Title of the Invention: **Dust boot for a damper of a vehicle suspension system**

Abstract Title: **A dust boot for a damper of a vehicle suspension system**

A dust boot 26 for a damper 10 of a vehicle suspension system is provided. The dust boot 26 includes an elongated body portion 32 having a central longitudinal axis L and including compressible and extensible upper and lower convoluted sections 48, 50 and an intermediate section 52 extending between the upper and lower convoluted sections 48, 50. The upper and lower convoluted sections 48, 50 of the body portion 32 of the dust boot 26 include a plurality of annular convolutions and the intermediate section 52 includes smooth inner and outer surfaces. References are also made to a vehicle suspension system incorporating such a dust boot, and to a vehicle including such a suspension system.
DUST BOOT FOR A DAMPER OF A VEHICLE SUSPENSION SYSTEM

TECHNICAL FIELD

The present invention relates to a dust boot for a damper of a vehicle suspension system. Aspects of the invention relate to a dust boot, to a suspension system, and to a vehicle.

BACKGROUND

Dampers, e.g., shock absorbers or struts, are used in suspension systems of automotive vehicles to smooth out or damp shock impulses and dissipate kinetic energy. Collapsible and extensible bellows-like covers known as dust boots are commonly used to protect such dampers from exposure to dirt, dust, mud and other external environmental debris.

Conventional dust boots, however, may shift unpredictably relative to a central axis of the damper during compression and rebound of the damper. For example, a bellows portion of a conventional dust boot may deflect to one side of the central axis of the damper or bow outwards during a compression stroke. When shifted, the inner and outer surfaces of the dust boot may come into contact or interfere with other components of the suspension system, which may damage the boot and/or the other components. In addition, contact between the dust boot and the other components may result in undesirable impact noise.

Accordingly, it is an aim of the present invention to address, for example, the disadvantages identified above.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a dust boot for a damper of a vehicle suspension system. The dust boot includes an elongated body portion having a central longitudinal axis and including compressible and extensible upper and lower convoluted sections and an intermediate section extending between the upper and lower convoluted sections. The upper and lower convoluted sections of the body portion of the dust boot include a plurality of annular convolutions and the intermediate section includes smooth inner and outer surfaces.

According to another aspect of the invention, there is provided a vehicle suspension system. The vehicle suspension system includes an outer tube, a top mount coupled to a vehicle body, and a piston rod coupled to the top mount and extending out of the outer tube in an axial direction. A cap is positioned over and around an upper end portion of the outer tube
that locates the piston rod within the outer tube and provides a fluid-tight seal around the piston rod. An elongated body portion of a dust boot extends in a generally downward direction from the top mount over the upper end portion of the outer tube such that the piston rod and the upper end portion of the outer tube are shielded from exposure to external debris. The elongated body portion of the dust boot has a central longitudinal axis and includes compressible and extensible upper and lower convoluted sections and an intermediate section extending between the upper and lower convoluted sections.

According to yet another aspect of the invention, there is provided a vehicle that includes the dust boot described herein.

According to yet another aspect of the invention, there is provided a vehicle that includes the vehicle suspension system described herein.

Optional features of the various aspects of the invention are set out below in the dependent claims.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples, and alternatives set out in the preceding paragraphs, in the claims, and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic perspective cross-sectional view of a portion of a hydraulic damper of a vehicle suspension system that includes a dust boot, in accordance with one embodiment of the invention;

FIG. 2 is a schematic perspective view of a dust boot, in accordance with another embodiment of the invention;

FIG. 3 is a side elevation view of the dust boot illustrated in FIG. 2;
FIG. 4 is an enlarged cross-sectional view of a portion of the dust boot, taken from circle 4 of FIG. 3;

FIG. 5 is an enlarged cross-sectional view of a portion of the dust boot, taken from circle 5 of FIG. 3; and

FIG. 6 is an enlarged cross-sectional view of a portion of the dust boot, taken from circle 6 of FIG. 3.

DETAILED DESCRIPTION

FIG. 1 illustrates a hydraulic damper 10 of a vehicle suspension system. The damper 10 includes an outer tube 12 and a piston rod 14 extending out of the tube 12 in an axial direction. A cap 16 is positioned over and around an upper end portion 18 of the tube 12 to help locate the piston rod 14 within the tube 12 and to provide a fluid-tight seal around the rod 14. The cap 16 also includes a bump surface 20 that abuts against a spring aid 22 during compression of the damper 10. The piston rod 14 and the spring aid 22 are coupled to a top mount 24, which is further connected to a vehicle body (not shown).

A dust boot 26 is provided over the damper 10 to effectively shield the spring aid 22, the piston rod 14, and the sealing area around the rod 14 of the damper 10 from exposure to dirt, dust, mud and other debris during compression and rebound of the damper 10. The dust boot 26 is oriented in coaxial relationship with the damper 10 and includes a top end 28, a bottom end 30, and an elongated body portion 32 having a central longitudinal axis L and extending from the top mount 24 over the end portion 18 of the outer tube 12.

The top and bottom ends 28, 30 of the dust boot 26 are attached to the top mount 24 and the outer tube 12, respectively, in a manner which forms a seal therebetween that prevents ingress of dirt, dust, mud and other debris into an interior volume 34 of the dust boot 26. For example, the top and bottom ends 28, 30 of the dust boot 26 may be configured to snap or clip onto existing features of the top mount 24 and the outer tube 12. As another example, the top and bottom ends 28, 30 of the dust boot 26 may be clamped or crimped around the top mount 24 and the outer tube 12, respectively, by securing a ring around the top and bottom ends 28, 30 of the boot 26 after the boot has been properly positioned over the damper 10.

In the embodiment illustrated in FIG. 1, the top mount 24 includes an annular rib 36 with a ridge 38 formed thereon that extends radially outwardly from the rib 36 for snap-fitting into an annular recess 40 located in the top end 28 of the boot 26. In addition, the bottom end 30 of
the boot 26 is secured around the outer tube 12 by a collar 42 that is fixed to an exterior surface of the tube 12 and includes a radially extending tang 44 for snap-fitting into an annular recess 46 located in the bottom end 30 of the boot 26.

The elongated body portion 32 of the dust boot 26 is configured to extend and retract in accordance with the extension and retraction of the piston rod 14, and to do so while avoiding contact with peripheral components of the suspension system. As such, the body portion 32 of the dust boot 26 has a relatively slender configuration, as compared to conventional dust boots. In addition, the body portion 32 of the dust boot 26 is configured to preferentially bend and flex during compression and rebound of the damper 10 so as to further reduce the occurrence of intermittent contact between the dust boot 26 and the peripheral components of the suspension system.

The body portion 32 of the dust boot 26 has a hybrid configuration and includes compressible and extensible upper and lower corrugated or convoluted sections 48, 50 and an intermediate section 52 extending between the upper and lower sections 48, 50. The inner and outer surfaces of the upper and lower sections 48, 50 include a plurality of axially spaced annular convolutions, while the intermediate section 52 includes generally smooth inner and outer surfaces.

The upper and lower sections 48, 50 of the body portion 32 are configured to extend and compress in an axial direction in accordance with the inward and outward movement of the piston rod 14 relative to the outer tube 12. In addition, the upper section 48 of the body portion 32 is configured to flex or bend in a radial and/or angular direction during compression and rebound of the damper 10, for example, to compensate for any radial or angular misalignment of the top mount 24 and the outer tube 12 during compression of the damper 10.

The intermediate section 52 of the body portion 32 couples the upper and lower sections 48, 50 of the body portion 32 to one another while also isolating the relative movements of the upper and lower sections 48, 50. Due to the relatively smooth inner and outer surfaces of the intermediate section 52, as compared to conventional dust boots, an insubstantial amount of noise will be generated if the intermediate section 52 of the body 32 should ever intermittently come into contact with any of the other components of the suspension system. Further, the construction of the intermediate section 52 gives it a degree of rigidity relative to the upper and lower convoluted sections 48, 50 that helps prevent bowing of the dust boot 26 during compression and rebound of the damper, and thus helps prevent or reduce the
occurrence of contact between the dust boot 26 and any peripheral components of the suspension system.

FIGS. 2–6 illustrate another embodiment of a dust boot 126 for shielding a piston rod of a damper from exposure to dirt, dust, mud and other external environmental debris during compression and rebound of the damper. Like the dust boot 26 illustrated in FIG. 1, the dust boot 126 has a central longitudinal axis L and includes top and bottom ends 128, 130, compressible and extensible upper and lower convoluted sections 148, 150, and an intermediate section 152. Together, the upper and lower convoluted sections 148, 150 and the intermediate section 152 of the dust boot 126 constitute a body portion of the dust boot 126.

The upper and lower convoluted sections 148, 150 are generally cylindrical and include a plurality of axially spaced annular corrugations or convolutions that provide flexibility to the sections 148, 150 by permitting axial contraction and expansion thereof. In other words, the annular convolutions of the upper and lower convoluted sections 148, 150 allow the axial length of the dust boot 126 to be increased or decreased during rebound and compression of the damper. In some specific embodiments, the axial length of the dust boot 126 may increase by about 33% when fully extended, and may decrease by about 23% when fully compressed. For example, the axial length of the dust boot 126 may increase by 30–50% when fully extended, and may decrease by 15–40% when fully compressed. In one specific example, the dust boot 126 may have an axial length in the range of about 290 mm to about 310 mm when at rest, an axial length in the range of about 230 mm to about 245 mm when fully compressed, and an axial length in the range of about 400 mm to about 420 mm when fully extended.

When the dust boot 126 is at rest, the combined axial length of the upper and lower convoluted sections 148, 150 will generally be greater than the axial length of the intermediate section 152. In some specific embodiments, the axial length of the upper convoluted section 148 may account for about 10–40% of the body portion of the dust boot 126, the axial length of the lower convoluted section 150 may account for about 25–50% of the body portion, and the axial length of the intermediate section 152 may account for about 10–65% of the body portion. For example, the axial length of the upper convoluted section 148 may account for 30–35% of the body portion of the dust boot 126, the axial length of the lower convoluted section 150 may account for 30–35% of the body portion, and the axial length of the intermediate section 152 may account for 30–35% of the body portion. In one specific example, the body portion may have an axial length in the range of about 260 mm to
280 mm, the upper convoluted section 148 may have an axial length in the range of about 75 mm to 95 mm, the lower convoluted section 150 may have an axial length of about 90 mm to 95 mm, and the intermediate section 152 may have an axial length of about 85 mm to 95 mm when the dust boot 126 is at rest.

The upper convoluted section 148 of the dust boot 126 includes a first portion 154 and a second portion 156 extending between the first portion 154 and the intermediate section 152 of the dust boot 126. The first portion 154 and the second portion 156 of the upper convoluted section 148 each include a plurality of annular convolutions 158, 160, respectively, that are generally equally spaced apart from one another along the longitudinal axis L of the dust boot 126.

The annular convolutions 158 in the first portion 154 have first mean diameters and the annular convolutions 160 in the second portion 156 have second mean diameters. As used herein, the mean diameter of a convolution is the algebraic average of the outside and inside diameters of the convolution. The mean diameters of the annular convolutions 158 in the first portion 154 may be greater than the mean diameters of the annular convolutions 160 in the second portion 156. For example: (i) the mean diameter of each of the annular convolutions 158 in the first portion 154 may be greater than the mean diameter of each of the annular convolutions 160 in the second portion 156, (ii) the average of the mean diameters of the annular convolutions 158 in the first portion 154 may be greater than the average of the mean diameters of the annular convolutions 160 in the second portion 156, and/or (iii) at least one of the annular convolutions 158 in the first portion 154 may have a mean diameter that is greater than that of at least one of the annular convolutions 160 in the second portion 156. Forming the annular convolutions 158, 160 in the first and second portions 154, 156 in this way may allow for angular deflection and/or angular rotation of the upper convoluted section 148 of the dust boot 126 relative to the central longitudinal axis L thereof.

In one specific embodiment, the mean diameters of the annular convolutions 158 in the first portion 154 may be about 2.5% greater than the mean diameters of the annular convolutions 160 in the second portion 156. For example, the mean diameters of the annular convolutions 158 in the first portion 154 may be 2–12% greater than the mean diameters of the annular convolutions 160 in the second portion 156. In one specific example, the annular convolutions 158 in the first portion 154 may each have outer diameters of about 96 mm, inner diameters of about 88 mm, and mean diameters of about 92 mm, and the annular convolutions 160 in the second portion 156 may each have outer diameters of about 94 mm, inner diameters of about 86 mm, and mean diameters of about 90 mm. As another example,
the mean diameters of the annular convolutions 158 in the first portion 154 may average about 92 mm, with some mean diameters being greater and some being less than 92 mm, whereas the mean diameters of the annular convolutions 160 in the second portion 156 may average about 90 mm. Of course different dimensions may be used for different applications.

By differentiating the mean diameters of the annular convolutions 158, 160 of the first and second portions 154, 156 of the upper convoluted section 148 in this way, the centerline of the upper convoluted section 148 of the dust boot 126 can more readily be displaced from a straight line (as shown in FIG. 3) to a circular arc during rebound and compression of the damper. In one specific embodiment, the centerline of the upper convoluted section 148 of the dust boot 126 may be displaced from the central longitudinal axis L of the dust boot 126 at an angle of about ±8°. For example, the centerline of the upper convoluted section 148 of the dust boot 126 may be displaced from the central longitudinal axis L of the dust boot 126 at an angle in the range of ±3° to ±15°. In addition, differentiating the mean diameters of the annular convolutions 158, 160 in the first and second portions 154, 156 of the upper convoluted section 148 in this way may allow the upper convoluted section 148 to be axially compressed in two phases, with the first portion 154 of the upper convoluted section 148 being at least initially compressed to a greater extent than the second portion 156.

In another embodiment, the annular convolutions 158 in the first portion 154 may have generally equal mean diameters and the annular convolutions 160 in the second portion 156 may have mean diameters that decrease in size in a step-wise manner from one convolution to the next and from the first portion 154 of the upper convoluted section 148 to the intermediate section 152. For example, the annular convolutions 158 in the first portion 154 may each have outer diameters of about 83 mm, inner diameters of about 73 mm, and mean diameters of about 78 mm, and the annular convolutions 160 in the second portion 156 may have mean diameters that gradually decrease from about 80 mm to about 74 mm. In such case, the second portion 156 of the upper convoluted section 148 may be tapered, and may have an opening angle or a cone angle of about 12°–13°, although different angles are certainly possible.

The axial length of the second portion 156 of the upper convoluted section 148 may be greater than the axial length of the first portion 154, and the number of annular convolutions 160 in the second portion 156 of the upper convoluted section 148 may be greater than the number of annular convolutions 158 in the first portion 154. In one specific embodiment, the first portion 154 of the upper convoluted section 148 may include about 4 annular convolutions 158 and the second portion 156 of the upper convoluted section 148 may
include about 11 annular convolutions 160. For example, the ratio of the number of annular convolutions 160 in the second portion 156 of the upper convoluted section 148 to the number of annular convolutions 158 in the first portion 154 may be in the range of about 2:1 to 10:1. In another embodiment, the axial length of the first portion 154 of the upper convoluted section 148 may be greater than the axial length of the second portion 156. For example, in one specific embodiment, the first portion 154 of the upper convoluted section 148 may include about 10 annular convolutions 158 and the second portion 156 of the upper convoluted section 148 may include about 5 annular convolutions 160, for a ratio of 2:1 annular convolutions in the first portion 154 to the second portion 156. The ratio of the number of annular convolutions 158 in the first portion 154 of the upper convoluted section 148 to the number of annular convolutions 160 in the second portion 156 may be in the range of about 2:1 to 10:1.

The lower convoluted section 150 of the dust boot 126 also includes a plurality of annular convolutions 162 that are equally spaced apart from one another along the central longitudinal axis L of the dust boot 126. The annular convolutions 162 in the lower convoluted section 150 have generally equal mean diameters. However, the mean diameters of the annular convolutions 162 in the lower convoluted section 150 are generally less than the mean diameters of the annular convolutions 158, 160 in the upper convoluted section 148 of the dust boot 126. This could mean (i) the mean diameter of each of the annular convolutions 162 in the lower convoluted section 150 is less than the mean diameter of each of the annular convolutions 158, 160 in the upper convoluted section 148, (ii) the average of the mean diameters of the annular convolutions 162 in the lower convoluted section 150 is less than the average of the mean diameters of the annular convolutions 158, 160 in the upper convoluted section 148, and/or (iii) at least one of the annular convolutions 162 in the lower convoluted section 150 has a mean diameter that is less than that of at least one of the annular convolutions 158, 160 in the upper convoluted section 148. Designing the upper and lower convoluted sections 148, 150 of the dust boot 126 in this way allows the dust boot 126 to be axially compressed in two phases, with the upper convoluted section 148 being at least partially compressed before the lower convoluted section 150, which may help prevent bowing or buckling of the dust boot 126 during rebound and compression of the damper.

In one specific embodiment, the mean diameters of the annular convolutions 158, 160 in the upper convoluted section 148 may be about 33–37% greater than the mean diameters of the annular convolutions 162 in the lower convoluted section 150. In another specific embodiment, the mean diameters of the annular convolutions 158, 160 in the upper
convoluted section 148 may be about 21% greater than the mean diameters of the annular convolutions 162 in the lower convoluted section 150. For example, the mean diameters of the annular convolutions 158, 160 in the upper convoluted section 148 may be about 20–40% greater than the mean diameters of the annular convolutions 162 in the lower convoluted section 150. In one specific example, the annular convolutions 162 in the lower convoluted section 150 may have outer diameters of about 72 mm, inner diameters of about 63 mm, and mean diameters of about 67 mm.

The intermediate section 152 of the dust boot 126 provides a junction between the upper and lower convoluted sections 148, 150 which helps localize the angular or conical movement of the upper convoluted section 148 of the dust boot 126, relative to the lower convoluted section 150. Also, the intermediate section 152 includes generally smooth inner and outer surfaces, which significantly reduces noise generation should the inner and/or outer surfaces of the dust boot 126 ever intermittently come into contact with other components of the suspension system, as compared to conventional dust boots that typically have annular convolutions running along their entire axial length. Further, the construction of the intermediate section 152 gives it a degree of rigidity relative to the upper and lower convoluted sections 148, 150 that helps prevent bowing of the dust boot 126 during compression and rebound of the damper, and thus helps prevent or reduce the occurrence of contact between the dust boot 126 and any peripheral components of the suspension system.

The intermediate section 152 may have a truncated conical shape that decreases in diameter as it extends from the upper convoluted section 148 to the lower convoluted section 150, and may include an upper conical section 164 and a lower conical section 166 that are connected to one another by a joint 168. The opening angle or the cone angle of the upper conical section 164 may be greater than the cone angle of the lower conical section 166, which may help streamline the profile of the dust boot 126 without sacrificing functionality. In one specific embodiment, the upper conical section 164 of the intermediate section 152 may have a cone angle of about 30° and the lower conical section 166 may have a cone angle of about 5°. In another specific embodiment, the upper conical section 164 of the intermediate section 152 may have a cone angle of about 10° and the lower conical section 166 may have a cone angle of about 0°. For example, the upper conical section 164 of the intermediate section 152 may have a cone angle in the range of 3–35° and the lower conical section 166 may have a cone angle in the range of 0–10°.
Referring now to FIGS. 4–6, the wall thickness Ta, Tb, Tc of the upper convoluted section 148, the intermediate section 152, and the lower convoluted section 150 may increase in a step-wise fashion from the upper convoluted section 148 to the lower convoluted section 150 of the dust boot 126. In one specific embodiment, the upper convoluted section 148 may have a wall thickness Ta of about 0.5 mm, the intermediate section 152 may have a wall thickness Tb of about 0.7 mm, and the lower convoluted section 150 may have a wall thickness Tc of about 0.8 mm. Increasing the wall thickness Ta, Tb, Tc of the dust boot 126 from the upper convoluted section 148 to the lower convoluted section 150 helps ensure that the upper convoluted section 148 is preferentially compressed at least partially before the lower convoluted section 150 of the dust boot 126, which may help avoid bowing or buckling of the dust boot 126 during rebound and compression of the damper.

As shown in FIG. 4, the annular convolutions 158, 160, 162 in the upper and lower convoluted sections 148, 150, respectively, are defined by alternating crests c and troughs t that are connected to one another by sidewalls s.

As shown in FIG. 5, the distance between adjacent convolutions may be referred to as the pitch P of the convolutions, and the distance between alternating crests c and troughs t may be referred to as the width W of the convolutions.

As shown in FIG. 6, the angle between opposing sidewalls s of the convolutions may be referred to as the angle between the convolutions α.

In general, the pitch P of the convolutions 158, 160 in the upper convoluted section 148 is less than the pitch P of the convolutions 162 in the lower convoluted section 150. This could mean that the pitch P of each of the convolutions 158, 160, the average pitch P of the convolutions 158, 160, or the pitch P of at least one of the convolutions 158, 160 in the upper convoluted section 148 is less than the pitch P of each of the convolutions 162, the average pitch P of the convolutions 162, or the pitch P of at least one of the convolutions 162 in the lower convoluted section 150. In one specific embodiment, the pitch P of the convolutions 162 in the lower convoluted section 150 may be about 20% greater than the pitch P of the convolutions 158, 160 in the upper convoluted section 148. For example, the pitch P of the convolutions 162 in the lower convoluted section 150 may be 15–60% greater than the pitch P of the convolutions 158, 160 in the upper convoluted section 148. In one specific example, the pitch P of the convolutions 158, 160 in the upper convoluted section 148 may be about 5 mm, and the pitch P of the convolutions 162 in the lower convoluted section 150 may be about 6 mm. In other embodiments, the pitch P of the convolutions 158,
160 in the upper convoluted section 148 may be about the same as the pitch P of the convolutions 162 in the lower convoluted section 150.

Also, the width W of the convolutions 158, 160 in the upper convoluted section 148 may be less than the width W of the convolutions 162 in the lower convoluted section 150. This could mean that the width W of each of the convolutions 158, 160, the average width W of the convolutions 158, 160, or the width W of at least one of the convolutions 158, 160 in the upper convoluted section 148 is less than the width W of each of the convolutions 162, the average width W of the convolutions 162, or the width W of at least one of the convolutions 162 in the lower convoluted section 150. In one specific embodiment, the width W of the convolutions 162 in the lower convoluted section 150 may be about 25% greater than the width W of the convolutions 158, 160 in the upper convoluted section 148. For example, the width W of the convolutions 162 in the lower convoluted section 150 may be 15–60% greater than the width W of the convolutions 158, 160 in the upper convoluted section 148. In one specific example, the width W of the convolutions 158, 160 in the upper convoluted section 148 may be about 4 mm, and the width W of the convolutions 162 in the lower convoluted section 150 may be about 5 mm.

Further, the angle between the convolutions α in the second portion 156 of the upper convoluted section 148 is generally greater than the angle between the convolutions α in the first portion 154, and the angle between the convolutions α in the lower convoluted section 150 is generally greater than the angle between the convolutions α in the second portion 156 of the upper convoluted section 148. In one specific embodiment, the angle between the convolutions α in the second portion 156 of the upper convoluted section 148 may be about 10% greater than the angle between the convolutions α in the first portion 154, and the angle between the convolutions α in the lower convoluted section 150 may be about 10% greater than the angle between the convolutions α in the second portion 156 of the upper convoluted section 148. For example, the angle between the convolutions α in the second portion 156 of the upper convoluted section 148 may be 10–50% greater than the angle between the convolutions α in the first portion 154, and the angle between the convolutions α in the lower convoluted section 150 may be 10–50% greater than the angle between the convolutions α in the second portion 156 of the upper convoluted section 148. In one specific example, the angle between the convolutions α in the first portion 154 of the upper convoluted section 148 may be about 46°, the angle between the convolutions α in the second portion 156 may be about 50°, and the angle between the convolutions α in the lower convoluted section 150 may be about 54°. The angle between the convolutions α in the upper and lower convoluted
sections 148, 150 may be controlled, for example, during the manufacturing process, to effect a desired thickness t and/or pitch P thereof.

The dust boot 126 may be made of a thermoplastic material and/or of rubber. Some examples of suitable thermoplastic materials include elastomeric thermoplastic polymers, e.g., polyurethanes, polyolefins, polyesters, copolyesters, vulcanizates, and combinations thereof. Some examples of suitable elastomeric rubber materials include natural rubbers, butadiene rubbers, styrene butadiene rubbers, ethylene propylene diene monomer rubbers, and combinations thereof. In one specific embodiment, the dust boot 126 may be made of a combination of polypropylene (PP) and ethylene-propylene-diene (EPDM).

The dust boot 126 may be manufactured, for example, using a blow molding or injection molding process. In such case, the dust boot 126 may be of unitary construction, meaning that the upper 148, intermediate 152, and lower 150 sections of the dust boot 126 are formed from one continuous piece of material.

It will be understood that the embodiments described above are given by way of example only and are not intended to limit the invention, the scope of which is defined in the appended claims. The invention is not limited to the particular embodiment(s) disclosed herein, but rather is defined solely by the claims below. Furthermore, the statements contained in the foregoing description relate to particular embodiments and are not to be construed as limitations on the scope of the invention or on the definition of terms used in the claims, except where a term or phrase is expressly defined above. Various other embodiments and various changes and modifications to the disclosed embodiment(s) will become apparent to those skilled in the art. For example, the specific combination and order of steps is just one possibility, as the present method may include a combination of steps that has fewer, greater or different steps than that shown here. All such other embodiments, changes, and modifications are intended to come within the scope of the appended claims.

As used in this specification and claims, the terms “for example,” “e.g.,” “for instance,” “such as,” and “like,” and the verbs “comprising,” “having,” “including,” and their other verb forms, when used in conjunction with a listing of one or more components or other items, are each to be construed as open-ended, meaning that that the listing is not to be considered as excluding other, additional components or items. Other terms are to be construed using their broadest reasonable meaning unless they are used in a context that requires a different interpretation.
1. A dust boot for a damper of a vehicle suspension system including:
an elongated body portion having a central longitudinal axis and including
compressible and extensible upper and lower convoluted sections and an intermediate
section extending between the upper and lower convoluted sections, wherein the upper and
lower convoluted sections include a plurality of annular convolutions and the intermediate
section includes smooth inner and outer surfaces.

2. The dust boot of paragraph 1 wherein the intermediate section is relatively rigid as
compared to the upper and lower convoluted sections.

3. The dust boot of paragraph 1 wherein the mean diameters of the annular
convolutions in the upper convoluted section are greater than the mean diameters of the
annular convolutions in the lower convoluted section.

4. The dust boot of paragraph 1 wherein the upper convoluted section includes first and
second portions, with the mean diameters of the annular convolutions in the first portion of
the upper convoluted section being greater than the mean diameters of the annular
convolutions in the second portion.

5. The dust boot of paragraph 4 wherein the wall thickness of the second portion of the
upper convoluted section is greater than the wall thickness of the first portion of the upper
convoluted section.

6. The dust boot of paragraph 5 wherein the wall thickness of the lower convoluted
section is greater than the wall thickness of the second portion of the upper convoluted
section.

7. The dust boot of paragraph 1 wherein the pitch of the convolutions in the lower
convoluted section is greater than the pitch of the convolutions in the upper convoluted
section.

8. The dust boot of paragraph 1 wherein the widths of the convolutions in the lower
convoluted section are greater than the widths of the convolutions in the upper convoluted
section.

9. The dust boot of paragraph 1 wherein the intermediate section has a truncated
conical shape that decreases in diameter as it extends from the upper convoluted section to
the lower convoluted section.
10. The dust boot of paragraph 1 wherein the intermediate section includes an upper conical section and a lower conical section connected by a joint.

11. The dust boot of paragraph 10 wherein the cone angle of the upper conical section is greater than the cone angle of the lower conical section.

12. The dust boot of paragraph 1 wherein the dust boot is made of a thermoplastic material.

13. The dust boot of paragraph 1 wherein the dust boot is of unitary construction.

14. A vehicle suspension system including:
   - an outer tube;
   - a top mount coupled to a vehicle body;
   - a piston rod coupled to the top mount and extending out of the outer tube in an axial direction;
   - a cap positioned over and around an upper end portion of the outer tube to locate the piston rod within the outer tube and to provide a fluid-tight seal around the piston rod; and
   - a dust boot including an elongated body portion having a central longitudinal axis and including compressible and extensible upper and lower convoluted sections and an intermediate section extending between the upper and lower convoluted sections, wherein the elongated body portion of the dust boot extends in a generally downward direction from the top mount over the upper end portion of the outer tube such that the piston rod and the upper end portion of the outer tube are shielded from exposure to external debris.

15. The vehicle suspension system of paragraph 14 wherein the upper and lower convoluted sections include a plurality of annular convolutions and the intermediate section includes smooth inner and outer surfaces.

16. The vehicle suspension system of paragraph 14 wherein the intermediate section is relatively rigid as compared to the upper and lower convoluted sections.

17. The vehicle suspension system of paragraph 14 wherein the dust boot is oriented in generally coaxial relationship with the piston rod.

18. The vehicle suspension system of paragraph 14 including a spring aid extending from the top mount around the piston rod, the spring aid being shielded from exposure to external debris by the elongated body portion of the dust boot.

19. A vehicle including the vehicle suspension system as recited in paragraph 14.
CLAIMS

1. A dust boot for a damper of a vehicle suspension system including:
an elongated body portion having a central longitudinal axis and including
compressible and extensible upper and lower convoluted sections and an intermediate
section extending between the upper and lower convoluted sections, wherein the upper and
lower convoluted sections include a plurality of annular convolutions and the intermediate
section includes smooth inner and outer surfaces.

2. The dust boot of claim 1 wherein the intermediate section is relatively rigid as
compared to the upper and lower convoluted sections.

3. The dust boot as in claim 1 or 2 wherein the mean diameters of the annular
convolutions in the upper convoluted section are greater than the mean diameters of the
annular convolutions in the lower convoluted section.

4. The dust boot as in any one of claims 1, 2, or 3 wherein the upper convoluted section
includes first and second portions, with the mean diameters of the annular convolutions in
the first portion of the upper convoluted section being greater than the mean diameters of
the annular convolutions in the second portion.

5. The dust boot of claim 4 wherein the wall thickness of the second portion of the
upper convoluted section is greater than the wall thickness of the first portion of the upper
convoluted section.

6. The dust boot of claim 5 wherein the wall thickness of the lower convoluted section is
greater than the wall thickness of the second portion of the upper convoluted section.

7. The dust boot as in any one of the preceding claims wherein the pitch of the
convolutions in the lower convoluted section is greater than the pitch of the convolutions in
the upper convoluted section.

8. The dust boot as in any one of the preceding claims wherein the widths of the
convolutions in the lower convoluted section are greater than the widths of the convolutions
in the upper convoluted section.

9. The dust boot as in any one of the preceding claims wherein the intermediate section
has a truncated conical shape that decreases in diameter as it extends from the upper
convoluted section to the lower convoluted section.
10. The dust boot as in any one of the preceding claims wherein the intermediate section includes an upper conical section and a lower conical section connected by a joint.

11. The dust boot of claim 10 wherein the cone angle of the upper conical section is greater than the cone angle of the lower conical section.

12. The dust boot as in any one of the preceding claims wherein the dust boot is made of a thermoplastic material.

13. The dust boot as in any one of the preceding claims wherein the dust boot is of unitary construction.

14. A vehicle suspension system including the dust boot as in any one of the preceding claims.

15. A dust boot as substantially described herein with reference to and as illustrated by the accompanying drawings.

16. A vehicle suspension system including:
   an outer tube;
   a top mount coupled to a vehicle body;
   a piston rod coupled to the top mount and extending out of an upper end portion of the outer tube in an axial direction;
   a means for locating the piston rod within the outer tube and for providing a fluid-tight seal between the piston rod and the upper end portion of the outer tube; and
   a dust boot including an elongated body portion having a central longitudinal axis and including compressible and extensible upper and lower convoluted sections and an intermediate section extending between the upper and lower convoluted sections, wherein the elongated body portion of the dust boot extends in a generally downward direction from the top mount over the upper end portion of the outer tube such that the piston rod and the upper end portion of the outer tube are shielded from exposure to external debris.

17. The vehicle suspension system of claim 16 wherein the upper and lower convoluted sections include a plurality of annular convolutions and the intermediate section includes smooth inner and outer surfaces.

18. The vehicle suspension system as in claim 16 or 17 wherein the intermediate section is relatively rigid as compared to the upper and lower convoluted sections.
19. The vehicle suspension system as in any one of claims 16, 17, or 18 wherein the dust boot is oriented in generally coaxial relationship with the piston rod.

20. The vehicle suspension system as in any one of claims 16, 17, 18, or 19 including a spring aid extending from the top mount around the piston rod, the spring aid being shielded from exposure to external debris by the elongated body portion of the dust boot.

21. A vehicle including the vehicle suspension system of any of claims 16 to 20.
**Patents Act 1977: Search Report under Section 17**

**Documents considered to be relevant:**

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<th>Category</th>
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<td>US 2012/0112392 A1 (OLDENETTEL) See especially the Abstract; and dust cover 13 in Figure 1.</td>
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<td>Y: 7, 8, 12, 16-21</td>
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<td>FR 2578934 A1 (QUEST CIE PRODUITS) See especially the WPI Abstract Accession Number 1986-280369; and Figures 1 &amp; 3.</td>
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<td>JP 2009162356 A (TIEN) See especially the WPI Abstract Accession Number 2009-L76840; and Figures 1 &amp; 2.</td>
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<td>JP 2000081071 A (SHOWA CORP.) See especially the WPI Abstract Accession Number 2000-287457; and Figure 2.</td>
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<td>US 2003/0209395 A1 (FUKAYA) See especially the Abstract; and Figure 1.</td>
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**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X:

Worldwide search of patent documents classified in the following areas of the IPC

B60G; F16F

The following online and other databases have been used in the preparation of this search report

WPI, EPDOC
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