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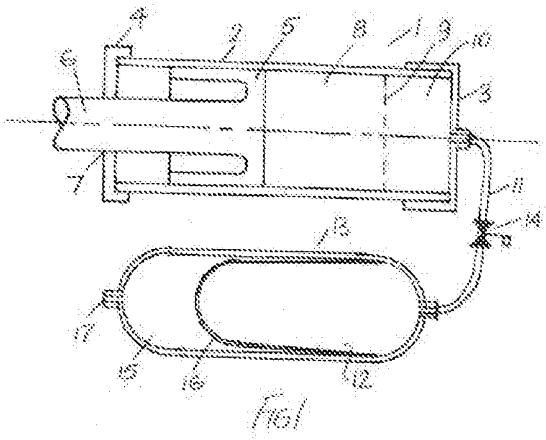
(54) **Vehicle suspension gas spring**

(57) A high pressure gas spring for vehicle suspension systems includes an integral gas damping system and an integral counter spring to reduce spring residual force at suspension rebound. The gas spring includes an inverted piston feature that reduces the overall length of the device. Additionally there are other innovative features incorporated in the gas spring to improve performance, reduce cost and minimize weight. <Figure 1>



"Vehicle Suspension Gas Spring"

Introduction

This invention relates to a gas spring and in particular a gas spring for a motor vehicle suspension system.

Background to the Invention

In heavy load carrying vehicles, the load variation on the suspension – especially the rear suspension – can be very significant – the laden being as much as three times the unladen weight. This causes difficulties with the unladen ride of the vehicle, causing undesirable levels of whole body vibration at the location of the driver and passengers.

This invention describes a gas spring which provides a solution to this problem.

Summary of the Invention

According to the invention, there is provided a vehicle suspension gas spring for mounting between a vehicle chassis/body and a vehicle wheel suspension member, including:

a cylinder closed at one end,

a piston slidably mounted within a bore of the cylinder,

a gastight seal between the piston and the cylinder bore,

a piston road attached to the piston and projecting outwardly of the cylinder,

connector means for attachment of the cylinder to one of the vehicle chassis/body and the vehicle suspension member and for attachment of the piston rod to the other of the vehicle chassis/body and the suspension member,

a gas working medium within the cylinder,

a first gas chamber within the cylinder comprising a swept volume portion of the cylinder and a clearance volume portion of the cylinder,

the first gas chamber communicating with an associated second gas chamber via a stop valve, and

means for pressurising gas in the second gas chamber for pressurising gas in the first gas chamber when this stop valve is open.

In one embodiment of the invention, the second gas chamber is part of an accumulator comprising a housing, an interior of the housing divided by an elastomeric bladder into the second gas chamber and a hydraulic fluid chamber, the hydraulic fluid chamber being connected to a source of pressurised hydraulic fluid.

In another embodiment, the bladder and associated accumulator housing are such that when the second gas chamber is in communication with the first gas chamber and the gas pressure within the first and second gas chambers is at a desirable pressure corresponding to a required neutral ride height unladen pressure, the bladder fills the accumulator housing.

In another embodiment, the cylinder is closed at one end by a cylinder head and at the other end by an end cap, the end cap having a central aperture for reception and slidable through passage of the piston rod which sealingly and slidable engages a sliding bearing mounted at the aperture, a gas feed pipe mounted between the cylinder head and the second chamber in the accumulator, the stop valve being mounted in the gas feed pipe.

Brief Description of the Drawings

The invention will be more clearly understood by the following description of some embodiments thereof, given by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic sectional elevational view of a vehicle suspension gas spring according to the invention; and

Fig. 2 is a graph which shows typical spring characteristics of the gas spring in accordance with the invention.

Detailed Description of the Preferred Embodiments

In Fig. 1, there is depicted an illustration of one embodiment of a vehicle suspension gas spring 1 in accordance with the invention. Fig. 1 is a diagrammatic sectional view of the gas spring 1. The gas spring 1 comprises a cylinder 2 which is closed at both ends by a cylinder head 3 at one end and an end cap 4 at the other end. Mounted within a bore of the cylinder 2 is a piston 5 which is free to slide within the cylinder 2 and forming a gas tight seal between the cylinder 2 and the piston 5. The piston 5 is attached to a piston rod 6 which may form part of the piston 5 or be attached by various means such as a threaded end of the piston rod 6 or a bolted flange end or any other means of securing the piston rod 6 to the piston 5. The end cap 4 has a suitable aperture 7 to allow the piston rod 6 to pass through. This aperture 7 is fitted with suitable seals and a sliding bearing or bearings (not shown) to support and seal the piston rod 6.

Swept volume 8 is the volume swept by the piston 5 from the bottom of its stroke adjacent to the end cap 4 and the other extreme of its stroke indicated by the dotted line 9, indicating top dead centre for the piston 5, adjacent but spaced-apart from the cylinder head 3. The free volume above the piston 5 at the extreme of its stroke, that is above the dotted line 9, is the clearance volume 10. A first gas chamber within the cylinder 2 is formed by the swept volume 8 and the clearance volume 10.

The clearance volume portion 10 of the first gas chamber is connected by a pipe 11 or any other suitable means to a second gas chamber 12 contained within an associated accumulator 13. The connection formed by the pipe 11 between the clearance volume 10 and the second gas chamber 12 may be cut off by a stop valve 14 mounted in the pipe 11. The accumulator 13 comprises the second gas chamber 12 and a hydraulic fluid chamber 15 divided by an elastomeric bladder 16.

When the gas spring 1 is charged to a pressure required to have a desired neutral ride height in the laden condition a certain pressure "A" is required in the swept volume 8 at the neutral point. When the vehicle is unladen the required pressure at the neutral ride height is a lower pressure "B". To charge the cylinder 2 to the lower pressure "B" in the unladen condition the valve 14 is opened and gas is released from the first gas chamber 8, 10 within the cylinder 2 into the second gas chamber 12 of the accumulator 13 until the accumulator 13 is filled to capacity with gas, including the volume of the second gas chamber 12 plus the volume of the hydraulic fluid chamber 15 by expansion of the bladder 16. The volumes 8, 10, 12, and 15 are so designed that the resultant gas pressure is equal to the required unladen pressure "B". When the system has settled at pressure "B" the valve 14 is closed.

When it is required to revert to the higher pressure "A" the valve 14 is opened and pressurised hydraulic fluid is admitted through a hydraulic fluid inlet 17 of the accumulator 13 into the hydraulic fluid chamber 15 and the bladder 16 is collapsed, forcing the gas in the second gas chamber 12 back into the first gas chamber (volumes 8 and 10). The valve 14 is closed and the gas spring 1 is now charged to the required higher pressure "A".

Referring now to Fig. 2, the principle and operation of the invention is explained. The curve 18 depicts the spring characteristic when the gas spring 1 is charged to the high pressure "A" that gives a suspension force to match the requirement of the suspension in the laden condition depicted by the point 19 on the graph in Fig. 2 corresponding to the neutral ride position depicted by point 20 on the curve. When the gas has been expelled from the gas spring 1 the spring characteristic is depicted by curve 21 in figure 2. The unladen weight 22 corresponds to the same neutral ride point 20 as in the laden condition. It can be seen from the graph that if the mechanism of the invention had not been used, the suspension would bottom out in rebound and the vehicle would have not effective suspension.

The terms "comprise" and "include", and any variations thereof required for grammatical reasons, are to be considered as interchangeable and accorded the widest possible interpretation.

The invention is not limited to the embodiments hereinbefore description which may

be varied in construction and detail within the scope of the appended claims.

CLAIMS

1. A vehicle suspension gas spring for mounting between a vehicle chassis/body and a vehicle wheel suspension member, including:

a cylinder closed at one end,

a piston slidably mounted within a bore of the cylinder,

a gastight seal between the piston and the cylinder bore,

a piston rod attached to the piston and projecting outwardly of the cylinder,

connector means for attachment of the cylinder to one of the vehicle chassis/body and the vehicle suspension member and for attachment of the piston rod to the other of the vehicle chassis/body and the suspension member,

a gas working medium within the cylinder,

a first gas chamber within the cylinder comprising a swept volume portion of the cylinder and a clearance volume portion of the cylinder,

the first gas chamber communicating with an associated second gas chamber via a stop valve, and

means for pressurising gas in the second gas chamber for pressuring gas in the first gas chamber when the stop valve is open.

2. The vehicle suspension gas spring as claimed in claim 1, wherein the second gas chamber is part of an accumulator comprising a housing, an interior of the housing divided by an elastomeric bladder into the second gas chamber and a hydraulic fluid chamber, the hydraulic fluid chamber being connected to a source of pressured hydraulic fluid.

3. The vehicle suspension gas spring as claimed in claim 2, wherein the bladder

and associated accumulator housing are such that when the second gas chamber is in communication with the first gas chamber and the gas pressure within the first gas chamber and the second gas chamber is at a desirable pressure, corresponding to a required neutral ride height unladen pressure, the bladder fills the accumulator housing.

4. The vehicle suspension gas spring as claimed in any preceding claim, wherein the cylinder is closed at one end by a cylinder head and at the other end by an end cap, the end cap having a central aperture for reception and slidable through passage of the piston rod which sealingly and slidably engages a sliding bearing mounted at the aperture, a gas feed pipe mounted between the cylinder head and the second chamber in the accumulator, the stop valve being mounted in the gas feed pipe.

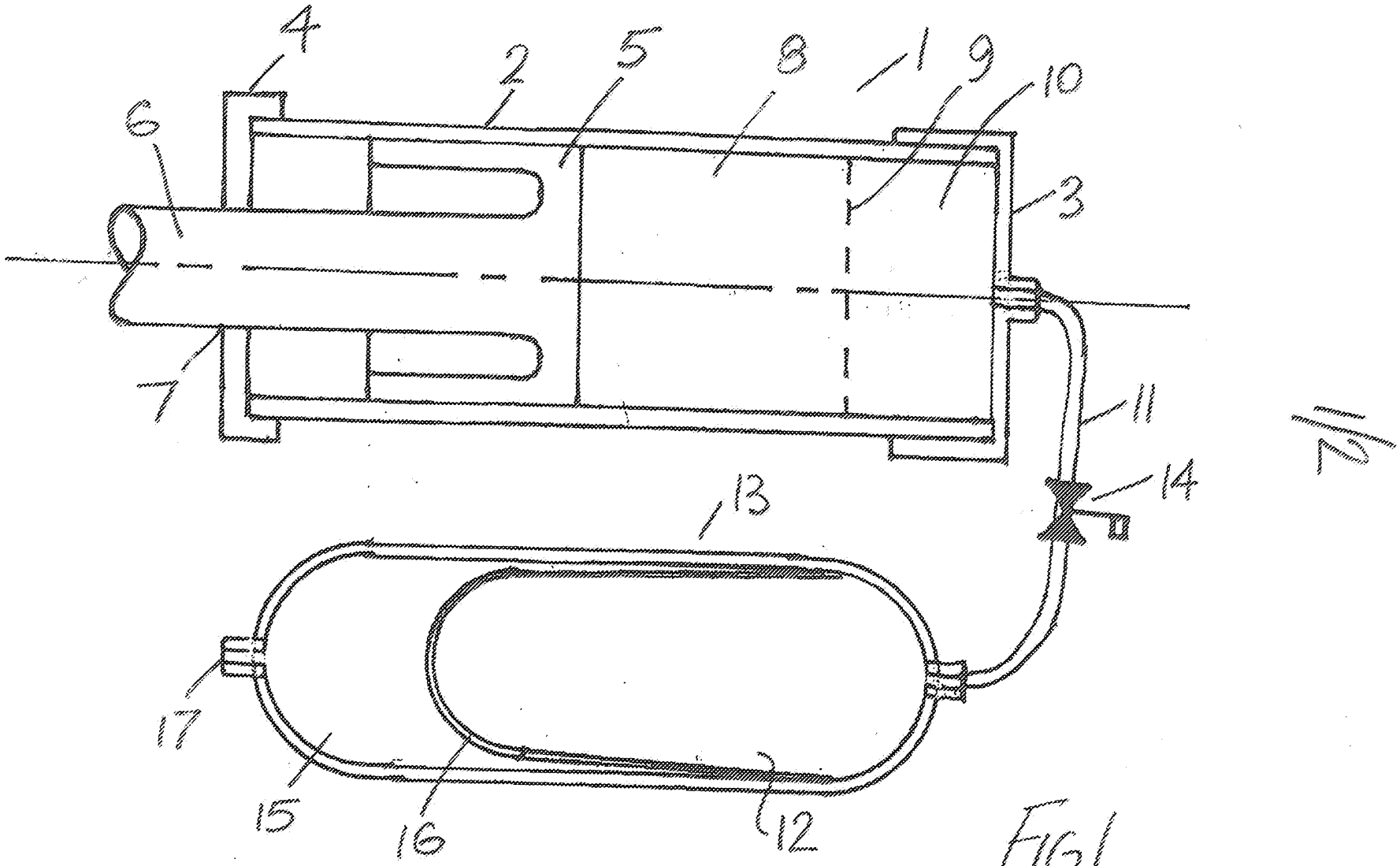


FIG 1

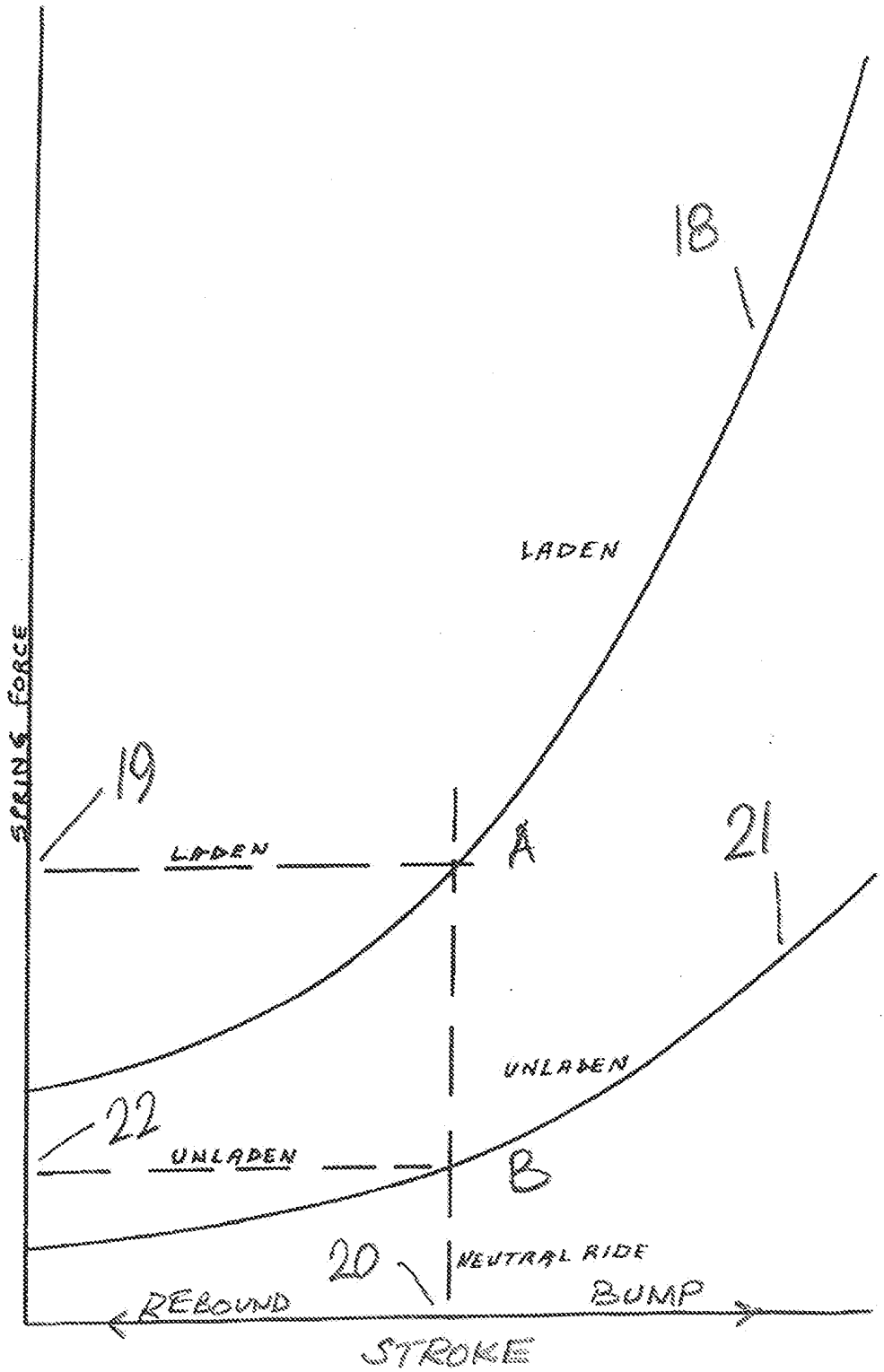


FIG2