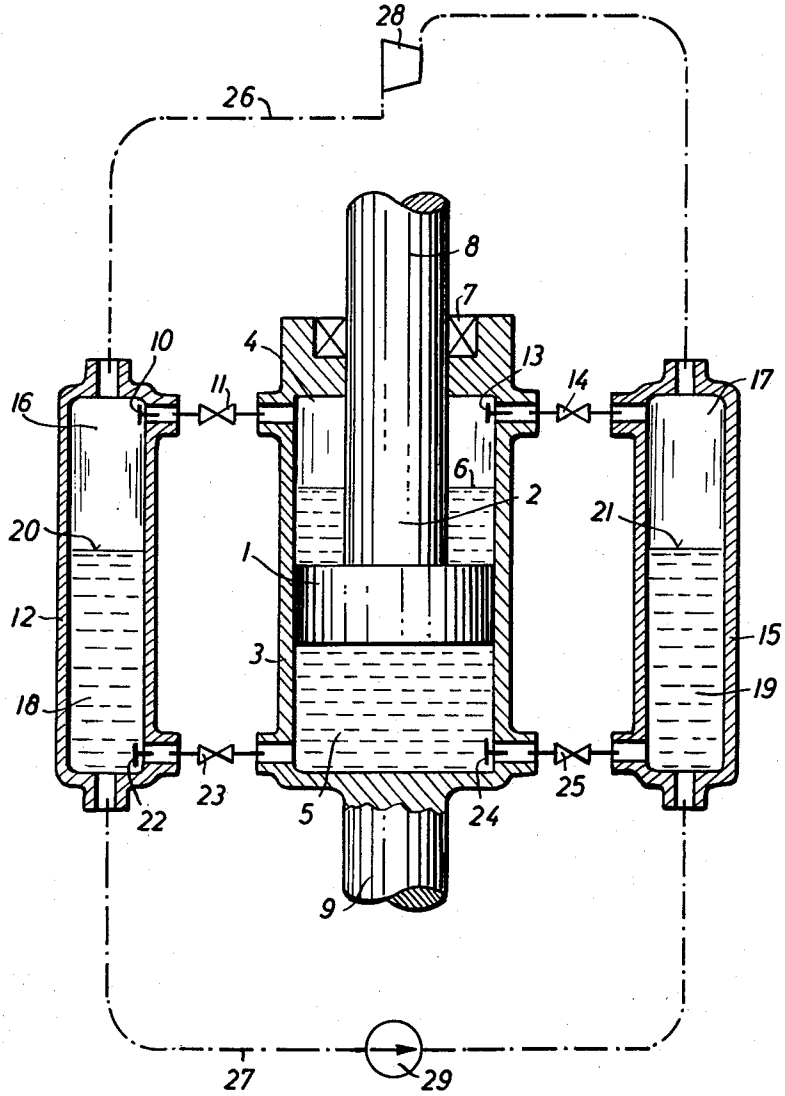
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PNEUMATIC SPRING STRUCTURES

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PNEUMATIC SPRING STRUCTURES

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This invention relates to the control of pneumatic spring structures, for example for vehicles, in which the spring force is produced by the elastic compression of a gas cushion and is variable, the gas pressure being suited to the vehicle load and/or to the state of the road. Controls are known in which gas can be discharged from the gas cushion through a valve into the open air, whereby the spring force is reduced, and gas can be admitted from a compressor or from a pressure bottle, whereby the spring force is increased. These controls have the disadvantage that the discharged gas itself and the energy contained in this gas while still compressed are completely lost. Also a compressor, for example, when air is used for springing, must overcome the whole pressure difference between the atmospheric pressure and the pressure in the cushion.

The control according to the invention is characterised by the gas cushion being connected through valves or other control members to two gas containers which are connected together through a compressor, of which one, the lower pressure container, is filled with gas at a lower pressure than the operating pressure of the gas cushion and the other, the higher pressure container, with gas at a higher pressure than the operating pressure of the cushion. If the pressure of the gas cushion is to be reduced, gas is discharged into the lower pressure container. Then only the energy corresponding to the pressure drop from the gas cushion to the container is lost. If the pressure of the gas cushion is to be raised, gas is admitted to it from the higher pressure container. The compressor between the lower pressure and higher pressure containers now only has to overcome the small pressure difference between these two containers. With the existence of the containers, in particular a higher pressure container, the advantage is at the same time obtained that the admission of gas into the cushion can take place very rapidly, in any case more rapidly than if the compressor had to supply gas directly to the cushion without the interposition of a gas container.

In pneumatic spring structures in which the gas cushion co-operates with a volume of oil which serves, for example, for hydraulic damping of vibrations, it is advantageous to let the lower pressure container and the higher presusre container also co-operate with volumes of oil and to connect all the oil volumes together through valves, in which case an oil pump may also be arranged between the low pressure container and the high pressure container. In this way, it is possible to reduce the volume of oil which is combined with the gas cushion by discharging oil into the low pressure container or to increase it by admitting oil from the high pressure container. In this way the volume of the gas cushion can be varied and a desired alteration in spring characteristic be obtained. Also the volume of oil co-operating with the gas cushion can be rectified if there is a free surface between the oil volume and the gas cushion, and upon discharge or admission of gas, oil may be carried with the gas so that the oil volume changes.

The accompanying drawing is a diagrammatic sectional view of an example of a pneumatic spring structure according to the invention which co-operates with a volume of oil.

A piston 1, having a piston rod 2, slides in a working cylinder 3 which contains a gas cushion 4 and an oil volume 5 separated by a free surface 6. The piston 1 is provided with valves not shown of a known kind which produce damping forces when the piston moves in the working cylinder. The free spring force corresponds to the product of the piston rod area and the pressure of the gas cushion. The damping and spring forces are transmitted from the end of the piston rod 8 and a base part 9 of the working cylinder 3 to corresponding parts of a vehicle. The piston rod is sealed in relation to the outside air by a packing 7.

The gas cushion 4 is in communication through a nonreturn valve 10 and a regulating valve 11 with a lower pressure container 12 and also through a non-return valve 13 and regulating valve 14 with a higher presusre container 15. The lower pressure container 12 and the higher pressure container 15 are filled in their upper parts 16, 17, respectively with gas and in their lower parts 18, 19, respectively with oil. The gas and oil are separated by the respective free surfaces 20 and 21. The oil space 5 of the spring element is connected with the oil space 18 of the lower pressure container through a non-return valve 22 and a regulator valve 23 and with the oil space 19 of the higher pressure container through a non-return valve 24 and a regulating valve 25. The function of the non-return valves 10 and 22 is to prevent the outflow of gas or oil from the lower pressure container, if when the regulating valve 11 or 23 is open in consequence of the movements of the piston rod 8, the pressure of the gas cushion 4 falls below the pressure within the lower pressure container. Similarly, the non-return valves 13 and 24 prevent the return of gas or oil into the higher pressure container when the valves 14 and 25 are open, if the pressure of the gas cushion should rise above the pressure in the higher pressure container, due to the movements of the piston rod 8.

The lower pressure container and higher pressure container are connected by pipes 26 and 27 in which are incorporated respectively a compressor diagrammatically indicated at 28 and pump diagrammatically indicated at 29, by which means the desired pressure difference between the lower pressure container and higher pressure container is maintained.

The invention is not restricted to the example illustrated.

I claim:

1. A pneumatic spring structure for use on vehicles comprising a gas cushion, a volume of oil co-operating with said gas cushion, a lower pressure container having a gas space communicating with said gas cushion, a volume of oil in said lower pressure container, a higher pressure container having a gas space communicating with said gas cushion, a volume of oil in said higher pressure container, connections between the volume of oil in said containers with the volume of oil co-operating with the gas cushion, means for regulating the flow of gas between said cushion and said containers, means for regulating the flow of oil between the oil co-operating with the gas cushion and that in the containers, a compressor connecting the gas space of said lower pressure container with the gas space of said higher pressure container, and an oil pump connecting the oil in said lower pressure container with the oil in said higher pressure container.

2. A pneumatic spring structure as set forth in claim 1 wherein said gas cushion is constituted by a gas filling

in a working cylinder which also contains the volume of oil co-operating with the gas cushion, said cylinder having a piston working therein immersed in the oil and having valves in the piston whereby movements of the piston are hydraulically damped, said piston being attached to a rod projecting out of said cylinder and said cylinder and piston rod constituting the anchorages of the spring structure.

3. A pneumatic spring structure as set forth in claim 1 also comprising non-return valves which prevent backflow of gas or oil from said lower pressure container to said gas cushion or the oil volume co-operating therewith and preventing backflow of gas or oil from said gas cushion or the volume of oil co-operating therewith to said higher pressure container.

4. A liquid pneumatic suspension system for vehicles, of the type which is variable in accordance with vehicle conditions, comprising in combination a cylinder having an oil volume and a gas cushion at elevated pressure above ambient, a piston in said cylinder for connection to a part of the vehicle, a first pressure container having an oil volume and a gas volume at elevated pressure above ambient but lower than the said gas cushion pressure, inter-communicating means between the said cylinder and the said first pressure container for regulating the flow of gas and oil, a second pressure container having an oil volume and a gas volume at elevated pressure above ambient and higher than the said gas cushion pressure, and intercommunicating means between the said cylinder and the said second pressure container for regulating the flow of gas and oil.

5. The invention as set forth in claim 4, including a compressor connected between the respective gas volumes of the said first and second pressure containers and an oil pump connected between the respective oil volumes of the said first and second pressure containers.

6. A pneumatic spring structure for vehicles comprising in combination, a gas cushion having a volume of oil and a volume of gas and variable pressure to suit external conditions such as loading or road surface conditions, a lower pressure container having a volume of oil and a volume of gas, a higher pressure container having a volume of oil and a volume of gas, control means connecting the volume of gas in each said container with the volume of gas in said gas cushion, a gas compressor connecting the respective volumes of gas in the said containers whereby pressures higher and lower than the operating pressures of the gas cushion are maintained respectively in the higher pressure container and the lower pressure container, and control means connecting the volume of oil in each said container with the volume of oil in said gas cushion.

7. A pneumatic spring structure as set forth in claim 6, including an oil pump connecting the respective volumes of oil in the said containers.

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