Abstract: A shock absorber includes a valve assembly which includes a valve disc engaging an inner and outer valve land defined by a valve body. The inner valve land is a non-circular valve land such that a radial dimension between the inner and outer valve land varies based upon a circumferential position of the radial dimension. The varying radial dimension provides a progressive valve opening for the valve assembly.
Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(H(i))

Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
LOW NOISE VALVE ASSEMBLY

FIELD

[0001] The present disclosure relates generally to hydraulic dampers or shock absorbers for use in a suspension system such as a suspension system used for automotive vehicles. More particularly, the present disclosure relates to a valve assembly which has an eccentric pressure area on a valve disc to control the opening of the valve assembly.

BACKGROUND

[0002] This section provides background information related to the present disclosure which is not necessarily prior art.

[0003] Shock absorbers are used in conjunction with automotive suspension systems to absorb unwanted vibrations which occur during driving. To absorb the unwanted vibrations, shock absorbers are generally connected between the sprung portion (body) and the unsprung portion (suspension) of the automobile. A piston is located within a pressure tube of the shock absorber and the pressure tube is connected to the unsprung portion of the vehicle. The piston is connected to the sprung portion of the automobile through a piston rod which extends through the pressure tube. The piston divides the pressure tube into an upper working chamber and a lower working chamber both of which are filled with hydraulic fluid. Because the piston is able, through valving, to limit the flow of the hydraulic fluid between the upper and the lower working chambers when the shock absorber is compressed or extended, the shock absorber is able to produce a damping force which counteracts the vibration which would otherwise be transmitted from the unsprung portion to the sprung portion of the vehicle. In a dual-tube shock absorber, a fluid reservoir or reserve chamber is defined between the pressure tube and a reserve tube. A base valve is located between the lower working chamber and the reserve chamber to also produce a damping force which counteracts the vibrations which would otherwise be transmitted from the unsprung portion of the vehicle to the sprung portion of the automobile.
[0004] As described above, for a dual-tube shock absorber, the valving on the piston limits the flow of damping fluid between the upper and lower working chambers when the shock absorber is extended to produce a damping load. The valving on the base valve limits the flow of damping fluid between the lower working chamber and the reserve chamber when the shock absorber is compressed to produce a damping load. For a mono-tube shock absorber, the valving on the piston limits the flow of damping fluid between the upper and lower working chambers when the shock absorber is extended or compressed to produce a damping load. During driving, the suspension system moves in jounce (compression) and rebound (extension). During jounce movements, the shock absorber is compressed causing damping fluid to move through the base valve in a dual-tube shock absorber or through a piston valve on the piston in a mono-tube shock absorber. A damping valve located on the base valve or the piston controls the flow of damping fluid and thus the damping force created. During rebound movements, the shock absorber is extended causing damping fluid to move through the piston in both the dual-tube shock absorber and the mono-tube shock absorber. A damping valve located on the piston controls the flow of damping fluid and thus the damping force created.

[0005] In a dual-tube shock absorber, the piston and the base valve normally include a plurality of compression passages and a plurality of extension passages. During jounce movements in a dual-tube shock absorber, the damping valve on the base valve opens the compression passages in the base valve to control fluid flow and produce a damping load. A fluid valve on the piston opens the compression passages in the piston to replace damping fluid in the upper working chamber but this check valve does not contribute or only partially contributes to the overall damping load. The damping valve on the piston closes the extension passages of the piston and a fluid valve on the base valve closes the extension passages of the base valve during a compression or jounce movement. During rebound movements in a dual-tube shock absorber, the damping valve on the piston opens the extension passages in the piston to control fluid flow and produce a damping load. The fluid valve on the base valve opens the extension passages in the base valve to replace damping fluid in the
lower working chamber but this fluid valve does not contribute or only partially contributes to the overall damping load.

[0006] In a mono-tube shock absorber, the piston normally includes a plurality of compression passages and a plurality of extension passages. The shock absorber will also include means for compensating for the rod volume flow of fluid as is well known in the art. During jounce movements in a mono-tube shock absorber, the compression damping valve on the piston opens the compression passages in the piston to control fluid flow and produce a damping load. The extension damping valve on the piston closes the extension passages of the piston during a jounce movement. During rebound movements in a mono-tube shock absorber, the extension damping valve on the piston opens the extension passages in the piston to control fluid flow and produce a damping load. The compression damping valve on the piston closes the compression passages of the piston during a rebound movement.

[0007] For most dampers, the damping valves are designed as a normal close/open valve even though some valves may include a bleed flow of damping fluid. Because of this close/open design, pressure oscillations can occur. These pressure oscillations can result in high frequency vibrations being generated by the shock absorber which can create an unwanted disturbance.

SUMMARY

[0008] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0009] A valve assembly for a shock absorber includes a valve disc that seats against an inner and outer sealing land formed on a valve body. Fluid pressure acts against the valve disc in the area between the inner and outer sealing lands to move the valve disc off of the sealing lands. The distance between the inner sealing land and the outer sealing land varies radially in relation to a circumferential position between the inner and outer sealing lands. This controls the initial opening of the valve assembly. Then, as the fluid pressure increases, an additional circumferential area of the valve disc will open until the entire circumferential area of the valve disc is open.
Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

Figure 1 is an illustration of an automobile having shock absorbers which incorporate the valve design in accordance with the present disclosure;

Figure 2 is a side view, partially in cross-section of a dual-tube shock absorber from Figure 1 which incorporates the valve design in accordance with the present disclosure;

Figure 3 is an enlarged side view, partially in cross-section of the piston assembly from the shock absorber illustrated in Figure 2;

Figure 4 is an enlarged side view, partially in cross-section of the base valve assembly from the shock absorber illustrated in Figure 2;

Figure 5 is a plan view of the piston body from the piston assembly illustrated in Figure 3;

Figure 6 is a plan view of the valve body from the base valve assembly illustrated in Figure 4; and

Figure 7 is a plan view of the valve disc used in both the piston assembly illustrated in Figure 3 and the base valve assembly illustrated in Figure 4.

Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

Example embodiments will now be described more fully with reference to the accompanying drawings.
The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. There is shown in Figure 1 a vehicle incorporating a suspension system having shock absorbers, each of which incorporates a piston assembly in accordance with the present invention, and which is designated generally by the reference numeral 10. Vehicle 10 includes a rear suspension 12, a front suspension 14 and a body 16. Rear suspension 12 has a transversely extending rear axle assembly (not shown) adapted to operatively support a pair of rear wheels 18. The rear axle is attached to body 16 by means of a pair of shock absorbers 20 and by a pair of springs 22. Similarly, front suspension 14 includes a transversely extending front axle assembly (not shown) to operatively support a pair of front wheels 24. The front axle assembly is attached to body 16 by means of a pair of shock absorbers 26 and by a pair of springs 28. Shock absorbers 20 and 26 serve to dampen the relative motion of the unsprung portion (i.e., front and rear suspensions 12, 14) with respect to the sprung portion (i.e., body 16) of vehicle 10. While vehicle 10 has been depicted as a passenger car having front and rear axle assemblies, shock absorbers 20 and 26 may be used with other types of vehicles or in other types of applications including, but not limited to, vehicles incorporating non-independent front and/or non-independent rear suspensions, vehicles incorporating independent front and/or independent rear suspensions or other suspension systems known in the art. Further, the term "shock absorber" as used herein is meant to refer to dampers in general and thus will include McPherson struts and other damper designs known in the art.

Referring now to Figure 2, shock absorber 20 is shown in greater detail. While Figure 2 illustrates only shock absorber 20, it is to be understood that shock absorber 26 also includes the valve design described below for shock absorber 20. Shock absorber 26 only differs from shock absorber 20 in the manner in which it is adapted to be connected to the sprung and unsprung masses of vehicle 10. Shock absorber 20 comprises a pressure tube 30, a piston assembly 32, a piston rod 34, a reserve tube 36 and a base valve assembly 38.

Pressure tube 30 defines a working chamber 42. Piston assembly 32 is slidably disposed within pressure tube 30 and divides working
chamber 42 into an upper working chamber 44 and a lower working chamber 46. A seal 48 is disposed between piston assembly 32 and pressure tube 30 to permit sliding movement of piston assembly 32 with respect to pressure tube 30 without generating undue frictional forces as well as sealing upper working chamber 44 from lower working chamber 46. Piston rod 34 is attached to piston assembly 32 and extends through upper working chamber 44 and through upper end cap 50 which closes the upper end of pressure tube 30. A sealing system seals the interface between upper end cap 50, reserve tube 36 and piston rod 34. The end of piston rod 34 opposite to piston assembly 32 is adapted to be secured to the sprung mass of vehicle 10. Valving within piston assembly 32 controls the movement of fluid between upper working chamber 44 and lower working chamber 46 during movement of piston assembly 32 within pressure tube 30. Because piston rod 34 extends only through upper working chamber 44 and not lower working chamber 46, movement of piston assembly 32 with respect to pressure tube 30 causes a difference in the amount of fluid displaced in upper working chamber 44 and the amount of fluid displaced in lower working chamber 46. The difference in the amount of fluid displaced is known as the "rod volume" and it flows through base valve assembly 38.

[0024] Reserve tube 36 surrounds pressure tube 30 to define a fluid reservoir chamber 52 located between tubes 30 and 36. The bottom end of reserve tube 36 is closed by a base cup 54 which is adapted to be connected to the unsprung mass of vehicle 10. The upper end of reserve tube 36 is attached to upper end cap 50. Base valve assembly 38 is disposed between lower working chamber 46 and reservoir chamber 52 to control the flow of fluid between chambers 46 and 52. When shock absorber 20 extends in length, an additional volume of fluid is needed in lower working chamber 46 due to the "rod volume" concept. Thus, fluid will flow from reservoir chamber 52 to lower working chamber 46 through base valve assembly 38 as detailed below. When shock absorber 20 compresses in length, an excess of fluid must be removed from lower working chamber 46 due to the "rod volume" concept. Thus, fluid will flow from lower working chamber 46 to reservoir chamber 52 through base valve assembly 38 as detailed below.
Referring now to Figure 3, piston assembly 32 comprises a valve body 60, a compression valve assembly 62 and a rebound valve assembly 64. Compression valve assembly 62 is assembled against a shoulder 66 on piston rod 34. Valve body 60 is assembled against compression valve assembly 62 and rebound valve assembly 64 is assembled against valve body 60. A nut 68 secures these components to piston rod 34.

Valve body 60 defines a plurality of compression passages 70 and a plurality of rebound passages 72. Seal 48 includes a plurality of ribs 74 which mate with a plurality of annular grooves 76 to permit sliding movement of piston assembly 32.

Compression valve assembly 62 comprises a support washer 78, a valve disc 80 and a spacer disc 82. Support washer 78 abuts shoulder 66 on one end and abuts spacer disc 82 on the opposite end. Spacer disc 82 abuts support washer 78 on one end and abuts valve disc 80 on the other end. Valve disc 80 abuts spacer disc 82 on one end and abuts valve body 60 on the other end. Valve disc 80 abuts valve body 60 and closes compression passages 70 while leaving rebound passages 72 open. During a compression stroke, fluid in lower working chamber 46 is pressurized causing fluid pressure to react against valve disc 80. When the fluid pressure against valve disc 80 overcomes the bending load of valve disc 80, valve disc 80 deflects away from valve body 60 to open compression passages 70 and allow fluid flow from lower working chamber 46 to upper working chamber 44. Typically only a small fluid pressure acting on valve disc 80 will cause the deflection of valve disc 80 and compression valve assembly 62 acts as a check valve between chambers 46 and 44 and does not generate a damping load or only partially generates a damping load. The damping characteristics for shock absorber 20 during a compression stroke are typically controlled by base valve assembly 38 which accommodates the flow of fluid from lower working chamber 46 to reservoir chamber 52 due to the "rod volume" concept. During a rebound stroke, compression passages 70 are closed by valve disc 80.

Rebound valve assembly 64 comprises a spacer 84, a plurality of valve discs 86, a retainer 88 and a spring 90. Spacer 84 is threadingly received on piston rod 34 and is disposed between valve body 60 and nut 68.
Spacer 84 retains valve body 60 and compression valve assembly 62 while permitting the tightening of nut 68 without compressing valve discs 86. Support washer 78, spacer disc 82, valve disc 80, valve body 60 and spacer 84 provide a continuous solid connection between shoulder 66 and nut 68 to facilitate the tightening and securing of nut 68 to spacer 84 and thus to piston rod 34. Valve discs 86 are slidingly received on spacer 84 and abut valve body 60 to close rebound passages 72 while leaving compression passages 70 open. Retainer 88 is also slidingly received on spacer 84 and it abuts valve discs 86. Spring 90 is assembled over spacer 84 and is disposed between retainer 88 and nut 68 which is threadingly received on spacer 84. Spring 90 biases retainer 88 against valve discs 86 and valve discs 86 against valve body 60. When fluid pressure is applied to valve discs 86, they will elastically deflect at the outer peripheral edge to open rebound valve assembly 64. A shim 108 is located between nut 68 and spring 90 to control the preload for spring 90 and thus the blow off pressure as described below. Thus, the calibration for the blow off feature of rebound valve assembly 64 is separate from the calibration for compression valve assembly 62.

[0029] During a rebound stroke, fluid in upper working chamber 44 is pressurized causing fluid pressure to react against valve discs 86. When the fluid pressure reacting against valve discs 86 overcomes the bending load for valve discs 86, valve discs 86 elastically deflect opening rebound passages 72 allowing fluid flow from upper working chamber 44 to lower working chamber 46. The strength of valve discs 86 and the size of rebound passages will determine the damping characteristics for rebound valve assembly 64. When the fluid pressure within upper working chamber 44 reaches a predetermined level, the fluid pressure will overcome the biasing load of spring 90 causing axial movement of retainer 88 and the plurality of valve discs 86. The axial movement of retainer 88 and valve discs 86 fully opens rebound passages 72 thus allowing the passage of a significant amount of damping fluid creating a blowing off of the fluid pressure which is required to prevent damage to shock absorber 20 and/or vehicle 10.

[0030] Referring to Figure 4, base valve assembly 38 comprises a valve body 92, a compression valve assembly 94 and a rebound valve assembly 96. Compression valve assembly 94 and rebound valve assembly 96 are
attached to valve body 92 using a rivet 98 or a bolt and a nut. Valve body 92 defines a plurality of compression passages 102 and a plurality of rebound passages 104.

[0031] Compression valve assembly 94 comprises a plurality of valve discs 106 that are biased against valve body 92 by rivet 98. During a compression stroke, fluid in lower working chamber 46 is pressurized and the fluid pressure within compression passages 102 will eventually open compression valve assembly 94 by deflecting valve discs 106 in a manner similar to that described above for rebound valve assembly 64. Compression valve assembly 62 will open to allow fluid flow from lower working chamber 46 to upper working chamber 44 and only the "rod volume" will flow through compression valve assembly 94. The damping characteristics for shock absorber 20 are determined by the design of compression valve assembly 94 of base valve assembly 38.

[0032] Rebound valve assembly 96 comprises support washer 78, valve disc 80 and spacer disc 82. Valve disc 80 abuts valve body 92 and closes rebound passages 104. Spacer disc 82 is disposed directly between valve disc 80 and support washer 78 and support washer 78 is disposed directly between spacer disc 82 and rivet 98. During a rebound stroke, fluid in lower working chamber 46 is reduced in pressure causing fluid pressure in reservoir chamber 52 to react against valve disc 80. When the fluid pressure against valve disc 80 overcomes the bending load of valve disc 80, valve disc 80 deflects from valve body 92 to open rebound passages 104 and allow fluid flow from reservoir chamber 52 to lower working chamber 46. Typically only a small fluid pressure acting on valve disc 80 will cause the deflection of valve disc 80 and compression valve assembly 94 acts as a check valve between reservoir chamber 52 and lower working chamber 46 and doesn't generate a damping load or only partially generates a damping load. The damping characteristics for a rebound stroke are controlled by rebound valve assembly 64 as detailed above.

[0033] While rebound valve assembly 64 is illustrated having spacer 84, the plurality of valve discs 86, retainer 88 and spring 90, it is within the scope of the present disclosure to replace rebound valve assembly 64 with
compression valve assembly 62. When compression valve assembly 62 is also used to replace rebound valve assembly 64, valve disc 80 would be redesigned such that the damping characteristics for shock absorber 20 are maintained during extension movements.

[0034] While compression valve assembly 94 is illustrated having the plurality of valve discs 106, it is within the scope of the present disclosure to replace compression valve assembly 94 with rebound valve assembly 96. When rebound valve assembly 96 is also used to replace compression valve assembly 94, valve disc 80 would be redesigned such that the damping characteristics for shock absorber 20 are maintained during jounce movements.

[0035] Referring now to Figures 3, 5 and 7, components of compression valve assembly 62 are illustrated in greater detail. As illustrated in Figures 3 and 5, valve body 60 comprises an outer valve land 110 and an inner valve land 112. Outer valve land 110 is illustrated as a circular land having its center located at the center of circular valve body 60. Inner valve land 112 is illustrated as a non-circular land having four sections A-B, B-C, C-D and D-A. Section A-B is a circular section having its center located at the center of valve body 60. Section C-D is a circular section having its center located at a point spaced to the left of the center point of valve body 60 in Figure 5. Sections B-C and D-A are transition sections between sections A-B and C-D. Sections B-C and D-A can be linear portions of inner valve land 112, they can be curved portions of inner valve land 112 or they can be any shape necessary to generate the required performance of compression valve assembly 62. Valve disc 80 engages the entire upper surface of outer and inner valve lands 110, 112.

[0036] As disclosed in Figure 5, the area between outer valve land 110 and inner valve land 112 has a width dimension in the radial direction of valve body 60 that varies based upon the circumferential position of the width dimension.

[0037] When fluid pressure acts against valve disc 80, which closes the area between outer valve land 110 and inner valve land 112, the portion of the area between outer valve land 110 and inner valve land 112 that has the largest width dimension will exert a greater force on valve disc 80 due to a larger area of valve disc 80 being exposed to the fluid pressure. Thus, the portion of
valve disc 80 located at the largest width direction of the area between valve lands 110 and 112 will open first followed by other portions of valve disc 80 in direct relation to the width dimension at these other portions. The curve that defines the opening of compression valve assembly 62 can be specified by the shape of outer valve land 110 and inner valve land 112.

[0038] As illustrated in Figure 5, the plurality of compression passages 70 are disposed only in a portion of the area between the outer valve land 110 and inner valve land 112 which correspond to a circumferential position where the width dimension between outer valve land 110 and inner valve land 112 is greater than the minimum width between outer valve land 110 and inner valve land 112. This location of compression passages 70 directs the fluid flow and the fluid pressure directly to the larger width dimension portions on valve disc 80 ensuring that the portion of valve disc 80 having the largest width dimension opens first.

[0039] Referring now to Figures 4, 6 and 7, components of rebound valve assembly 96 are illustrated in greater detail. As illustrated in Figures 4 and 6, valve body 92 comprises outer valve land 110 and inner valve land 112. Outer valve land 110 is illustrated as a circular land having its center located at the center of circular valve body 92. Inner valve land 112 is illustrated as a non-circular land having four sections A-B, B-C, C-D and D-A. Section A-B is a circular section having its center located at the center of valve body 92. Section C-D is a circular section having its center located at a point spaced to the left of the center point of valve body 92 in Figure 6. Sections B-C and D-A are transition sections between sections A-B and C-D. Sections B-C and D-A can be linear portions of inner valve land 112, they can be curved portions of inner valve land 112 or they can be any shape necessary to generate the required performance of compression valve assembly 62. Valve disc 80 engages the entire upper surface of outer and inner valve lands 110, 112.

[0040] As disclosed in Figure 6, the area between outer valve land 110 and inner valve land 112 has a width dimension in the radial direction of valve body 92 that varies based upon the circumferential position of the width dimension.
When fluid pressure acts against valve disc 80, which closes the area between outer valve land 110 and inner valve land 112, the portion of the area between outer valve land 110 and inner valve land 112 that has the largest width dimension will exert a greater force on valve disc 80 due to a larger area of valve disc 80 being exposed to the fluid pressure. Thus, the portion of valve disc 80 located at the largest width direction of the area between valve lands 110 and 112 will open first followed by other portions of valve disc 80 in direct relation to the width dimension at these other portions. The curve that defines the opening of compression valve assembly 62 can be specified by the shape of outer valve land 110 and inner valve land 112.

As illustrated in Figure 6, the plurality of rebound passages 104 are disposed only in a portion of the area between the outer valve land 110 and inner valve land 112 which correspond to a circumferential position where the width dimension between outer valve land 110 and inner valve land 112 is greater than the minimum width between outer valve land 110 and inner valve land 112. This location of rebound passages 104 directs the fluid flow and the fluid pressure directly to the larger width dimension portions on valve disc 80 ensuring that the portion of valve disc 80 having the largest width dimension opens first.

While compression valve assembly 62 and rebound valve assembly 96 are illustrated as a clamped valve disc design, it is within the scope of the present disclosure to use any other valve design for shock absorbers known in the art including, but not limited to, designs where the valve disc is biased against the piston body or the valve body by the biasing member such as a coil spring, a flange spring or other biasing members.

The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from
the disclosure, and all such modifications are intended to be included within the scope of the disclosure.
CLAIMS

What is claimed is:

1. A shock absorber comprising:
   a pressure tube defining a fluid chamber;
   a piston assembly disposed within said pressure tube, said piston assembly dividing said fluid chamber into an upper working chamber and a lower working chamber;
   a first valve assembly engaging said piston assembly, said first valve assembly including a first valve body and a first valve disc engaging said first valve body; wherein
   said first valve body defines a first outer valve land and a first non-circular inner valve land, said first valve disc engaging said first inner and said outer valve lands.

2. The shock absorber according to Claim 1, wherein said first outer valve land is a circular valve land.

3. The shock absorber according to Claim 1, wherein said first inner valve land includes a first circular portion.

4. The shock absorber according to Claim 3, wherein said first inner valve land includes a second circular portion.

5. The shock absorber according to Claim 4, wherein said first inner valve land includes a transition portion between said first and second circular portions.

6. The shock absorber according to Claim 4, wherein said first inner valve land includes a first and a second transition portion between said first and second circular portions.
7. The shock absorber according to Claim 1, wherein a radial dimension between said first inner and said first outer valve land varies based upon a circumferential position of said radial dimension.

8. The shock absorber according to Claim 7, wherein a plurality of passages defined by said first valve body are located circumferentially in a position between said first inner and said first outer valve lands where said radial dimension is greater than a smallest radial dimension between said first inner and said first outer valve lands.

9. The shock absorber according to Claim 1, further comprising:
   a reserve tube surrounding said pressure tube, a reservoir chamber being defined between said pressure tube and said reservoir tube;
   a second valve assembly engaging said base valve assembly, said second valve assembly including a second valve body and a second valve disc engaging said second valve body; wherein
   said second valve body defines a second outer valve land and a second non-circular inner valve land, said second valve disc engaging said second inner and said second outer valve lands.

10. The shock absorber according to Claim 9, wherein said second outer valve land is a circular valve land.

11. The shock absorber according to Claim 9, wherein said second inner valve land includes a first circular portion.

12. The shock absorber according to Claim 11, wherein said second inner valve land includes a second circular portion.

13. The shock absorber according to Claim 12, wherein said second inner valve land includes a transition portion between said first and second circular portions.
14. The shock absorber according to Claim 12, wherein said second inner valve land includes a first and a second transition portion between said first and second circular portions.

15. The shock absorber according to Claim 9, wherein a radial dimension between said second inner and said second outer valve land varies based upon a circumferential position of said radial dimension.

16. The shock absorber according to Claim 15, wherein a plurality of passages defined by said first valve body are located circumferentially in a position between said second inner and said second outer valve lands where said radial dimension is greater than a smallest radial dimension between said second inner and said first outer valve lands.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

F16F 9/32(2006.01)i, F16F 9/34(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F16F 9/32; F16K 16/00; F16F 9/34H; B60G 17/08; F16F 9/46; F16F 9/34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

ekOMPASS(KIPO internal) & Keywords: shock, absorber, valve, pressure

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 6899207 B2 (STEFAN DEFERME et al.) 31 May 2005 See column 3, line 20-column 7, line 18 and figures 2-6a.</td>
<td>1-16</td>
</tr>
<tr>
<td>A</td>
<td>US 50489855 A (DE CARBON, CHRISTIAN B.) 13 February 1990 See column 5, line 62-column 6, line 4 and figure 4.</td>
<td>1-16</td>
</tr>
<tr>
<td>A</td>
<td>US 6464053 B1 (HOEBRECHTS, ALBERT) 15 October 2002 See column 4, lines 45-55 and figures 3,4.</td>
<td>1-16</td>
</tr>
<tr>
<td>A</td>
<td>JP 2009-505024 A (TENNECO AUTOMOTIVE OPERATING COMPANY INC.) 05 February 2009 See paragraph [0026] and figure 7.</td>
<td>1-16</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

Date of the actual completion of the international search


Date of mailing of the international search report


Name and mailing address of the ISA/KR

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 341-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LIM, Hae Young

Telephone No. 82-42-481-5518

Form PCT/ISA/210 (second sheet) (My 2009)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CN: 1875203 A</td>
<td>06.12.2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN: 1875203 CO</td>
<td>01.10.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE: 11200400 1829 B4</td>
<td>09.09.2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE: 11200400 1829 T5</td>
<td>31.08.2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 0606018 DO</td>
<td>03.05.2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2421294 A</td>
<td>21.06.2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2421294 A8</td>
<td>21.05.2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2437182 A</td>
<td>17.10.2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US: 2005-0067238 A</td>
<td>31.03.2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE: 10035640 B4</td>
<td>16.11.2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2352493 A</td>
<td>31.01.2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2352493 B</td>
<td>19.03.2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN: 101243266 A</td>
<td>13.08.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN: 101243266 CO</td>
<td>13.08.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN: 102102730 A</td>
<td>22.06.2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN: 102141 104 A</td>
<td>03.08.2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE: 112006002168 T5</td>
<td>26.06.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 0802565 DO</td>
<td>19.03.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2442188 A</td>
<td>26.03.2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB: 2442188 B</td>
<td>13.05.2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP: 05-008667 B2</td>
<td>08.06.2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wo: 2007-02 1753 A2</td>
<td>22.02.2007</td>
</tr>
</tbody>
</table>