ABSTRACT: Shock absorber with a dashpot assembly whose piston (3) carries two axially spaced heads (4, 18) cooperating with an interposed annular partition (24) on the inner wall of the cylinder (2) and with the two cylinder end walls (5, 9) to form four chambers of variable volume, i.e., a first damping chamber (22) partly filled with air and communicating with a surrounding oil reservoir (11), a pumping chamber (23) connected with an inlet (10) from the oil reservoir containing a check valve, an intermediate chamber (29) receiving oil from the pumping chamber through one-way orifices (26) of the partition (24), and a second damping chamber (16) receiving oil from the intermediate chamber through one-way passages (31) in the adjoining piston head (4) while also communicating with a fluid space (15) under pressure from a surrounding air cushion (13), the latter chamber having an exit to the pumping chamber blocked by a regulating valve (38) in a contracted position of the assembly. In an extended position, in which a tube (34) rigid with the cylinder (2) opens the regulating valve (38), the pumping chamber (23) is in two-way communication with the reservoir (11) through an opening (20) unblocked by the other piston head (18). An extended position, in which a tube (34) rigid with the cylinder (2) opens the regulating valve (38), the pumping chamber (23) is in two-way communication with the reservoir (11): THROUGH - N OPENING (20) unblocked by the other piston head (18).
SELF-LEVELING HYDROPNEUMATIC SHOCK ABSORBER

My present invention relates to a self-leveling shock absorber, e.g. for automotive vehicles, wherein a dashpot assembly is urged into an extended position by a hydraulic liquid under pressure from an air cushion or similar pressure-accumulating means. A system of this general character has been disclosed in my copending application Ser. No. 699,510 filed Jan. 22, 1968.

In the system of my prior application, the piston of the dashpot assembly has a head subdividing the interior of its cylinder into two compartments which are in restricted two-way communication via narrow orifices in the piston head, one of these compartments being connected with a fluid reservoir via a supply conduit containing cascaded check valves; this fluid-intake compartment is also open toward an annular space in which the hydraulic working liquid is subjected to the pressure of a surrounding air cushion. A pumping chamber formed within the hollow piston, into which a tubular plunger extends from an end of the cylinder, communicates through that plunger with the supply conduits leading from the reservoir to the intake compartments, this pumping chamber being vented directly to the reservoir in an extended position of the assembly in which a normally closed overflow valve is opened by a lost motion linkage.

An object of my present invention is to provide an improved system of this character wherein the pumping chamber is not confined to the interior of a hollow piston but is disposed within the larger cylinder space surrounding the piston for more effective fluid delivery with smaller oscillatory amplitudes of the dashpot assembly.

Another object of this invention is to provide means in such a system for effectively retarding the discharge of excess hydraulic liquid (e.g. oil) from the pumping chamber in the extended position of the assembly, thereby lessening the impact due to the changeover from the closed to the open state of the regulating or overflow valve upon transition from a relatively contracted to a relatively extended position as a result of the compensatory pumping action or of a reduction in load.

A further object is to provide improved damping means in an effective in the outer dead center position of the expanding and contracting assembly.

These objects are realized, pursuant to my present invention, by providing the piston of the dashpot assembly with two axially spaced piston heads which, together with an internal partition on the peripheral cylinder wall, define an annular pumping chamber and an intermediate chamber communicating with each other via one or more one-way passages in the partition, the intermediate chamber in turn being connected by way of similar one-way passages with an adjoining damping chamber formed between a transverse cylinder wall and the nearer one of the two piston heads. A one-way inlet, containing a check valve, leads to the pumping chamber from a reservoir which advantageously is formed as a ring space between the cylinder and a surrounding portion of a housing rigid therewith; a pressure accumulator, similar to the one disclosed in my above-identified earlier application, communicates with the damping chamber and may be accommodated in another annular space between the cylinder and the housing. The damping chamber is connected with the fluid reservoir by a set of conduits which include an axially extending bore in the piston rod, this bore containing the aforementioned regulating valve which, as in my prior system, is opened only after the assembly has reached a certain degree of expansion.

Thus, after the dashpot assembly contracted by a load increase has been reexpanded through the influx of additional hydraulic liquid into the damping chamber, excess liquid can be returned from that chamber to the reservoir over the aforedescribed path, yet effective pumping action continues in the intermediate chamber. This is true even when, in accordance with a preferred embodiment of my invention, the return path extends from the piston bore to the pumping chamber which in turn is placed in two-way communication with the pumping chamber, substantially concurrently with the opening of the regulating valve, by unblocking of an outlet leading from the pumping chamber to the reservoir.

The liquid in the reservoir may be maintained at approximately atmospheric pressure, or at a somewhat higher pressure less than that of the main accumulator, by an overlying air volume confined within the closed housing of the reservoir. Thus, according to another feature of my invention, I prefer to position a filter screen between the regulating valve and the throttling means so as to prevent any clogging of the latter.

In accordance with a further feature of my invention, I provide a second damping space at the opposite end of the assembly, i.e., between the piston head bounding the pumping chamber and an end wall of the cylinder penetrated by the piston rod. This damping space may permanently communicate with the reservoir through a port disposed beyond the sweep of the last-mentioned piston head, in contradistinction to the outlet which is unblocked by that head only in a relatively extended position of the assembly. The assembly, when in equilibrium, always operates with hydraulic liquid circulating from the pumping chamber via the intermediate and damping chambers back to the pumping chamber during part of the oscillating stroke, with a return to the reservoir of excess liquid aspirated into the pumping chamber on a preceding phase.

The above and other features of my invention will be described in greater detail hereinafter with reference to the accompanying drawing the sole FIGURE of which shows a preferred embodiment in longitudinal axial section.

The shock absorber shown in the drawing comprises a cylindrical housing 1 whose vertical axis coincides with that of a dashpot assembly including a piston rod 3 with two piston heads 4, 18 in a hydraulic cylinder 2. The top of housing 4 is closed by a cap 11 holding the dashpot assembly in position while leaving clearance for the piston rod 3 which is connected above the housing with a structure 50 to be supported by the shock absorber, generally the chassis of an automotive vehicle. The lower end of the housing upon another structural element 51 which may form part of the axle housing of one of the wheels of the vehicle, e.g. of a dirigible front wheel thereof.

A washer 42 over lain by cap 11 bears upon gasket 7 seated in a disc 9 which forms an end wall of both housing 1 and cylinder 2, a packing ring 8 in an outer peripheral groove of this disc forming an airtight seal between the interior of the housing and the ambient atmosphere. A transverse partition 6 divides the annular space between housing 1 and cylinder 2 into two compartments 11 and 15, the upper compartment 11 being partly filled with oil over lain by a confined volume of air 12 under suitable pressure which may be adjusted through a normally closed inlet nipple not shown. A similar air cushion 13 is disposed in the annular space 15 and is bounded by a flexible membrane 14 separating it from a high-pressure chamber of variable volume which forms part of compartment 15 and communicates via ports 17 with a damping chamber 16 in the lower end of cylinder 2, the latter chamber being bounded by piston head 4 and by a disc 5 on the bottom of housing 1 forming the other end wall of cylinder 2. The air cushion 13 may also be provided with a filling nipple, not shown, for regulating its pressure.

The space within cylinder 2 bounded by piston heads 4 and 18 is subdivided into two chambers of variable volume by an internal partition 24 of cylinder 2, the partition-forming ring
being locked to the cylinder wall by a deformation 2 thereof. These chambers are a pumping chamber 23 between head 18 and partition 24, communicating with the oil reservoir 11 by way of an inlet 16 containing a check valve 28, and an interconnecting partition 24 between partition 23 and piston head 4 acting as a secondary pumping chamber. A one-way fluid path from chamber 23 to chamber 29 is formed by several orifices 26 in partition 24, these orifices being overlain at their lower ends by a yieldable valve plate 27 under pressure from a spring 44 which is seated on a ring 45 sprung into an annular groove of the inner cylinder wall. Similar one-way passages are provided between chambers 29 and 16 in the form of channels 31 in head 4 containing check valves 46 whose spherical valve bodies rest on a resilient valve plate 30 held in position by a nut 47. Packing rings 19 and 32 form a fluid tight seal between cylinder 2 and piston heads 18 and 4, respectively, a similar seal is provided by packing rings 25 on partition 24 bearing upon piston rod 3.

The piston rod 3 is hollow and has an axial bore 33 open toward damping chamber 16; a channel 39 of reduced width extends from the top of that bore outwardly so as to open into pumping chamber 23. A regulating valve 38 firmly seated at the junction of bore 33 with channel 39 comprises a movable plug 37 with a depending stem 36 extending partly into a tube 34 rising from cylinder wall 5, this tube also housing a coil spring 35 which bears upon a boss 36 of stem 36 to urge the valve member 37 against its seat so as to block communication between chambers 16 and 23. Valve 38 has a recess above the seat of plug 37 which contains a throttling diaphragm 40 and a filter screen 41 wedged into the recess below the diaphragm to prevent the clogging of the diaphragm aperture by oil-entrained solids.

In the relatively contracted position of the dashpot assembly 2, 3 shown in the drawing, the oil in pumping chamber 23 cannot return to reservoir 11 since the check valve 28 in the chamber inlet 10 blocks such escape. When, however, the chassis 50 rises with reference to axle housing 51, i.e., when the dashpot assembly 2, 3 expands under pressure of the oil in chamber 16 during upward oscillation of the vehicle body or upon a sudden unloading of the vehicle, piston head 18 passes an orifice 20 to establish two-way communication between chamber 23 and reservoir 11. The unblocking of this orifice in a relatively extended position of the assembly substantially coincides with the engagement of boss 36' by an inturnd lip 34' at the top of tube 34 whereby plug 37 is withdrawn from its seat on valve 38 against the force of its loading spring 35. In the latter position, therefore, oil can flow from chamber 23 via orifices 26, chamber 29 and orifices 31 to chamber 16 and can return to chamber 23 by way of bore 33, valve 38 and channel 39, this circulation taking place in response to alternate contractions and expansions of primary and secondary pumping chambers 23 and 29 while excess fluid from the circulatory system drains off into reservoir 11 through orifice 20 until equilibrium is reestablished. The air pressure prevailing at 12 in reservoir 11 is also communicated, through a permanently open port 21, to a damping space 22 in the upper end of cylinder 2 filled partly with oil and partly with air, this space being bounded by the piston head 18 and by the top wall 9 of cylinder 2.

Thus, in the operation of the shock absorber shown in the drawing, the assembly will tend to balance itself under varying load conditions at a level substantially coinciding with the incipient venting of damping chamber 16 to reservoir 11 via pumping chamber 23, i.e. the level at which the valve member 37 is seated by tube 34 while the lower face of piston head 18 just clears the orifice 20, the assembly then oscillating about that level in response to the normal unevenness of the road. If the load of the vehicle is increased, the assembly temporarily contracts to cut off the outflow from chamber 15 until sufficient additional liquid has been pumped into that chamber to compress the orifice 20 to a degree generating the countercurrent pressure required to restore the normal level. Conversely, if the vehicle is lightened, the assembly expands so that the return path from chamber 16 to reservoir 11 is unblocked during most or all of an oscillatory cycle until enough oil has escaped from chamber 16 to restore the balance. The continuity of the pumping action under all operating conditions mitigates the shocks accompanying the blocking and un-blocking of the outlet 20 of chamber 23, thereby increasing to the comfort of the riders.

I claim:

1. A shock absorber comprising: a generally cylindrical housing; a dashpot assembly in said housing including a cylinder rigidly joined to said housing and a piston axially displaceable in said cylinder, said piston having a pair of axially spaced heads, said cylinder having a first end penetrating by said piston, a second end sealed by a transverse wall and an inner annular partition slidably bearing upon said piston at a location between said piston heads, one of said piston heads proximal to said first end defining with said partition an annular pumping chamber of variable volume, the other of said piston heads defining with said partition an annular intermediate chamber of variable volume and with said transverse wall a damping chamber of variable volume; a reservoir of hydraulic liquid; first unidirectionally effective valve means forming a one-way fluid path from said reservoir to said pumping chamber, said partition and said other of said piston heads having passages provided with second and third unidirectionally effective valve means, respectively, for letting hydraulic liquid travel from said pumping chamber by way of said intermediate chamber to said damping chamber upon relative reciprocation of said piston and said cylinder in any relative position thereof; conduit means forming a return path for excess liquid from said damping chamber to said reservoir; flow-blocking means in said return path effective in a relatively contracted position of said dashpot assembly; release means effective in a relatively extended position of said dashpot assembly for deactivating said flow-blocking means; and pressure-accumulating means for said hydraulic liquid communication with said damping chamber.

2. A shock absorber as defined in claim 1 wherein said position has a terminal portion with an axially extending bore open toward said damping chamber and forming part of said conduit means, said flow-blocking means including a valve member seated in said bore.

3. A shock absorber as defined in claim 2 wherein said release means comprises a link extending from said transverse wall into said bore and forming a lost-motion connection with said valve member.

4. A shock absorber as defined in claim 3 wherein said link is a tube, said valve member being provided with a stem extending into said tube and terminating in a boss within said tube engageable by an inward projection on said tube, said flow-blocking means further including a spring in said tube bearing upon said boss for urging said valve member against a seat.

5. A shock absorber as defined in claim 2 wherein said path is provided with throttle means beyond said valve member and with a filter screen between said throttle means and said valve member.

6. A shock absorber as defined in claim 2 wherein said piston is provided with a channel forming part of said conduit means and extending therefrom beyond said valve member to said pumping chamber, said return path further including an outlet from said pumping chamber unblocked by said one of said piston heads in said relatively extended position.

7. A shock absorber as defined in claim 6 wherein said reservoir is part of a ring space defined by said housing and a portion of said cylinder proximal to said first end thereof, said pressure-accumulator means being disposed in an annular
space between said housing and a portion of said cylinder proximal to said second end thereof.

8. A shock absorber as defined in claim 7 wherein said pressure-accumulating means comprising an air cushion in said annular space.

9. A shock absorber as defined in claim 7 wherein said housing is provided with an end wall sealing said ring space and forming a damping space within said cylinder between said end wall and said one of said piston heads, said outlet being disposed on said cylinder in the region of said reservoir and opening into the interior of said cylinder at a location within the sweep of said one of said piston heads, said cylinder further having a port beyond said sweep permanently interconnecting said damping space and said reservoir.

10. A shock absorber as defined in claim 9 wherein said cylinder and piston are upright, said piston projecting from the top of said housing, said damping space and said reservoir containing a confined air volume above the liquid level thereof, said port being located above said level.