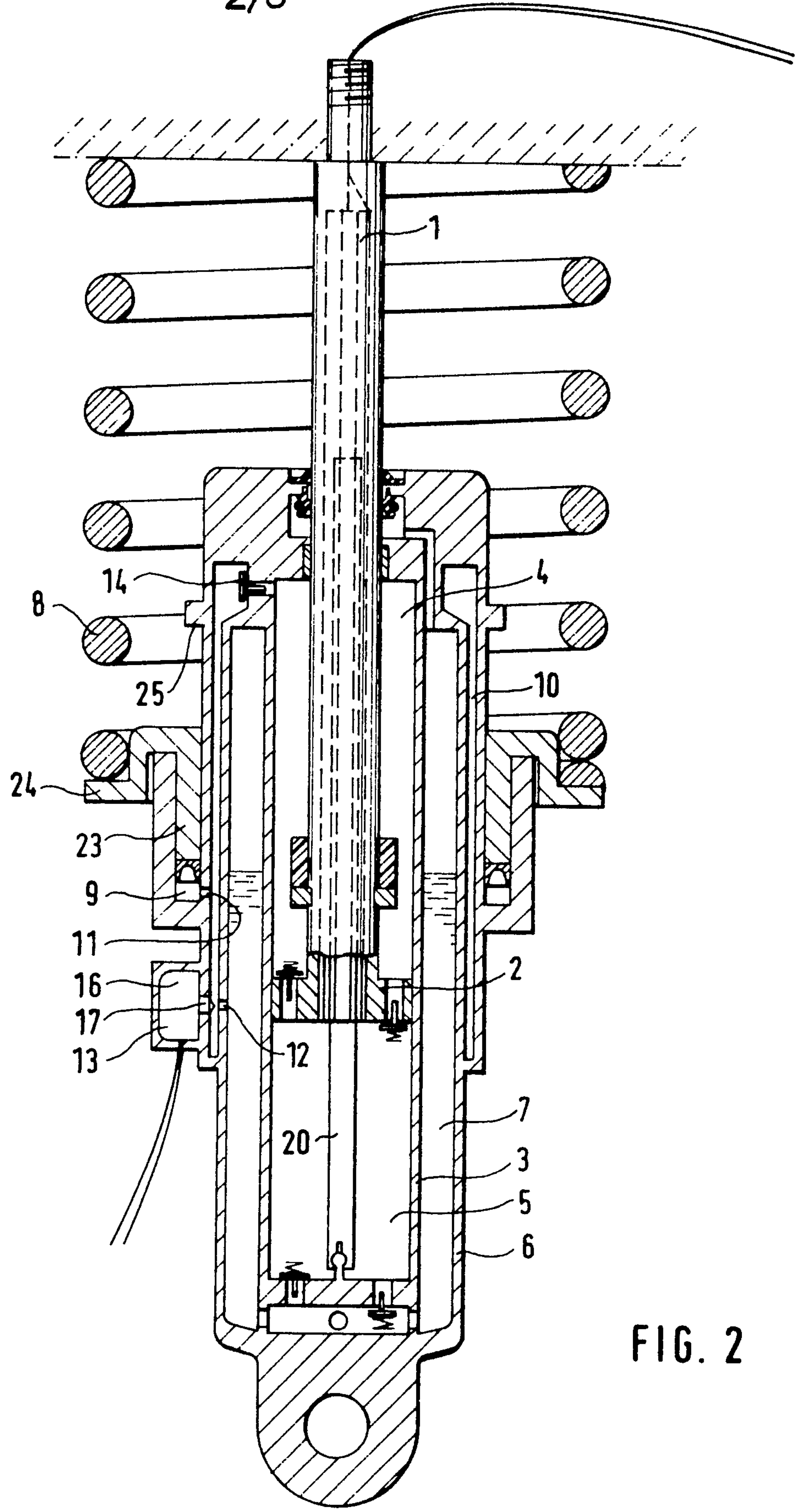

FIG. 2

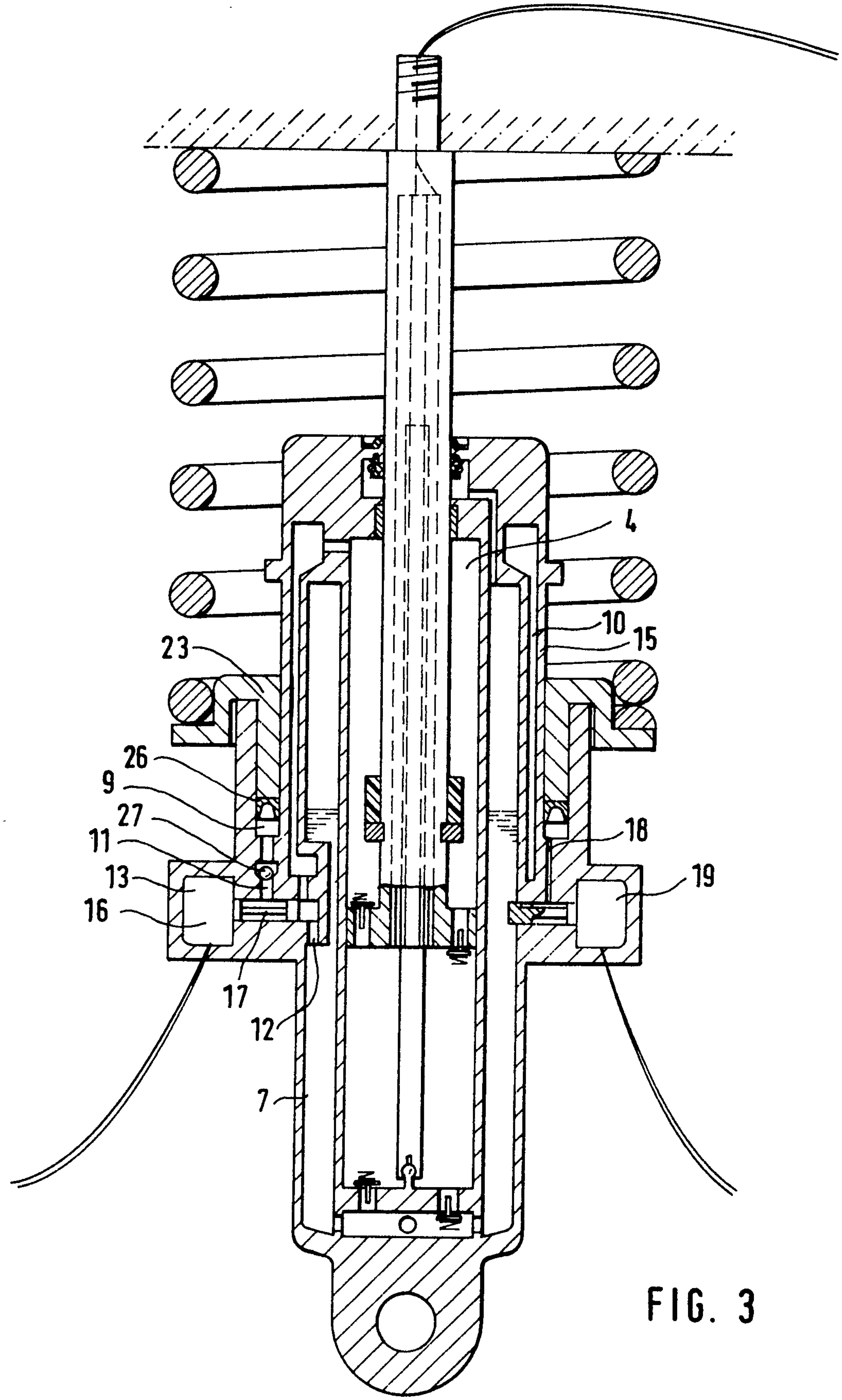

FIG. 3

SPECIFICATION

An adjustable hydraulic damper

This invention relates to an adjustable hydraulic damper which comprises a working cylinder divided by a damping piston secured on a piston rod into two working chambers filled with damping fluid, the damper having at least one throttle member, a compensating chamber formed between the working cylinder and a surrounding cover tube, and a coil spring which surrounds and is coaxial with the cover tube and which is supported by an axially displaceable annular piston exposed to the pressure of the damping fluid present in a lifting cylinder.

Dampers are known (e.g. DE-OS 25 27 530) in which the load of a coil spring is varied by means of a lifting cylinder so that varying loadings of the vehicle are automatically balanced out. In such an arrangement the level of the vehicle is, following a variation, restored to a predetermined level. A drawback of this arrangement is that the control assembly is located in the region of the base of the damper and, as compared with a two-tube vibration damper of the same constructional length, the overall stroke of the piston is not fully utilised. A further drawback is that the lifting cylinder is exposed solely to the volume of fluid displaced by the piston rod on its downward stroke. A pumping action is accordingly only effective in the contraction phase and higher damping occurs in the contraction phase only for the duration of the pumping process. On completion of the pumping process the normal damping is re-established. Such a system is not appropriate for use in wheel-locating spring struts or suspension units as the flexing loads which have to be handled require a piston rod which is thicker in diameter and, because of the larger quantity of oil delivered, a correspondingly larger reserve chamber or lifting cylinder chamber has to be provided.

In addition dampers are known (e.g. DE-AS 14 05 781), in which, by means of an electro-magnetic device, the damping characteristic can be adjusted by altering the cross-sectional area of a throttle point. Such an electro-magnetic device may comprise a rotary transmitter switch, a multiple turn switch, a star wheel and a blocking wheel. This arrangement provides a finely graduated control of the throttle point. By brief energisation of the electromagnet the throttle member is brought step by step into a desired position so as to regulate a predetermined throughput of oil. Apart from the fact that such a step-wise switching arrangement is a really expensive design, this system can only influence the damping characteristic but cannot compensate for the variation in the height of the vehicle structure upon changes in the loading.

It is an aim of the present invention to provide a damper in which a simple electrically controlled alteration of the load capacity can be achieved, and in which the damping on extension and contraction can be adjusted in a load-dependent manner.

According to the present invention there is provided an adjustable hydraulic damper comprising a working cylinder which is divided by a damping piston secured on a piston rod into two working chambers filled with damping fluid, the damper having at least one throttle member, a compensating chamber formed between the working cylinder and a surrounding cover tube, and a coil spring which surrounds and is coaxial with the cover tube and which is supported by an axially displaceable annular piston that is exposed to the pressure of damping fluid in a lifting cylinder,the upper working chamber being connected to the compensating chamber by means of a connecting passage which is in communication with the lifting cylinder through an opening and which leads into the compensating chamber through a port which is closable by a valve.

In the present invention the connecting passage between the upper working chamber and the compensating chamber forms a bypass which can be closed or opened by means of the valve. When the bypass is closed by the valve, oil is pumped through the opening into the lifting cylinder and, after a predetermined time of travelling, the annular piston is pumped up against a stop. As the coil spring is supported at its lower end by the annular piston and at its upper end supports the vehicle body-work, the increased pre-loading of the spring causes a corresponding lifting of the vehicle structure. When the lifting cylinder is filled with oil so as to lift the vehicle structure, then a harder damping is also set to oppose the higher loading, since now the oil can only pass through the throttle member. Also while the annular piston is on the way up, the degree of damping progressively rises.

On opening of the valve the vehicle body-work sinks again, and then the bypass again operates in parallel with the normal damping and the damping is correspondingly softer and more comfortable.

Preferably a non-return valve is provided in the connecting passage. The non-return valve may be disposed in the upper part of the connecting passage which leads from the upper working chamber. Alternatively the non-return valve may be disposed in the opening from the connecting passage to the lifting cylinder.

In a preferred embodiment of the invention the connecting passage comprises an annular passage which surrounds and is coaxial with the compensating chamber and which is formed between the cover tube and a further surrounding tube. In this arrangement the entire annular space operates as a bypass, with the valve opening or closing the port leading into the compensating chamber.

The opening from the connecting passage into the lifting cylinder may conveniently comprise at least one bore provided in the further surrounding tube. When the bypass is closed the damping fluid is pumped into the lifting cylinder through this opening.

The valve for closing the port leading into the compensating chamber may comprise an electromagnet comprising a coil and an armature. Preferably, the armature co-operates directly with the port; for example, the armature may be of conical shape and be engageable with an appropriate valve seating of a bore forming the port. Alternatively, the valve member may be a separate element connected to the armature.

In one preferred construction the opening from the connecting passage into the lifting cylinder and the port leading into the compensating chamber are arranged parallel to one another and a valve member of stepped form is movable either to close the port and open the opening or to open the port and close the opening. In this arrangement again a bypass is formed, and the stepped form of the valve member allows the desired pumping function in the lifting cylinder to take place when the port is closed by the valve member.

For a variable regulation of the load capacity and the damping force, the lifting cylinder may be connected to the compensating chamber through a discharge bore, and a discharge valve is arranged to open or close the discharge bore. The discharge valve may be separately controlled to regulate downward movement of the annular piston by allowing oil to flow through the discharge bore.

Conveniently, the valve for closing the port into the compensating chamber and/or the discharge valve is controlled by a suitable electronic circuit. Preferably this circuit acts in response to signals produced by a sensor incorporated within the damper so that the electronic circuit can control the regulation upwards and downwards.

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 diagrammatic section through a two-tube damper which has a lifting cylinder and a coil spring;

Figure 2 is a diagrammatic section through a modified two-tube damper which is similar to that of Figure 1 but which incorporates an integrated sensor; and

Figure 3 is a diagrammatic section through a further two-tube damper provided with a valve for upward regulation and a further valve for downward regulation.

The damper illustrated in Figure 1 comprises a working cylinder 3 and a damping piston 2 secured on the end of a damping rod 1. The damping piston 2 divides the interior of the working cylinder 3 into an upper working chamber 4 and a lower working chamber 5. The damping piston 2 has damping valves 21 which serve to damp the oscillations. Attachment means are provided on the top and bottom ends of the damper for securing the damper in a vehicle. The volume of fluid displaced by the piston rod as it enters the cylinder 3 is conducted through a base valve 22 into a compensating chamber 7 which is formed between the working cylinder 3 and a surrounding cover tube 6.

An annular connecting passage 10 which surrounds and is coaxial with the cover tube 6 connects the upper working chamber 4 to the compensating chamber 7 and a non-return valve 14 is provided in the upper part of the connecting passage 10 which leads from the upper chamber 4. The passage 10 is in communication with the lifting cylinder 9 through an opening 11 which comprises a bore provided in a further surrounding tube. Damping fluid supplied through the opening 11 into the lifting cylinder 9 acts on an annular piston 23 which is formed directly in one piece with a spring plate 24 that carries a coil spring 8. When the lifting cylinder 9 is exposed to pressure it displaces the annular piston 23 to an extent which is limited by a stop 25. The annular passage 10 is connected to the compensating chamber 7 through a port 12. This port 12 can be closed by a valve 13 in the form of an electromagnet which comprises a coil 16 and an armature 17.

Adjustment of the damper illustrated in Figure 1 can be controlled by means of the valve 13. When the electromagnet is energised it closes the passage 10, and the annular piston 23, together with the spring plate 24, is urged towards the upper stop 25. Thus the vehicle structure is lifted. At the same time the degree of damping rises automatically, which is desirable for an increased loading of the vehicle. The pressure in the lifting cylinder 9 required to lift the annular piston 23 and the spring plate 24 is determined by the setting of the damping valves 21,22. In the extension and contraction phases relatively small quantities of oil are fed into the lifting cylinder 9 so that regulation of the height in accordance with the nature of the road surface takes a certain amount of time in response. By appropriate adjustment of the damping valves 21 and the base valve 22, when the piston rod 1 moves downwards into the cylinder 3 the damping medium is fed partially into the compensating chambers 7 and also into the lifting cylinder 9. Likewise when the piston rod 1 moves out of the cylinder 3 damping fluid is forced through the damping valve 21 and into the lifting cylinder 9. As relatively small quantities of oil are fed into the lifting cylinder on movement in extension and contraction, a particularly uniform and gentle lifting of the vehicle is achieved. At the same time the damping in extension and compression is raised by degrees. This takes place because the port 12 closed by the valve 13 closes off the connecting passage 10 and therefore there is no bypass around the damping valves 21,22. Accordingly the damping occurs solely by means of these damping valves 21,22.

When the port 12 is opened again by the valve 13 the vehicle structure sinks because the damping medium flows back from the lifting cylinder 9 through the connecting passage 10 and into the compensating chamber 7. The bypass once again operates in parallel with the damping valves 21 and so the damping is now softer and more comfortable.

Where an electromagnet is used to form the valve 13 there is no need to provide return means for the armature because the pressure of the damping medium acts continuously on an annular surface of the armature so as to move it to its open position.

Figure 2 shows a damper which is similar to that of Figure 1 but with the difference that a sensor 20 is incorporated within the piston rod 1, which is of hollow form. The sensor 20 is arranged to control the valve 13 through a suitable electronic circuit so that the position of the annular piston 23 can be adjusted continuously in response to the prevailing loading of the vehicle. In this manner the loading of the coil spring 8 is adjusted. When the electronic circuit is de-energised the annular piston 23 is returned to its lower normal position as the internal pressure of the system causes the armature 17 of the electromagnet to return to its retracted position so as to uncover the port 12.

Figure 3 shows a further embodiment similar to that of Figures 1 and 2 in which the annular connecting passage 10 is again formed between the further surrounding tube 15 and the cover tube 6. The passage 10 and the port 12 again form a bypass leading from the upper working chamber 4 into the compensating chamber 7. The armature 17 of the electromagnet 13 is located in a passage which branches off from the main connecting passage 10 and the opening 11 leads from this branch passage into the lifting cylinder 9. Once again the annular piston 23 in the lifting cylinder 9 carries a seal 26. The electromagnetic valve 13 is arranged either to close or to open the bypass and when the bypass is closed the flow of oil is diverted into the lifting cylinder 9. A non-return valve 27 is provided in the recess 11 so that the discharge of the damping fluid from the lifting cylinder 9 must take place through a discharge bore 18 and a discharge valve 19. The discharge bore 18 forms a connection between the compensating chamber 7 and the lifting cylinder 9 which can be opened or closed by means of the discharge valve 19. In this embodiment the damping valves 21,22 are strongly spring-loaded so that the vehicle can be rapidly raised. When the valve 13 closes the bypass and opens the opening 11 large quantities of oil are fed into the lifting cylinder 9. When the vehicle structure is being raised the damping is extremely hard but then when a desired level is reached the damping is correspondingly reduced. This reduction is achieved when the bypass is opened by moving the step-shaped armature 17 of the electromagnet so as to uncover the port 12 and close off the opening 11. By means of suitable electronics the level of the vehicle can be maintained by appropriate control of the valve 13 and the discharge valve 19.

The lowering of the vehicle structure is achieved by actuation of the discharge valve 19 so that the damping fluid from the lifting cylinder 9 reaches the compensating chamber 7 through the discharge bore 18. By means of a suitable electronic control circuit it is also possible, for example, to lower the vehicle structure at a predetermined vehicle speed in order to reduce the wind resistance and to stabilise the vehicle dynamically by displacement of the centre of gravity. When the speed of the vehicle falls below this predetermined speed the vehicle structure can be raised in the manner described above.

CLAIMS

1. An adjustable hydraulic damper comprising a working cylinder which is divided by a damping piston secured on a piston rod into two working chambers filled with damping fluid, the damper having at least one throttle member, a compensating chamber formed between the working cylinder and a surrounding cover tube, and a coil spring which surrounds and is coaxial with the cover tube and which is supported by an axially displaceable annular piston that is exposed to the pressure of damping fluid in a lifting cylinder, the upper working chamber being connected to the compensating chamber by means of a connecting passage which is in communication with the lifting cylinder through an opening and which leads into the compensating chamber through a port which is closable by a valve.

2. A damper according to claim 1, in which a non-return valve is provided in the connecting passage.

3. A damper according to claim 2, in which the non-return valve is disposed in the opening from the connecting passage to the lifting cylinder.

4. A damper according to any of the preceding claims, in which the connecting passage comprises an annular passage which surrounds and is coaxial with the compensating chamber and which is formed between the cover tube and a further surrounding tube.

5. A damper according to claim 4, in which the opening from the connecting passage into the lifting cylinder comprises at least one bore

provided in the further surrounding tube.

6. A damper according to any of claims 1 to 4, in which the opening from the connecting passage into the lifting cylinder and the port leading into the compensating chamber are arranged parallel to one another, and a valve member of stepped form is movable either to close the port and open the opening or to close the port and close the opening.

7. A damper according to any of the preceding claims, in which the valve for closing the port leading into the compensating chamber comprises an electromagnet comprising a coil and an armature which co-operates directly with the port.

8. A damper according to any of the preceding claims, in which the valve for closing the port leading into the compensating chamber is controlled in response to electronic signals.

9. A damper according to any of the preceding claims, in which the lifting cylinder is connected to the compensating chamber through a discharge bore and a discharge valve is arranged to open or close the discharge bore.

10. A damper according to claim 9, in which the discharge valve is controlled in response to electronic signals.

11. A damper according to either or both of claims 8 and 10, in which the electronic signals for controlling the valve for closing the port and/or the discharge valve are produced by a sensor incorporated within the damper.

12. An adjustable hydraulic damper substantially as described herein with reference to Figure 1 of the accompanying drawings.

13. An adjustable hydraulic damper substantially as described herein with reference to Figure 2 of the accompanying drawings.

14. An adjustable hydraulic damper substantially as described herein with reference to Figure 3 of the accompanying drawings.

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