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(58) Field of search
F2S

(54) **Hydraulic telescopic shock-absorber with rebound end stop**

(57) The shock absorber has a spring loaded additional piston 13 disposed above the main piston 4. The additional piston 13 has an axial hole 14 and means 12 for limiting its axial downward travel and is capable of coming into or nearly into contact by the upper portion of its outer surface with the cylinder 2 to define a calibrated clearance. The cylinder 2 is provided in a location opposite to at least part of the outer surface of the additional piston 13 with an expansion 11. An annular element 16 on the piston rod closes the axial hole 14 of the additional piston 13 when the piston rod 3 is retracted from the cylinder 2, so that liquid can only flow from above to below the additional piston 13 via the calibrated clearance, which may take various forms (Figs. 2–4, not shown).

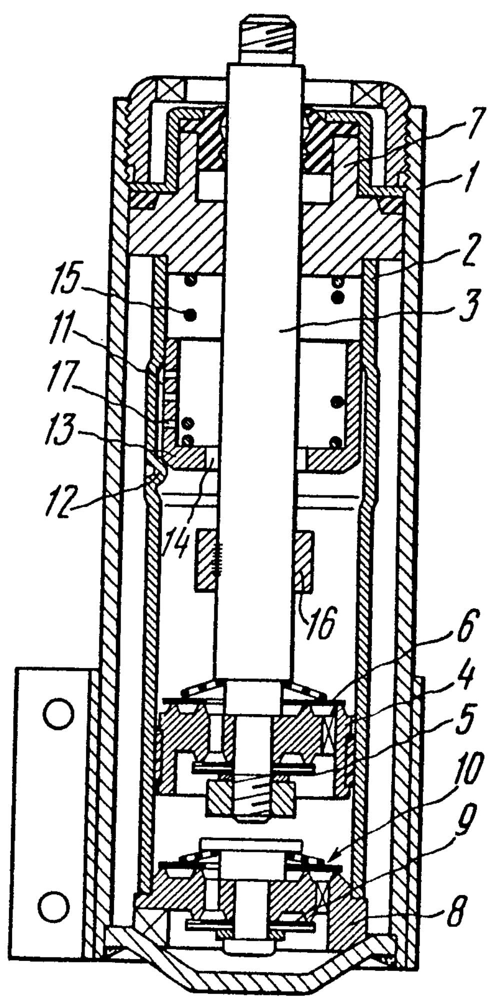

FIG. 1

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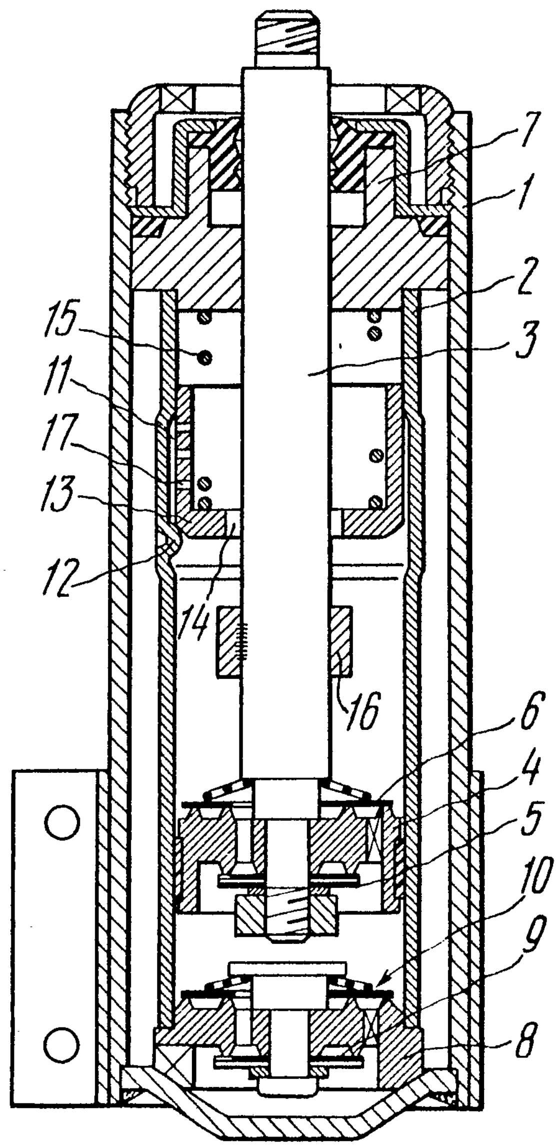

FIG.1

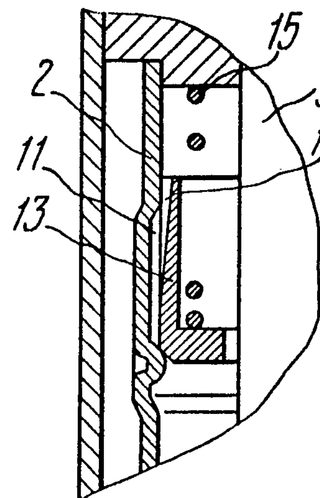

FIG. 2

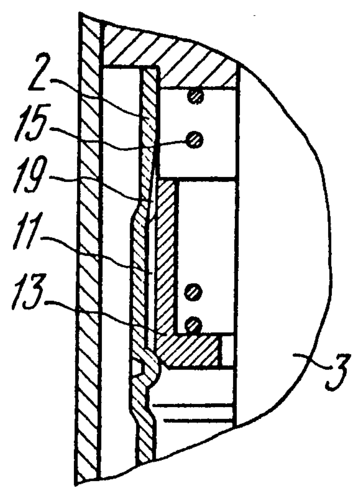

FIG. 3

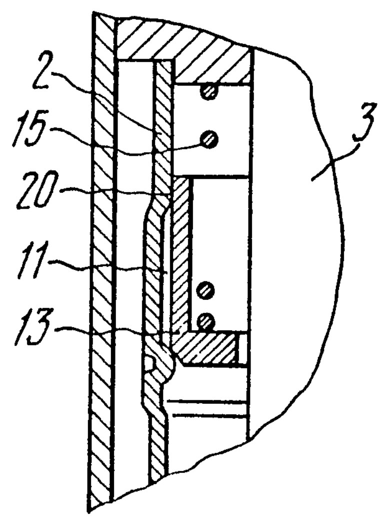

FIG. 4

SPECIFICATION

Hydraulic telescopic shock-absorber with a rebound bumper

This invention relates to hydraulic telescopic shock-absorbers with rebound bumpers, particularly but not solely for motor vehicles.

At present, motor vehicle suspensions make use to an increasing extent of rebound bumpers in hydraulic telescopic shock-absorbers, these rebound bumpers enabling one to reduce the overall weight of vehicles and bring down the costs associated with their manufacture, as well as to make the suspensions more compact. Hydraulically operated rebound bumpers are a new concept in the field of designing hydraulic telescopic shock-absorbers. One substantial advantage of such rebound bumpers resides in their improved efficiency and therefore extended service life of hydraulic telescopic shockabsorbers and motor vehicles in which such rebound bumpers are employed.

Hydraulic telescopic shock-absorbers with rebound bumpers are known comprising a housing, a cylinder disposed coaxially inside the housing, a piston rod with a main piston secured thereon, an additional piston arranged coaxially inside the cylinder, and a sleeve serving as a guide means for the piston rod and encapsulating one end of the cylinder, the other end of the cylinder being enclosed by the housing of a compression valve.

The additional piston is adapted to confine the volume of fluid and to move toward reducing this volume from which the fluid is caused to blow off through throttling passages having progressively reducing effective cross-section. This action is accompanied by a gradual increase in resistance to the travel of the additional piston and the piston rod of the shock-absorber connected thereto. A closed volume of fluid is formed between the coaxially arranged additional piston and a sleeve having a sealing ring received by the additional piston (cf., e.g. British Patent No. 949,426). The sealing ring also functions as a nonreturn valve intended to admit the fluid to the closed volume during the return stroke.

Inherent in the above construction of a hydraulic telescopic shock-absorber is a disadvantage which resides in the complexity and bulkiness of the piston rod guiding sleeve and the need to have such a sleeve made up of two pieces. Also, the groove which receives the sealing ring must necessarily worked mechanically, while the split sealing ring requires a high degree of manufacturing precision and suffers from insufficient reliability and a rather short service life due to dry friction thereof against the additional piston. Further, the addition piston requires the use of high-strength expensive materials due to high working pressures of the fluid caused by the low effective area of the interior volume of this piston.

A double-stage hydraulic telescopic shock-absorber is disclosed in U.S. Patent No. 3,447,644. This shock-absorber with a rebound bumper comprises a housing, a cylinder arranged coaxially inside the housing, a piston rod having main and additional pistons secured thereon, a non-return valve arranged on the additional piston, a sleeve functioning as a guide means for te piston rod and encapsulating one end of the cylinder, a housing of a compression valve encapsulating the cylinder at the other end thereof, and an additional cylinder disposed at the end of the main cylinder. The additional piston is arranged such that it can be received by the additional cylinder. Provided between the additional cylinder and the additional piston is a clearance for the passage of fluid, this clearance tending to become smaller toward the end of the piston stroke to thereby increase resistance to the travel of the additional piston as it enters the additional cylinder. Also, this shockabsorber construction provides for a non-return valve to ensure the passage of fluid exclusively to the additional cylinder when the additional piston is retracted therefrom (during the return stroke).

However, the arrangement of the rebound bumper in this known shock-absorber by way of placing inside the main cylinder of the additional cylinder and providing the additional piston on the piston rod calls for high precision during fabrication of the additional piston and additional cylinder. It also leads to the use of a greater number of parts, which structurally complicates the device and requires the employment of highstrength materials due to high working pressure of the fluid caused by relatively small effective area of internal volume of the additional cylinder to result in insufficient reliability and short service life of the hydraulic shock-absorber.

What is desired, therefore, is a hydraulic telescopic shock-absorber with a rebound bumper of such a construction as to ensure increased service life, to improve reliability, and to provide for greater structural simplicity of the shock-absorber.

The present invention provides a hydraulic telescopic shock-absorber with a rebound bumper comprising a housing, a cylinder disposed inside the housing coaxially therewith, a piston rod having a main piston arranged coaxially inside the cylinder, a sleeve functioning as a guide for the piston rod and encapsulating one end of the cylinder, a housing of a compression valve encapsulating the cylinder on the other end thereof, and an additional piston arranged inside the cylinder above the main piston, in which an axially spring-loaded additional valve having an axial hole and provided with a means for limiting its downward travel is adapted to contact by the upper part of its outer surface with the cylinder to define a calibrated annular clearance, whereas in a location opposite at least part of the outer surface of the additional piston the cylinder has an expansion, an annular element closing the axial hole in the additional piston when the piston rod is retracted from the cylinder being secured on the piston rod between the main piston and the additional piston.

Such a construction of the hydraulic telescopic shock-absorber with a rebound bumper, thanks to the use of the inner surface of the main cylinder, allows one to simplify the shape of the additional piston, reduce the number of parts (since no additional cylinder is required), bring down the working pressure of the fluid, and thus make the shock-absorber more reliable and durable. By virtue of the additional piston being capable of self-alignment inside the cylinder, there is no need for assuring its precise coaxiality with the cylinder normally attainable by high accuracy of fabrication and assembly.

In addition, the shock-absorber is structurally simplified thanks to the spring-loaded additional piston functioning as a non-return valve, whereby no additional non-return valve parts are required. This in turn structurally simplifies the hydraulic telescopic shock-absorber to result in reduced manufacturing cost thereof.

Preferably, at least one projection is provided on the inner surface of the cylinder for limiting the travel of the additional piston. This arrangement enables one to limit the downward travel of the additional piston without the need for extra parts and with a minimum of production operations.

Preferably, in the hydraulic telescopic shock-absorber with a rebound bumper, at least one radial hole, or else one groove of variable cross-section lengthwise thereof with progressively increasing cross-section toward the upper portion of the additional piston is provided on the side surface of this additional piston. This enables one to assure optimum dependence of resistance encountered by the piston rod during its retraction from the cylinder on the piston rod stroke.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates a hydraulic telescopic shock-absorber with a rebound bumper, in axial section;

Figure 2 shows a possible embodiment of throttling passages;

Figure 3 shows an alternative embodiment of the throttling passages; and

Figure 4 shows yet another modified form of a throttling passage in the form of an annular clearance.

With reference to Figure 1 of the drawings, there is shown a hydraulic telescopic shock absorber with a rebound bumper. The shock absorber comprises a housing 1 in which there is disposed substantially coaxially a cylinder 2 containing a piston rod 3 connected to a main piston 4. The main piston 4 accommodates a rebound valve 5 controlling the passage of fluid from a chamber overlying the main piston 4 to a chamber underlying the main piston 4 during the upward travel of the piston rod 3; the main piston 4 also comprising a by-pass valve 6 capable of freely releasing the fluid from the chamber underlying the main piston 4 to the chamber overlying the main piston 4 during the downward travel of the piston rod 3.

A sleeve 7 functioning as a guide for the piston rod 3 encapsulates or closes the cylinder 2 at its upper end. At its bottom end the cylinder is enclosed by a housing 8 of a compression valve. The housing 8 includes a compression valve 9 controlling the flow of fluid from the cylinder 2 during the downward travel of the piston rod 3, and an intake valve 10 for freely admitting the fluid from the housing 1 to the chamber underlying the main piston 4 of the cylinder 2 during the upward travel of the piston rod 3. The cylinder 2 has a locally expanded portion 11 at some distance from the upper end thereof. The lower part of the expansion 11 in the cylinder 2 may include one or more projections 12 (alternatively, one annular projection may be provided).

An additional piston 13 is provided in the cylinder 2 to overlie the main piston 4 and to be capable of axial displacement and thrust against the projection 12. The additional piston 13 has a calibrated outer diameter. An axial hole 14 is provided at the bottom of the additional piston 13. By virtue of the fact that the additional piston 13 is centered radially exclusively by the surface of the cylinder 2 and fails to contact radially with the piston rod 3, a high degree of coaxiality of the outer and inner cylindrical surface of the additional piston 13 is not necessary.

From above, the additional piston 13 is spring-loaded by a light-pressure return spring 15 centrally aligned against the inner circumference of the additional piston 13. By its upper end the return spring 15 bears against the sleeve 7 acting as a guide of the piston rod 3, whereas its lower end bears against the bottom of the additional piston 13. Rigidly secured on the piston rod 3 between the main piston 4 and the additional piston 13 is an annular element 16, which may be disposed either in close proximity to the main piston 4, or on the surface of the piston rod 3 above the main piston 4.

The annular element 16 serves for closing the axial hole 14 in the bottom of the additional piston 13 at the start of operation of the rebound bumper of the hydraulic telescopic shock-absorber. The hydraulic rebound bumper is understood to imply all the elements of the shock-absorber providing for an increase in the resistance to the outward movement of the piston rod 3 from the cylinder 2 at the end of the rebound stroke thereof thanks to throttling of the fluid.

The contacting surfaces of the annular element 16 and the bottom of the additional piston 13 are fabricated with a high degree of accuracy to be precision-fitted and thereby prevent leakage. Alternatively, the place of contact between the annular element 16 and the bottom of the additional piston 13 may be hermetized by placing a seal on the piston rod 3. In this case, no high degree of planeness of the annular element 16 and the bottom of the additional piston 13 at the place of contact therebetween is required.

For a more smooth engagement of the rebound bumper and prevention of clatter at the moment the annular element 16 comes into contact with the bottom of the additional valve 13, an elastic annular member, such as one fabricated from rubber or plastics, may be attached to the upper end face of the annular element 16. This elastic annular member may simultaneously function as a means for sealing the place of contact between the annular element 16 and the bottom of the additional valve 13.

On the side surface of the additional piston 13 opposite the expansion 11 of the cylinder 2 there are provided radial holes 17 (Figure 1) or grooves 18 (Figure 2) having variable sectional area increasing toward the upper part of the additional piston 13. Grooves 19 with variable cross-section lengthwise thereof may also be provided on the inner surface of the cylinder 2 above the expansion 11, as shown in Figure 3.

The expansion 11 on the inner surface of the cylinder 2 is intended for gradual closing of the radial holes 17 (or grooves 18 and 19 with variable cross-section) by the surface of the cylinder 2 or by the side surface of the additional piston 13 during its upward travel, in order to increase resistance to the escape of the fluid from the chamber of the cylinder 2 overlying the additional piston 13 to the chamber between the additional piston 13 and the main piston 4. Therewith, the size, number, and vertical arrangement of the radial holes 17 (or the configuration and number of the grooves 18 and 19) on the side surface of the additional piston 13 or on the surface of the cylinder 2 are selected so as to ensure that the resistance experienced by the piston rod 3 in the course of its travel away from the cylinder is dependent on the stroke of this piston rod 3 in a required manner.

A clearance between the surface of the cylinder 2 above the expansion 11 and the side surface of the additional piston 13 may be pressure-sealed by providing a sealing element on the additional piston 13.

In some instances, when the provisions of the holes 17 or grooves on the additional piston 13 and on the cylinder 2 is either inexpedient or complicated, an annular clearance 20 (Figure 4) between the surface of the cylinder 2 above the expansion 11 and the side surface of the additional piston 13 may be used for controlling the escape of fluid from the chamber overlying the additional piston. The required increase in resistance to the escape of fluid from the chamber overlying the additional piston 13 is assured here by the extended length of the annular clearance 20 between the cylinder 2 and the side surface of the additional piston 13 when this piston 13 moves upwards.

The hydraulic telescopic shock-absorber with a rebound bumper operates in the following manner.

When the annular element 16 (Figure 1) is not in contact with the additional piston 13, the rebound bumper is not operable and thereby fails to influence the functioning of the hydraulic shock-absorber.

During the end portion of the rebound stroke, when the annular element 16 is brought into contact with the additional piston 13, the volume of fluid in the chamber overlying the additional piston 13 is closed. During further travel of the piston rod 3 together with the additional piston 13 upwards the fluid is throttled from the chamber overlying the additional piston 13 to the chamber underlying the additional piston 13 to thereby produce resistance to the outward movement of the piston rod 3 from the cylinder 2. As the additional piston 13 moves upwards, some of the holes 17 are closed by the surface of the cylinder 2, whereby resistance to the flow of fluid from the chambr overlying the additional piston 13 increases. As a result, the rebound force on the piston rod 3 grows accordingly. This leads to a progressively pronounced deceleration in the speed of the upward movement of the piston rod 3 to terminate in a complete stop of the piston rod 3 without sizeable impact loads exerted on the hydraulic telescopic shock-absorber and parts thereof intended for fitting on a vehicle suspension.

In the case of embodying the passages for throttling the fluid from the chamber overlying the additional piston 13 as the grooves 18 (Figure 2) having variable cross-section on the side surface of the additional piston 13 or as the grooves 19 (Figure 3) on the surface of the cylinder 2 above the expansion 11, the progressively growing resistance to the outward movement of the piston rod 3 from the cylinder 2 is ensured by that the gradually reducing effective sections of the profile of the grooves 18 or 19 during the travel of the additional piston 13 upwards are brought into the contact zone between the side surface of the additional piston 13 and the cylinder 2.

In the course of throttling of the fluid from the chamber overlying the additional piston 13 exclusively through the annular clearance

20 (Figure 4) between the cylinder 2 above the expansion 11 and the additional piston 13 (when the holes 17 or the grooves 19 in the cylinder 2, or when the grooves 18 in the additional piston 13 are not provided) an increase in the amount of resistance to the outward travel of the piston rod 3 from the cylinder 2 is assured by the continuously increasing length of the annular clearance 20 between the cylinder 2 and the additional piston 13 as the additional piston 13 moves upwards.

Because the additional piston 13 (Figure 1) is selfalignable inside the cylinder 2, the upward travel of the additional piston 13 is not susceptible to jamming or wedging actions inside the cylinder 2.

The upward stroke of the additional piston 13 terminates when its upper end thrusts against the lower end of the sleeve 7 serving as a guide for the piston rod 3. Therewith, the spring 15 is not compressed until projections come into contact, and consequently is not burdened by an added axial load.

During a return downward stroke of the piston rod 3 the annular element 16 departs from the additional piston 13 as pressure of fluid momentarily drops in the chamber overlying the additional piston 13 when it moves downwards, whereas a substantial pressure is always present in the chamber underlying the additional piston 13. As a result, throughout the return stroke the additional piston 13 is raised above the annular element 16, whereby thanks to the negligeable load of the spring 15 the fluid is freely admitted from the chamber underlying the additional piston 13 to the chamber overlying this additional piston 13. The load of the spring 15, the passage area of the axial hole 14, and the effective area of the pressure of fluid from the chamber underlying the additional piston 13 on this additional piston 13 at the hole 14 closed by the annular element 16 are selected to assure a lack of excessive pressure drop of the fluid in the chamber overlying the additional piston 13, which would affect the operation of the hydraulic telescopic shock-absorber.

The return downward stroke of the additional piston 13 is limited by bearing against the projections 12 in the cylinder 2. The downward travel of the additional piston 13 may be restricted by other suitable means, such as by the spring 15 being affixed by its upper end to the sleeve 7 and by its lower end to the additional piston 13.

Since the additional piston 13 provided with the light-pressure return spring 15 functions as a valve for admitting the fluid to the chamber overlying the additional piston, there is no need for the employment of an additional inlet valve.

In view of the foregoing, the hydraulic telescopic shockabsorber is more efficient, has a longer service life, simple in construction, and easy to manufacture. Its fabrication is less labour-consuming and less costly.

CLAIMS

1. A hydraulic telescopic shock-absorber with a rebound bumper, comprising a housing having a cylinder disposed axially in the interior thereof; a piston rod having a main piston and being arranged axially inside the cylinder; one end of the cylinder being closed by a sleeve functioning as a guide for the piston rod, the other end of the cylinder being closed by a housing of a compression valve; an additional piston having an axial hole and being disposed inside the cylinder above the main piston, the additional piston being axially spring-loaded and having means for limiting its axial downward travel, the additional piston being further capable of coming into or nearly into contact by the upper part of its outer surface with the cylinder to define a calibrated clearance; the cylinder having an expanded portion in a location opposite at least part of the outer surface of the additional piston; and an annular element closing the axial hole in the additional piston in a retracted position of the piston rod and being secured on the piston rod between the main piston and the additional piston.

2. A shock-absorber as claimed in claim 1, in which at least one projection is provided on the inner surface of the cylinder for limiting the downward travel of the additional piston.

3. A shock-absorber as claimed in claim 1 or 2, in which at least one radial hole or at least one groove of variable cross-section lengthwise thereof with progressively increasing cross-section toward the upper portion of the additional piston is provided on the side surface of the additional piston.

4. A hydraulic telescopic shock-absorber with a rebound bumper substantially as described with reference to the accompanying drawings.

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