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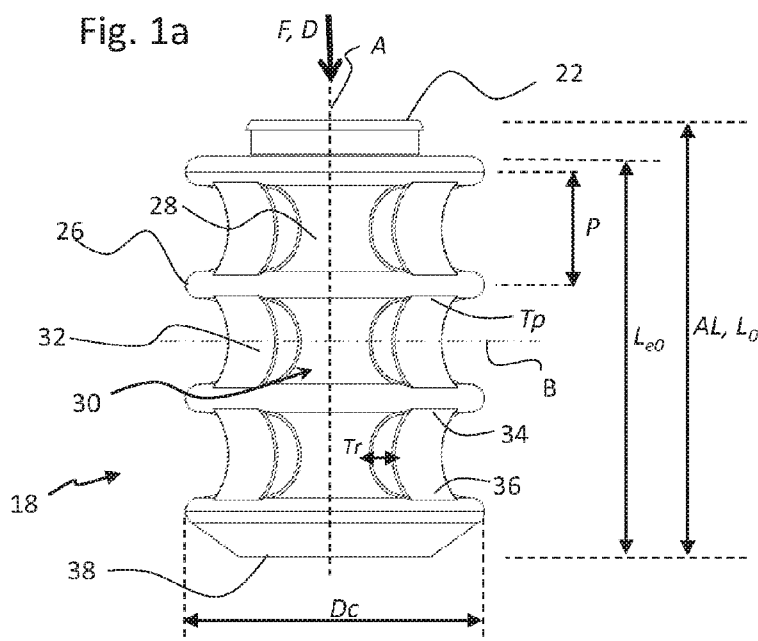
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(54) Title: JOUNCE BUMPER



(57) **Abstract:** Provided herein is a jounce bumper (18) for mounting in a vehicle suspension system (2) comprising a shock absorber (6), the jounce bumper (18) having a central bore (20) extending in an axial direction (A). The jounce bumper (18) comprises an elastically compressible bumper portion (24) comprising a plurality of convolutes stacked in an axial direction (A) of the jounce bumper (18), each convolute comprising a crest (26) and a root (28). A cross-section of the compressible portion (24) perpendicular to the axial direction (A) is non-circular, the non-circular shape being configured to provide a variable compression resistance in relation to an axial compression displacement (C_d) of the jounce bumper (18).

Title of the Invention

Jounce Bumper

Cross-reference to Related Application

- 5 This application claims priority under 35 U.S.C. § 119 to U.S. Provisional Appln. No. 62/117,563, filed on February 18, 2015, which is incorporated herein by reference in its entirety.

Field of the Invention

- 10 This invention relates to a jounce bumper for a vehicle suspension system.

Background of the Invention

- Several patents and publications are cited in this description in order to more fully describe the state of the art to which this invention pertains. The entire disclosure of
15 each of these patents and publications is incorporated by reference herein.

- Jounce bumpers are found in vehicle suspension systems and typically comprise an elastic body mounted around a shock absorber rod and fixed to a structural element of the vehicle. The jounce bumper provides an elastic cushion for the end of travel
20 of the shock absorber and coil spring under compression. The effect of the jounce bumper is to absorb impact, and it dampens noise, vibration and harshness (NVH) by preventing the articulated suspension components from fully compacting during shock impacts caused by heavy loads, potholes, curbs or objects in the road. In general, it is desired to maximize the absorption of energy in a jounce bumper in
25 order to provide a progressive compression resistance and achieve a smoother ride over a wide range of driving and load conditions.

- The energy absorption behavior of a jounce bumper can be measured by a compression test, where a plotted result of applied force and compression
30 displacement (i.e. deformation) illustrates the elastic behavior of the jounce bumper. Usually deformation is plotted on the x-axis (in mm), and applied load (force) is plotted on the y-axis. Specifically, the area under the plotted curve represents the energy absorbed by the jounce bumper.

If the thickness profile of the wall of a jounce bumper is increased, the level of force required to compress the jounce bumper is also increased. However, this results in a stiffer jounce bumper but with reduced compression displacement, whereby less
5 energy is absorbed in the jounce bumper.

An example of a jounce bumper with a non-uniform wall thickness is disclosed in US2014183804. Specifically, the wall thickness of the jounce bumper is non-uniform, such that the wall thickness in a root and a crest are different. The effect of
10 the non-uniform wall thickness is a superior absorption of energy in relation to the applied force and axial deformation of the jounce bumper.

Summary of the Invention

It is an object of the present invention to provide a jounce bumper with high energy
15 storage and a large compression displacement at high forces.

It would be advantageous to provide a jounce bumper that is compact.

It would be advantageous to provide a jounce bumper that is economical to
20 manufacture.

It would be advantageous to provide a jounce bumper that is easy to assemble in a suspension system and this assembly is strong and durable.

25 It would be advantageous to provide a jounce bumper that is robust and reliable.

Objects of this invention have been achieved by providing the jounce bumper according to claim 1.

30 Disclosed herein is a jounce bumper for mounting in a vehicle suspension system, the jounce bumper comprising a central bore extending along a compression axis, said jounce bumper comprising an elastically compressible bumper portion having a wall comprising a plurality of convolutes stacked in a direction of said compression

axis. The jounce bumper has an elastically compressible bumper portion comprising a plurality of convolutes stacked in the compression axis direction of the jounce bumper, each convolute comprising a crest and a root. A cross-section of the compressible portion taken perpendicular to the compression axis direction is non-circular, the non-circular shape being configured to provide a variable compression resistance in relation to an axial compression displacement of the jounce bumper.

In an embodiment, the jounce bumper comprises stiffening elements arranged in the root of said convolutes, the stiffening elements being configured to provide a variable compression resistance in relation to a compression displacement of the jounce bumper.

The stiffening elements may advantageously be arranged at a regular distance from each other around the outer circumference of the jounce bumper.

There may advantageously be provided at least four stiffening elements arranged around a peripheral circumference of the convolute.

In an embodiment, the stiffening elements extend axially in the form of discrete ribs.

In an embodiment, the stiffening elements are formed as an integral portion of the jounce bumper wall, such that the stiffening elements are seamlessly integrated into the wall of the jounce bumper.

The relationship L_{e0}/D_c between effective length of the jounce bumper (L_{e0}) and the crest outer diameter (D_c) may advantageously be smaller than 3.

In an embodiment, the pitch (P) between a crest to nearest adjacent crest is constant along the elastically compressible bumper portion.

In an embodiment, the pitch (P) between a crest to adjacent crest is variable along the elastically compressible bumper portion.

In an embodiment, the root is formed as an inward convolute and the crest is formed as an outward convolute in relation to the center longitudinal axis (A) of the jounce bumper, the root radius (R_r) being larger than the crest radius (R_c).

- 5 In an embodiment, the stiffening elements are provided with a maximum radial thickness in the center of the root and a decreasing radial thickness towards the crests.

- 10 In an embodiment, the stiffening element comprises a radial outer wall having a constant or variable width in the direction of the peripheral circumference of the jounce bumper, according to the variant, and sidewalls extending from the root to the radial outer wall.

- 15 In an embodiment, the stiffening elements may have a maximum width in the center of the root, the width decreasing in an axial direction towards ends of the stiffening element.

- 20 In an embodiment, the radial outer wall of the stiffening element has a radius of curvature that is larger than the radius of curvature of the root ($R_s > R_r$).

- 25 In an embodiment, a ratio (W) of the circumferential width of the ribs to the root circumference, defined by: the number of ribs, multiplied by the width of a rib at root (W_s), multiplied by 100, divided by the root diameter (D_r) multiplied by the constant π (approx. 3.14), is preferably in a range of $25 < W < 50$ with $W = (\text{number of ribs} * W_s * 100) / (\pi * D_r)$.

In an embodiment, the stiffening element built has a height above 0.5mm and preferably in a range of 2 to 6mm.

- 30 In an embodiment, the sidewalls of the stiffening elements are angled at a non-zero draft angle in relation to a radial line extending through the centre of the stiffening element.

The draft angle (α_d) may advantageously be in the range of 2° to 15° .

The invention is also directed to an automotive vehicle suspension system, comprising a jounce bumper according to embodiments of the invention installed in
5 a suspension of a vehicle so as to absorb the energy of extreme displacements of the suspension system. In particular, the jounce bumper may be installed on a suspension rod of a vehicle between a vehicle chassis and a shock absorber.

Further objects and advantageous aspects of the invention will be apparent from the
10 claims, and from the following detailed description and accompanying figures.

Brief Description of the drawings

The invention will now be described with reference to the accompanying drawings, which by way of example illustrate the present invention and in which:

15 Fig. 1a is a side view of a jounce bumper according to an embodiment of the invention;

Fig. 1b is a bottom view of the jounce bumper of figure 1a;

20 Fig. 1c is a cross-sectional view of the jounce bumper through line A of figure 1a;

Fig. 1d is a cross-sectional view through line B of the jounce bumper in figure 1a;

25 Fig. 2 is a view in perspective of a jounce bumper according to an embodiment of the invention;

Fig. 3 is a side view of a jounce bumper according to an embodiment of the invention;

30 Figure 3a is a schematic simplified view of a stiffening element to illustrate a draft angle;

Fig. 4 is a graphical representation of the relationship between the compression displacement and the applied force of a prior art jounce bumper and a jounce bumper according to an embodiment of the invention;

- 5 Figs. 5a is a schematic perspective view of a jounce bumper according to an embodiment of the present invention when mounted on a suspension strut of a vehicle; and

10 Figure 5b is a cross-sectional view of a portion of the suspension system illustrated in figure 5a.

Detailed description of embodiments of the invention

Referring to the figures, starting with figures 5a, 5b, a vehicle suspension system 2 comprises a coil spring 4, a shock absorber 6, and a jounce bumper assembly 14.

- 15 The suspension system 2 is typically mounted between an upper frame structure and a lower frame structure in a vehicle and arranged to reduce impact transfer therebetween.

Referring now to figure 1c, the jounce bumper assembly comprises a jounce bumper 18 having an elastically compressible bumper portion 24, a mounting portion 22 for fixing the jounce bumper to a structural element and a central bore 20 extending through the elastically compressible portion 24. On the elastically compressible bumper portion 24, opposite to the mounting portion 22 a contact edge 38 is arranged as a free end which in use is configured to contact (see figure 5a) an end wall 10 of a cylinder 8 of the shock absorber 6 at a certain distance of travel of the shock absorber 6.

Referring to figure 5b, the jounce bumper assembly 14 may also comprise a structural element 16 such as a cushion or saturation cup. The structural element is part of, or fixed to, the vehicle structural element or elements to which the end of the shock absorber piston rod 12 is fixed. The structural element 16 serves to receive the jounce bumper 18 therein, as it is being compressed, and to limit the radial expansion of the jounce bumper 18 during compression thereof. Although the

cushion cup 16 is advantageous in many configurations, certain jounce bumpers may function without the cushion cup and may thus be fixed on a structural element that is not in the form of a cushion cup. For instance, for thermoplastic elastomer jounce bumpers it is advantageous for there to be no contact between the outer diameter of the jounce bumper and the inner diameter of the saturation cup. Contrarily to polyurethane foam jounce bumpers, thermoplastic elastomer jounce bumpers typically do not need to limit their radial expansion.

Referring now to figures 1a to 1d, the elastically compressible bumper portion 24 of the present invention has a bellow-shaped wall 30 comprising a plurality of convolutions in the shape of crests 26 and roots 28, with flank portions 29 extending between the crests 26 and the roots 28. The convolutions form bellows where each bellow is defined as a crest 26 and a root 28. As illustrated in the figures, the crest 26 can be seen as an outward convolute and the root 28 can be seen as an inward convolute in relation to a center longitudinal axis *A* of the jounce bumper 18. As seen in figure 1b, each crest 26 forms a closed shape defining a peripheral circumference *Op* of the jounce bumper 18 when viewed in the direction of the compression axis *A*.

The size of the inward and the outward convolutes of the crests 26 and the roots 28 can be defined by their curve radius. As best seen in figure 1c, the inward convolutes formed by the roots 28 can be defined as a segment of a circle with a root radius *Rr*. In a similar way, the outward convolutes formed by the crests 26 can be defined as a segment of a circle with a crest radius *Rc*. In the context of this invention, an “inward” jounce bumper is a jounce bumper wherein the root radius *Rr* is larger than the crest radius *Rc*. Conversely, an “outward” jounce bumper is a jounce bumper wherein the root radius *Rr* is smaller than the crest radius *Rc*. The root 28 has a diameter *Dr* and the crest 26 has a diameter *Dc*.

Still referring to figures 1a to 1d, the distance in the axial compression direction *A* from crest 26 to nearest adjacent crest 26 is defined as the pitch *P*. In the illustrated example, the pitch *P* is constant, meaning that the distance from crest 26 to nearest adjacent crest 26 is always the same. However, within the scope of the present

invention it is also possible to arrange the crests 26 with a variable pitch P along the axial length AL of the jounce bumper 18.

5 The rigidity of the jounce bumper 18 is also dependent on the wall thickness of the bellow-shaped wall 30. The thicker the bellow shaped wall 30 is, the higher the rigidity of the jounce bumper 18 is.

As best seen in figures 1a and 1b, the jounce bumper 18 according to an embodiment is configured as an inward jounce bumper provided with crests 26 and
10 roots 28 and stiffening elements 32 arranged in the convolutions of the jounce bumper 18. In this embodiment, the crests 26 may have a circular profile in a cross-section orthogonal to the compression axis, as best seen in figures 1b or 1d. As best seen in figure 1d, a cross section of the jounce bumper taken perpendicularly to the compression axis, shows a non-circular shape of the root and flank portion of
15 the convolute because of the presence of the stiffening elements 32 that are in the form of axially extending ribs that locally projects from the roots 28. Preferably there are at least 3 discrete stiffening elements 32 arranged spaced apart around the axis A, preferably spaced apart equidistantly. There may advantageously be four to eight stiffening ribs 32 arranged around each convolute. In some embodiments, jounce
20 bumpers 18 comprise fewer than four or more than eight stiffening elements 32. The stiffening elements 32 are preferably formed as an integral portion of the bellow-shaped wall 30 and are preferably hollow 33. The jounce bumper 18 may advantageously be formed in a blow-molding process.

25 The stiffening elements 32 are preferably arranged as projections from the bellow-shaped wall 30, and are formed within the root 28 and flank 29. Advantageously, the stiffening elements 32 are arranged in the convolute 28 having the largest curve radius R_r . In a variant (not shown), the stiffening elements 32 may also be formed on a radially inner surface of the jounce bumper wall, for instance in a similar
30 manner to the aforementioned stiffening elements 32, namely discrete axially extending ribs projecting radially inwardly.

Now referring to figure 1a, the stiffening elements 32 have a first end 34 and a second end 36. The first end 34 and the second end 36 may advantageously be positioned in a transition point T_P between the root 28 and the crest 26. As best seen in figure 1a and 1c, the transition point T_P can be defined as a point on the bellow shaped wall 30 where the tangents of the crest 26 and the root 28 coincide. The stiffening elements 32 preferably have a maximum radial height Tr at the position of the axial center height of the root 28 and a decreasing height therefrom towards the crests.

Referring now to figure 4, the jounce bumper 18 provides essentially two stages of compression S1 and S2, whereby the rigidity under a first stage of compression is smaller than the rigidity of the jounce bumper 18 in a second stage of compression. The stiffening elements 32 are provided with a shape which enables a smoother transition of the value of the rigidity between the first and second stage of compression. This is illustrated in the graph of figure 4 comparing the Force/Displacement curve C_i of a ribbed design according to the invention and the Force/Displacement curve C_c of a conventional jounce bumper without ribs. The stiffening ribs of the inventive jounce bumper 18 advantageously results in a less abrupt and more progressive compression of the jounce bumper 18 as it transitions from the first stage S1 to the second stage S2 and approaches full compression.

Referring to the specific examples tested in figure 4, the two jounce bumpers with three convolutes have been produced with a constant thickness parison and the same settings of Ossberger machine (70% of die opening with straight profile). A constant thickness parison means no variation of thickness along its length before blowing. The measure dimensions of molded parts (as molded without any load conditioning) are presented in the table below.

	Control or reference jounce bumper without any rib	Invention jounce bumper 18 with Rib
Weight	54.1 g	53.8 g
Effective length (from upper shoulder to bending lip included)	79.3 mm	78.8 mm
Outer diameter at peak (Dc)	59.1 mm	58.9 mm

Inner diameter at trough (Dr)	36.9 mm	36.5 mm
Pitch (P)	22.7 mm	22.5 mm
Maximum wall thickness at root Tc	3.9 mm	4.1 mm
Thickness at intermediate location (Tm)	1.5 mm	1.5 mm
Number of ribs	0	4 equally distributed
Width of the rib (Ws)	na	8.2 mm
Rib draft angle (alpha d)	na	10 deg
Height of rib at root (tr)	na	3.0 mm
<p><i>Note:</i> <i>Each rib can be defined by its width at trough, its depth at trough and a draft angle to connect it to the jounce bumper convolute. The dimensions above are average dimensions measured on molded parts. Shrinkage of the material and variation of molding from shot to shot may affect these dimensions slightly.</i></p>		

Another significant benefit of the invention is the increase of energy absorption when the jounce bumper 18 is fully compressed. In the above example, the energy absorbed when a force of 9900N is applied is respectively 43.7 Joules and 51.4 Joules for the control and the inventive jounce bumper 18 (+17.6% relative increase of energy absorption). The stiffening elements 32 according to embodiments of the invention increases the rigidity of the jounce bumper 18 without reducing its ability to be fully compressed and this explains the significant increase of energy absorption.

Referring now to figure 1d, the stiffening element 32 comprises a radial outer wall 32a having a width W_s in the direction of the peripheral circumference Op (figure 1b) of the jounce bumper 18, and sidewalls 32b extending from the root 28 to the radial outer wall 32a. For an inward jounce bumper embodiment as illustrated in figure 1c, the radial outer wall 32a of the stiffening elements 32 has a radius of curvature R_s that is larger than the radius of curvature R_r of the root 28.

By way of example, in certain embodiments the stiffening ribs of a jounce bumper according to an embodiment of the invention may be defined by the following dimensions:

- W_s = width of the rib at root or maximum width of the rib. (An example may for instance have a value of $W_s = 8.2$ mm).

- W = number of ribs $\times W_s \times 100 / (3.14 \times Dr)$. A preferred range is $25\% < W < 50\%$. (An example may for instance have a value $W = (4 \times 8.2 \times 100) / (3.14 \times 36.5) = 28.6\%$).
- Tr is radial height of the rib measured at root. Generally speaking, it is the maximum distance between the root and stiffening element radii in case of an inward curved jounce bumper. (An example may for instance have a value of $Tr = 3.0\text{mm}$).
- α_d is the draft angle on each side of the stiffening rib (An example may for instance have a value of $\alpha_d = 10^\circ$).

10

Referring now to figures 3 and 3a, in an embodiment, the axial ends 34, 36 of the stiffening element 32 may be essentially tangent to the jounce bumper convolutions proximate the crest 26. In variants, the stiffening elements 32 may however occupy only a portion of the root or terminate at a non-tangential angle with the adjacent root section.

15

As best seen in figure 3, in an embodiment the average width of the stiffening element 32 may vary along the axial direction A of the jounce bumper 18. Preferably, the stiffening elements 32 have a maximum width W_s in the center of the root, which may decrease in a direction towards the first end 34 and second end 36. The sidewalls may be angled at a non-zero draft angle α_d (see figure 3a) in relation to a normal N (radial line) extending through the centre of the stiffening element. The draft angle α_d may advantageously be in the range of 3° to 30° .

20

As best seen in figures 1c and 1d, the elastically compressible bumper portion 24 of the jounce bumper 18 has a non-circular shape in a cross-section orthogonal to the compression center axis A . Specifically, in the illustrated embodiment the stiffening elements 32 produce a non-circular cross-section of the root 28, whereas at the crest 26, the cross-section of the elastically compressible bumper portion 24 may be circular.

30

According to an exemplary (non-illustrated) embodiment of the present invention, it is also possible to configure the elastically compressible bumper portion as an

“outward” jounce bumper, whereby the crest radius is larger than the root radius and the stiffening ribs are located in the crest inside the jounce bumper.

In a preferred embodiment, the jounce bumper 18 comprises a plurality of stacked
5 crests 26 and roots 28 that are essentially identical and aligned in the axial direction A as shown in the illustrated embodiment of figures 1a, 1b. However, in a variant (not illustrated), the stiffening elements 32 of one convolution may be angularly offset with the stiffening elements 32 of another convolution such that the stacked stiffening elements are not aligned in the compression direction A.

10 The jounce bumper 18 according to the present embodiment may advantageously be made from a single part by extrusion blow molding process, providing a robust and resistant jounce bumper with high performance compression characteristics that is nevertheless economical to produce and to assemble. However, it is also
15 possible to manufacture the jounce bumper by other processes, such as injection blow molding, corrugated extrusion or rotomolding.

Materials for the jounce bumper 18 according to the present invention are preferably resilient and have an excellent flex life. Suitable materials include, without limitation,
20 any thermoplastic elastomer. Preferably, a thermoplastic elastomer is used that has a relatively high melt viscosity (i.e. a melt flow rate between 0.5 and 8 g/10min, more preferably between 1 and 8 g/10 min, more preferably between 2 and 6 g/10 min, more preferably between 3 and 5 g/10 min, particularly preferably 4 g/10 min at 230°C under 5kg load according to ISO1133). Preferably the elastomer has a
25 hardness between at or about 45 and 60D, more preferably at or about 47 to 55D (at 1s according to ISO868). Examples of thermoplastic elastomers useful for the jounce bumper 18 of the present invention include those defined in ISO 18064:2003(E), such as thermoplastic polyolefinic elastomers (TPO), styrenic thermoplastic elastomers (TPS), thermoplastic polyether or polyester polyurethanes
30 (TPU), thermoplastic vulcanizates (TPV), thermoplastic polyamide block copolymers (TPA), copolyester thermoplastic elastomers (TPC) such as copolyetheresters or copolyesteresters, and mixtures thereof; also suitable materials are thermoplastic polyesters and mixtures thereof.

List of references in the drawings:

- 2 suspension system (automotive)
- 4 coil spring
- 6 shock absorber
- 5 8 cylinder (housing)
- 10 end wall
- 12 piston rod
- 14 jounce bumper assembly
- 16 structural element (cushion/saturation cup)
- 10 18 jounce bumper
- 20 central bore
- 22 mounting portion
- 24 elastically compressible bumper portion
- convolute
- 15 26 crest
- 28 root
- 29 flank
- 30 wall (bellow-shaped)
- 32 stiffening elements
- 20 34 first end
- 36 second end
- 32a radial outer wall
- 32b side walls
- 33 hollow
- 25 38 contact edge
- A* center longitudinal axis / compression axis / axial direction
- AL* axial length
- P* pitch
- Rc* crest radius
- 30 *Rr* Root radius
- Rs* stiffening element radius
- L_{eo}* effective length of the jounce bumper
- Ch* crest height
- Tc* wall thickness
- 35 *Tm* wall thickness at intermediate location
- Tr* radial height of stiffening element
- Tp* transition point
- Ws* stiffening element width
- α_d draft angle
- 40 *N* normal
- Op* peripheral circumference
- F* applied force
- D* direction of compression

While certain of the preferred embodiments of the present invention have been described and specifically exemplified above, it is not intended that the invention be limited to such embodiments. Rather, it is to be understood that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

Claims

1. A jounce bumper (18) for mounting in a vehicle suspension system
5 comprising a shock absorber, the jounce bumper having a central bore (20)
extending along a compression axis (A), said jounce bumper (18) comprising an
elastically compressible bumper portion (24) having a wall (30) comprising a
plurality of convolutes stacked in a direction of said compression axis (A), each
convolute comprising a crest (26) and a root (28), **characterized in that** the
10 convolutes comprise stiffening elements (32), and in that a cross-section of the
jounce bumper perpendicular to the compression axis is non-circular, the non-
circular shape resulting from the stiffening elements and configured to provide a
variable compression resistance in relation to an axial compression displacement of
the jounce bumper.
- 15
2. The jounce bumper according to claim 1, wherein it comprises a plurality of
stacked crests and roots that are essentially identical and aligned in the axial
direction.
- 20
3. The jounce bumper according to any preceding claim, wherein the stiffening
elements (32) are arranged in the root of said convolutes.
4. The jounce bumper according to any preceding claim, wherein the stiffening
elements are arranged at a regular distance from each other around the outer
25 circumference of the jounce bumper.
5. The jounce bumper according to any preceding claim, wherein at least four
stiffening elements are arranged around a peripheral circumference (*Op*) of the
convolute.
- 30
6. The jounce bumper according to any preceding claim, wherein the stiffening
elements extend axially in the form of discrete ribs.

7. The jounce bumper according to any preceding claim, wherein the stiffening elements are provided with a maximum radial height (Tr) in the center of the root and a decreasing radial thickness towards the crests.

5 8. The jounce bumper according to any preceding claim, wherein a ratio- (L_{e0}/D_c) of the jounce bumper effective length (L_{e0}) over the crest outer diameter (D_c) is smaller than 3.

9. The jounce bumper according to any preceding claim, wherein the stiffening
10 element comprises a radial outer wall (32a) having a width (Ws) in the direction of the peripheral circumference (Op) of the jounce bumper, and sidewalls (32b) extending from the root (28) to the radial outer wall (32a).

10. The jounce bumper according to the directly preceding claim, wherein a ratio
15 of the circumferential width of the ribs to the root circumference, defined by:
the number of ribs multiplied by the width of a rib (Ws),
divided by the root diameter (Dr) multiplied by Pi (approx. 3.14);
is in a range of 0.25 to 0.5.

20 11. The jounce bumper according to either of the two directly preceding claims, wherein the radial outer wall of the stiffening element has a radius of curvature (Rs) that is larger than the radius of curvature (Rr) of the root.

12. The jounce bumper according to any of the preceding claims, wherein the
25 stiffening elements are formed as an integral portion of the jounce bumper wall.

13. The jounce bumper according to any of the preceding claims, wherein the stiffening elements have a maximum width (Ws) in the center of the root, which decreases in a direction towards the first end (34) and second end (36).

30

14. The jounce bumper according to any one of the preceding claims, wherein sidewalls of the stiffening elements are angled at a non-zero draft angle (α_d) in relation to a radial line (N) extending through the centre of the stiffening element.

15. The jounce bumper according to the preceding claim, wherein the draft angle (α_d) is in the range of 2° to 30° .

5 16. The jounce bumper according to any of the preceding claims, wherein the pitch (P) between a crest to nearest adjacent crest is constant along the elastically compressible bumper portion (24).

10 17. The jounce bumper according to any of the preceding claims 1 to 15, wherein the pitch (P) between a crest to adjacent crest is variable along the elastically compressible bumper portion (24).

18. The jounce bumper according to any of the preceding claims, wherein root is formed as an inward convolute and the crest is formed as an outward convolute in
15 relation to the center longitudinal axis (A) of the jounce bumper, a root radius (R_r) being larger than a crest radius (R_c).

19. An automotive suspension system (2), comprising the jounce bumper according to any one of the preceding claims.

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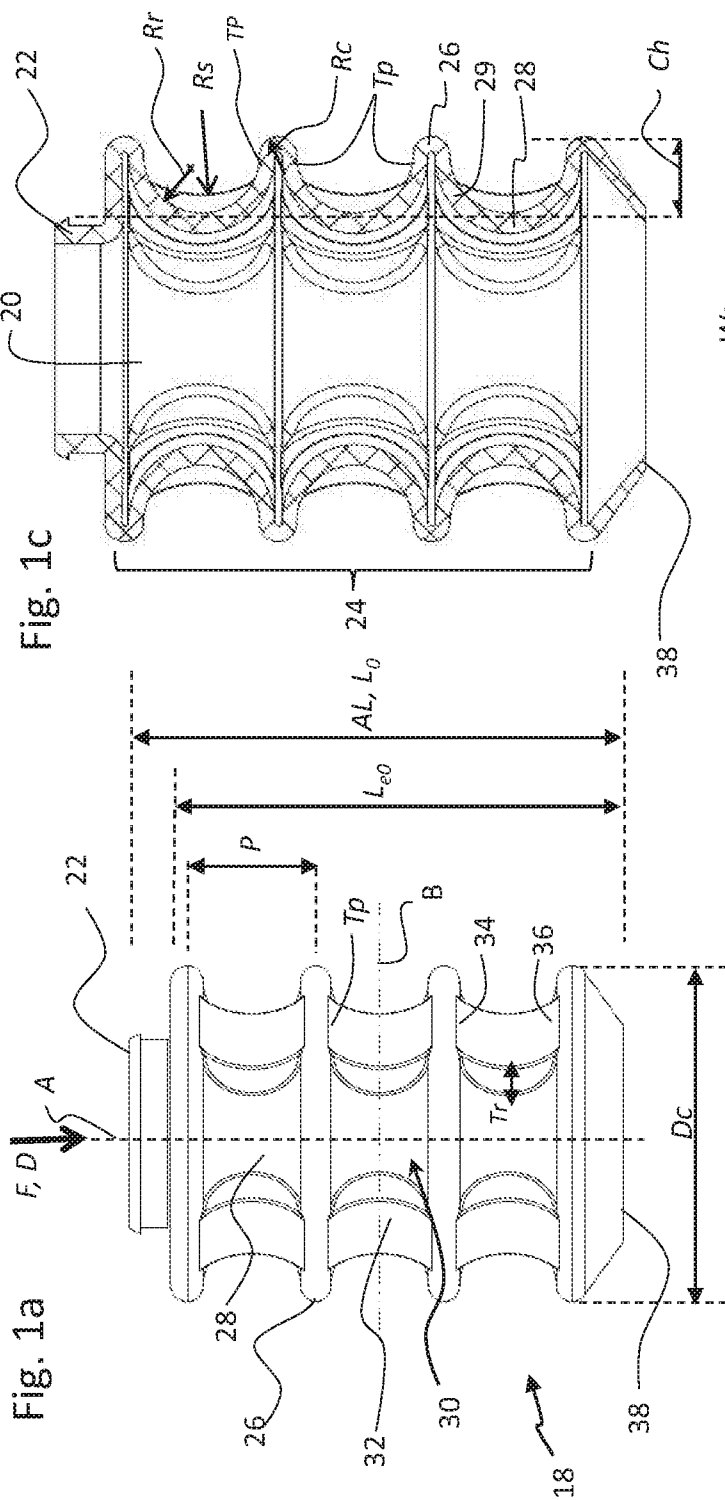


Fig. 2

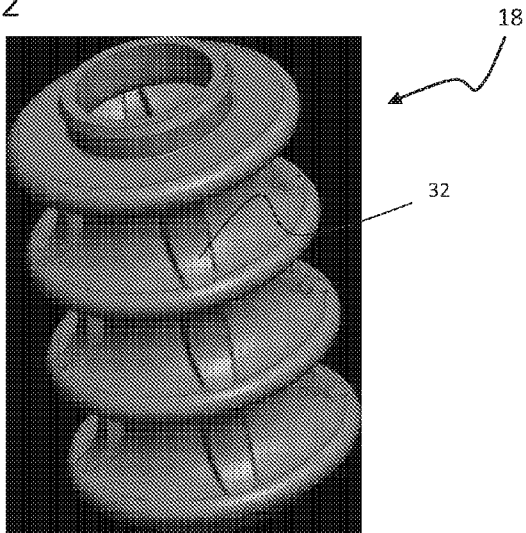


Fig. 3

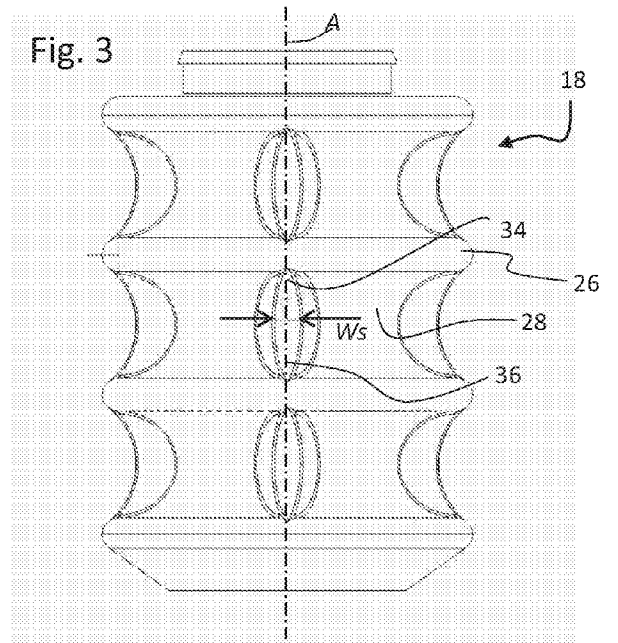
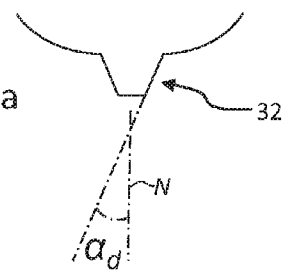


Fig. 3a



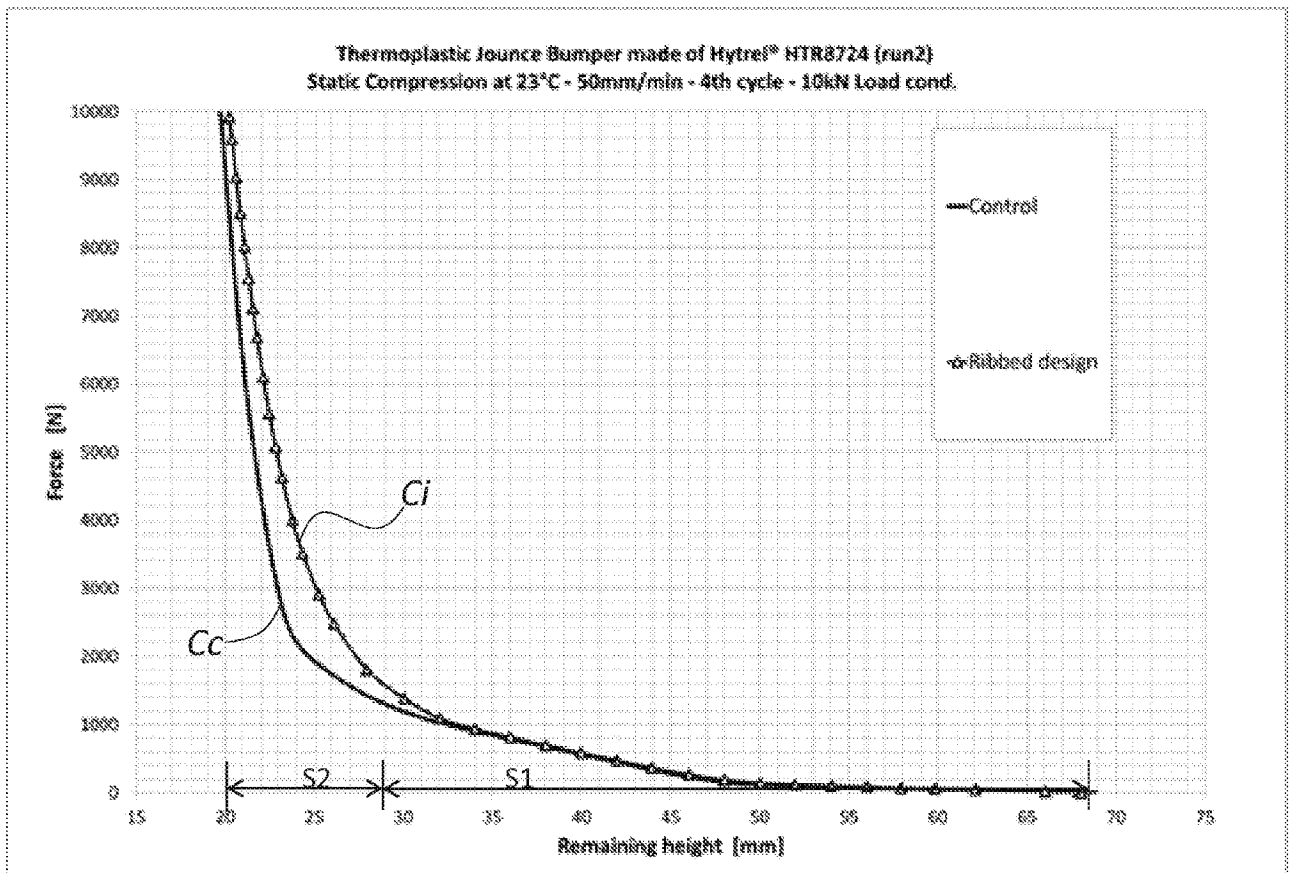
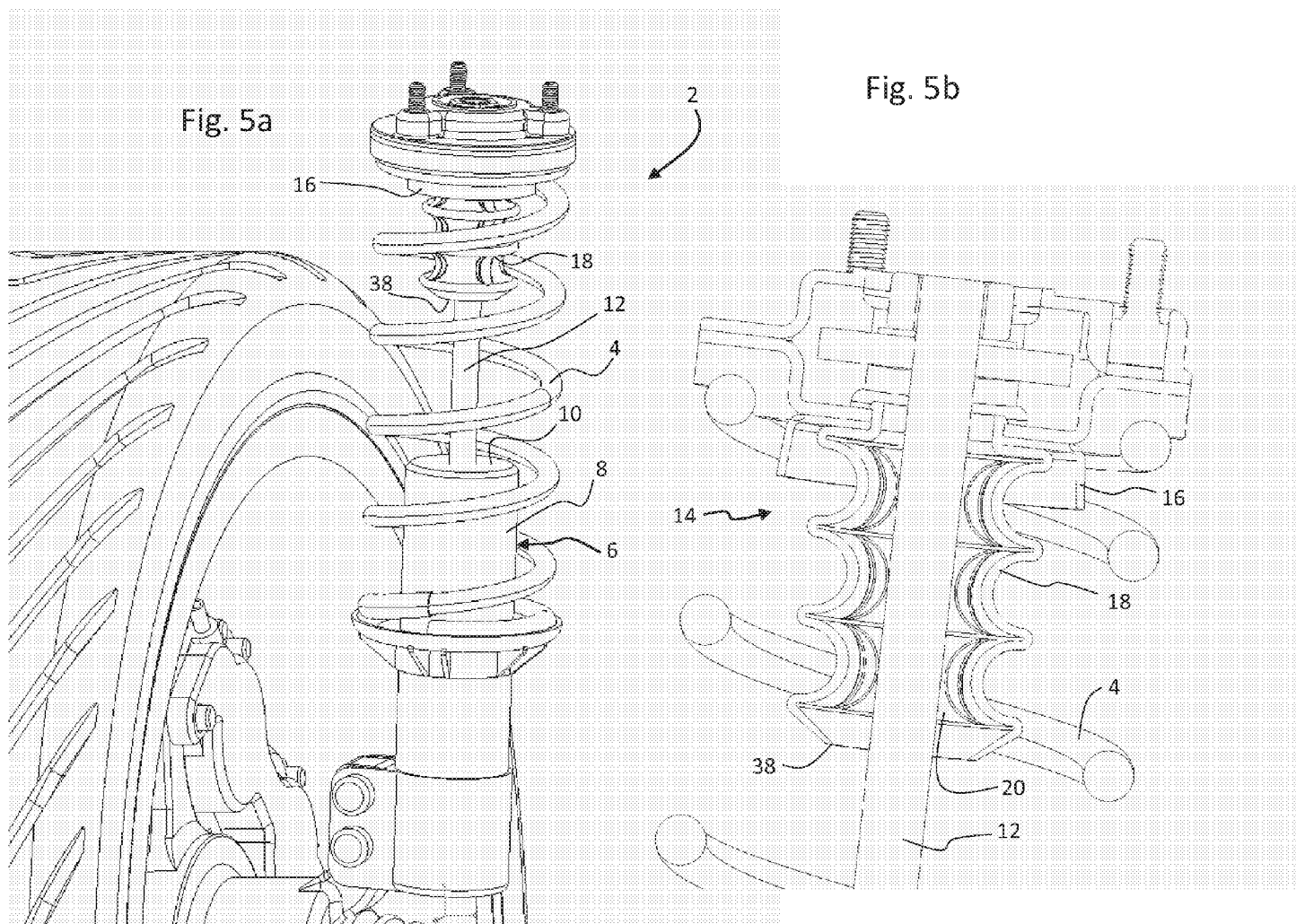


Fig. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/017530

A. CLASSIFICATION OF SUBJECT MATTER INV. F16F1/371 F16F9/58 F16F1/376 F16F1/373 ADD.		
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		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/133380 A1 (HARDEN JAMES D [US] ET AL) 9 June 2011 (2011-06-09) paragraphs [0013] - [0020], [0022] - [0024] figures 2-5	1-19
A	----- WO 2012/021612 A1 (DU PONT [US]; SZEKELY PETER LASZLO [FR]; VAN DER ZYPPE DAMIEN [FR]) 16 February 2012 (2012-02-16) pages 6-8 figures 1-2B -----	1-19
<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Further documents are listed in the continuation of Box C. </div> <div> <input checked="" type="checkbox"/> See patent family annex. </div> </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search <div style="text-align: center; font-size: 1.2em;">25 May 2016</div>		Date of mailing of the international search report <div style="text-align: center; font-size: 1.2em;">02/06/2016</div>
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer <div style="text-align: center; font-size: 1.2em;">Blazquez Lainez, R</div>

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/017530

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