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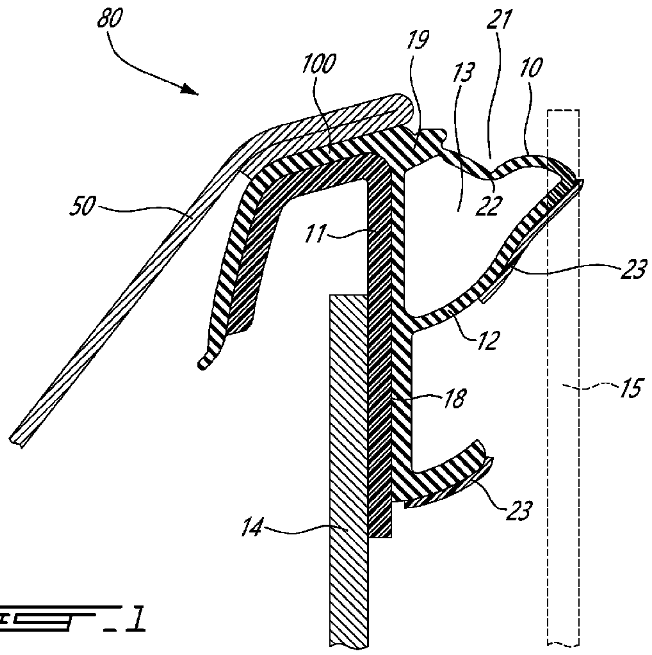

FIG. 1

(57) **Abstract:** There is provided a sealing structure for sealing a gap between two or more panels in a vehicle, the sealing structure comprises a longitudinal member which in turn comprises a first component consisting of a resilient sealing bulb of thermoplastic elastomer coupled to a second component consisting of a substrate configured to be fastened to a substrate retaining structure within the vehicle, wherein the resilient sealing bulb comprises a hollow section defining a lumen extending along the longitudinal member.

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SEALING STRUCTURES FOR AUTOMOTIVE VEHICLES

TECHNICAL FIELD

[0001] This invention relates generally to sealing structures for automotive vehicles.

BACKGROUND

[0002] Sealing structures in automotive vehicles play important functional roles. Among them, sealing structures may be used to prevent infiltration of water and particles and may be used for sound proofing. Seals for doors, tailgates and windows are particularly important. The configuration of these seals differs according to the configuration of the vehicle, but they commonly share a basic geometry that comprises a resilient lip or bulb that is positioned to fill a gap at the junction between a structural frame and a door, hood or window panel to realize the seal.

[0003] Door seals as well as seals for slidable windowpanes are subjected to complex, transient dynamic compression. Commonly implemented configurations of seals are not always optimal to achieve a constant and efficient dynamic and/or static seal. Complex vehicle designs are challenging from the point of view of achieving uniform sealing and minimal required force to close the opening while still retaining good static sealing compression. Furthermore, the prolonged and repeated application of a strain, such as deformation of the seal by the closed door, causes the elastomer to set over time. In complex seal designs some portions of the structure are compressed while others are in tension. The elastomers are prone to setting in both conditions and can be more sensitive to tension in some cases. Environmental conditions such as cold, snow and ice can also adversely impact the dynamic properties of seals.

[0004] For example, the so-called open lips seal configuration as disclosed for example in US 5,544,448 is prone to lip flipping, stick-slip effect and poor compression set. Lip flipping occurs when the lip becomes misaligned relative to its normal functioning configuration due to factors such as friction, buckling, aging (alteration of resiliency), presence of particles such as dirt or ice and sub-optimal fixation to the vehicle. Stick-slip effect consists essentially in a jerking motion of the seal (in part due to the molecular structure of the seal) during static and dynamic frictional interactions with the door or tailgate and causes squeaking noises as well as accelerated wear of the seal. Compression set, or the loss of dynamic properties of the seal, results from aging (changes in molecular structure) of the seal material as well as from sub-optimal design of seal structure configuration which can be limited by the method of manufacturing the seal.

[0005] In addition, attachment of seals to the vehicle structures is a crucial aspect of the seal performance and presents an additional challenge to seal design.

[0006] Seals are predominantly made of the thermoplastic elastomers manufactured into shape using extrusion or injection molding. Extrusion presents several disadvantages with regards to design flexibility since it is limited to design in the cross-section dimension (2-dimensional) the third dimension being strictly linear. Contoured shapes of parts manufactured by extrusion are imparted by secondary operations such as stretch bending which introduce important residual stress in the thermoplastic elastomer detrimental to its sealing functions. Furthermore, a metal core is often encapsulated within the extruded seal to provide structural support to an otherwise unstable 3-D shaped extrusion. The metal core adds significant, undesirable weight to the sealing structure. Additionally, thermoplastic elastomers extrusions are poorly adaptable with regard to their viscoelastic sealing properties.

[0007] The requirements or specification of both dynamic and static compression load deflection (CLD) properties along the path of a seal can vary. Sections of a seal may contribute differently to the CLD making it challenging to achieve a uniform seal. Current sealing structures often are compromises that sacrifice good sealing properties in some parts along the seals in order to achieve an “average” seal with acceptable properties.

[0008] Other problems with prior art seals include, without being limited to, poor soundproofing, infiltration of particles and water and the like.

[0009] The above-described problems of the prior art seals often result in poorly performing seal functions. There is therefore a need for better designed seals.

Summary

[0010] In an aspect of the invention there is provided a sealing structure for sealing a gap between two or more panels in a vehicle, the sealing structure comprising: a longitudinal member comprising a first component consisting of a resilient sealing bulb of thermoplastic vulcanizate (TPV) coupled to a second component consisting of a substrate configured to be fastened to a substrate retaining structure within the vehicle, wherein the resilient sealing bulb comprises a hollow section defining a lumen extending along the longitudinal member, the hollow section comprising a wall having a cross-sectional width surrounding the lumen and wherein the TPV of the wall exhibits a gradient of anisotropy in the direction of the width.

[0011] In another aspect there is provided a sealing structure for sealing a gap between two or more panels in a vehicle, the sealing structure comprising: a contoured longitudinal member comprising a first component consisting of a resilient sealing bulb of thermoplastic vulcanizate (TPV) coupled to a second component consisting of a substrate configured to be fastened to a substrate retaining structure within the vehicle, wherein the resilient sealing bulb comprises a hollow section defining a lumen extending along the longitudinal member and wherein the resilient sealing bulb is free of residual stress.

[0012] In yet another aspect there is provided a method for manufacturing a longitudinal sealing structure comprising a resilient sealing bulb and a substrate, the method comprising the steps of determining the local sealing compression energy required along a gap between two panels to generate sealing requirements; determining the configuration and properties of the sealing structure based on the sealing requirements, wherein the determining of the configuration and properties of the sealing structure comprises determining the configuration and properties of the resilient sealing bulb and the substrate, to generate a sealing structure design; manufacturing the sealing structure according to the sealing structure design wherein the manufacturing comprises overmolding the resilient sealing bulb on the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will be better understood by way of the following detailed description of embodiments of the invention with reference to the appended drawings, in which:

[0014] Figure 1 is a cross-sectional view of a sealing structure as part of an outerbelt in accordance with an embodiment of the invention.

[0015] Figure 2 is a longitudinal cross-sectional view of the bulb in accordance with another embodiment of the invention.

[0016] Figure 3 is a cross-sectional view of a sealing structure as part of an outer belt in accordance with yet another embodiment of the invention.

[0017] Figure 4 is a cross-sectional view of a sealing structure as part of a lift gate in accordance with an embodiment of the invention.

[0018] Figure 5 are cross-sectional and perspective views of a sealing structure showing sealing features in accordance with another embodiment of the invention.

[0019] Figure 6 is a cross-sectional view of a sealing structure as part of a B-pillar according to an embodiment of the invention.

[0020] Figure 7 is a perspective view of a sealing structure according to another embodiment of the invention.

[0021] It will be noted that throughout the appended drawings, like features are identified by like reference numerals. The drawings are not to scale.

DETAILED DESCRIPTION

[0022] In the present description by injection molding it is meant the production of parts by injecting material, most commonly but not exclusively thermoplastic and thermosetting polymers, into a mold.

[0023] By overmolding it meant the process of forming a structure by injecting a melted thermoplastic material such as a thermoplastic elastomer in a mold cavity in which at least part of another structure (commonly referred to as a substrate) is exposed such as to enable the molding of the injected melted material on the substrate. Overmolding is sometimes also referred to as insert molding.

[0024] By bi-components it is meant a structure made of two different materials at least one of which is overmolded on the other.

[0025] By residual stress it is meant the permanent deformation of an extruded part to conform it to a contoured shape and which creates stress in the elastomer in the contoured section that modifies the elastomeric properties.

[0026] By sealing compression energy, it is meant the energy stored or absorbed in the sealing structure when the panels defining a gap are brought in sealing configuration.

[0027] By dynamic compression energy it is meant the energy stored in the seal structure when the seal is dynamically compressed by a panel such as a door or a sliding window.

[0028] By anisotropy it is meant a non-random (non-isotropic) spatial distribution of molecules within a thermoplastic structure with the result that the thermoplastic structure has at least one physical property that has a different value when measured in different directions.

[0029] Disclosed herein is a sealing structure for sealing gaps in automotive vehicles dynamic openings between a panel such as doors, tailgates and windows and adjacent structural components. The sealing structure comprises a longitudinal member comprising a first component consisting of a resilient sealing member and a second component consisting of a substrate. A cross-section of an exemplary sealing structure is shown in Figure 1 as part of an outerbelt. The resilient sealing member together with the substrate provides the compression sealing forces and is coupled to the substrate **11** which is sufficiently rigid to support and orient the resilient sealing member and to be fastened to a substrate retaining structure **14**. Preferably the resilient sealing member is a bulb **10** configured to make contact with the panel, for example window **15** in Figure 1, to realize the sealing.

[0030] Referring to Figure 1, the bulb **10** comprises a wall **12** of a predetermined shape and width (or thickness) and defining a hollow space forming a lumen **13** in the longitudinal direction of the sealing structure.

[0031] The bulb may be made of any elastomer or thermoplastic elastomers suitable for injection molding which may comprise other chemical components to fine tune their viscoelastic and/or textural properties. In one embodiment, the bulb is preferably made of a thermoplastic vulcanizate (TPV) which comprises a mixture of polyolefin plastic such as polypropylene (PP) and a cross-linked olefin copolymer elastomer such as an ethylene-propylene-diene rubber (EPDM). In one embodiment, the wall **12** of the bulb is characterized by at least one zone or layer **16** of orientated polymer fibers forming a gradient of alignment along the width or thickness of the wall as schematically represented in Figure 2. This gradient is referred to as anisotropy in the alignment of the fibers. At least one zone or layer of alignment is adjacent the outer surface **17** of the bulb.

[0032] In one aspect the bulb has a tensile strength ratio $0^o/90^o$ of between about 2.0 and 1.0 and more preferably between about 1.8 and 1.2. The tensile strength ratio can be obtained by stretching a section of the wall in the direction of the alignment of the fibers, which is in the longitudinal direction of the sealing structure (the 0^o angle stretch) to obtain the 0^o tensile strength measurement (in N/mm^2 or MPa) and then in the direction perpendicular (the 90^o angle stretch) to obtain the 90^o tensile strength measurement.

[0033] In a preferred embodiment, the ratio of surface area of lumen **13** to wall **12** thickness is between 1:1 and 80:1, more preferably between 2:1 and 60:1 and more preferably between 4:1 and 40:1.

[0034] In one preferred embodiment, the bulb **10** is overmolded on the substrate **11** by injection molding. In one aspect, the sealing structure is a bi-component structure with the bulb made of one component and the substrate made of a second component. Preferably, the bulb is made of TPV and the substrate is made predominantly of PP. In other embodiments, the substrate 11 may be made of more than one component provided the components which are overmolded by the bulb are compatible for adhesion between the bulb and the component.

[0035] The resilient sealing bulb **10** is attached to a carrier or substrate **11** at an attachment region (or interface) **18** to create a bi-component interface and the resilient longitudinal bulb is configured to maintain a desired range of dynamic spatial geometry to realize a predetermined sealing resiliency. By dynamic spatial geometry it is meant that the bulb **10** undergoes conformational changes during the dynamic displacement of the components or panels of a dynamic opening relative to one another. For example, this effect is observed when the resilient sealing bulb is compressed into sealing position or released to a non-sealing position by the reciprocal action of the component parts or panels of the dynamic opening. The substrate **11** is configured to optimize and maintain a high degree of functionality of the resilient sealing bulb upon repeated cycles of sealing compression and return to optimal pre-sealing compression position.

[0036] The longitudinal sealing structure may comprise a bulb conformation support **19**. In one aspect the bulb conformation support comprises at least two adjacent (that may or may not be contiguous) components, more rigid than the bulb, at an angle and configured to generate resulting force vectors to counteract or oppose the sealing compression force applied on the bulb in at least a direction substantially perpendicular and substantially directly opposite the sealing compression force.

[0037] In one aspect the bulb conformation support is “L” shaped or inverted “L” shaped as shown in Figure 3 in which the bulb conformation support **19** is part of the substrate **11**. In another aspect one of the components of the bulb conformation support is made of the same material as the bulb but is thicker than the part of the wall of the bulb making sealing contact with the panel.

[0038] In yet another aspect one of the components of the bulb conformation support is a flange of the same material as the bulb and integral to the bulb and configured to contact a structure when installed as part of the sealing structure in the vehicle to achieve a compression counteracting force.

[0039] The sealing structure also comprises functionalities to anchor the sealing structure to a vehicle support structure such as a frame, pillar, brackets and the like. Thus, in an embodiment there is provided a sealing structure comprising a longitudinal member comprising a resilient sealing member such as a bulb **10** overmolded on a substrate **11** and wherein the substrate **11** comprises fastening elements **20** to anchor the sealing structure on a substrate retaining structure in the vehicle. In yet a further aspect the substrate is injection molded and the localized fastening elements are an integral part of the injection molded design of the substrate which is manufactured in a one-shot injection.

[0040] In another aspect, longitudinal member of the sealing structure is contoured. By contoured it is meant that the longitudinal member, comprising the resilient bulb and the substrate, comprises one or more 3-dimensionally curved section(s) designed to closely follow curve-shaped gaps in a vehicle structure. The resilient bulb is overmolded on a contoured substrate and is itself shaped in a predetermined contoured configuration. The contoured bulb is substantially free of residual stress. That is to say, the contoured conformation of the bulb is realized within the mold and no secondary operations are needed to shape the sealing structure into its final conformation.

[0041] In an embodiment, the wall of the contoured bulb is characterized by an anisotropy in the alignment of the fibers. In one aspect the wall of the contoured bulb has a tensile strength ratio

(0°/90°) as expressed by the tensile strength in the direction of the alignment (0° angle) over the tensile strength in the direction perpendicular to the alignment (90° angle) of between about 2.0 and 1.0 and more preferably between about 1.8 and 1.2.

[0042] In a preferred embodiment, the dimensionless ratio of surface area of lumen to wall thickness is between 1:1 and 80:1, more preferably between 2:1 and 60:1, even more preferably between 2:1 and 40:1 and yet even more preferably between 4:1 and 20:1.

[0043] The overmolded resilient bulb enables the design of sealing structure configurations that optimize the positioning of the resilient sealing bulb in sealing compression and non-compression states as well as the directional compression sealing forces to optimize the compression load deflection (CLD). For example, minimizing localized stress from the sealing compression by creating a repartition (or distribution) of the sealing compression energy on more than one bending part in the resilient bulb.

[0044] The residual stress-free overmolded bulb is particularly advantageous in contoured seal configurations in which bending in prior art seal arrangements, such as in extruded bulb, creates a localized increase or decrease in compression load deflection (CLD) particularly in the dynamic CLD. Thus, the sealing structure with an overmolded bulb of the present invention considerably improves CLD in contoured seal configurations such as a door seal.

[0045] In some instances, the sealing structure of the present invention can reduce the CLD energy (area under the load-deformation curve) by up to 25% when compared to sealing structures of the prior art while still retaining a sufficient CLD to absorb to prevent a breakdown of the energy absorption upon closure of a door that would result in “over-slamming”.

[0046] In one aspect, the degree of anisotropy in the direction of the width of the wall of the bulb provides a directional modulation of the elastomeric properties of the bulb.

[0047] In an aspect, there is provided a contoured sealing structure with a substantially uniform CLD along the curvature of the resilient bulb. The contoured resilient bulb exhibits substantially uniform tensile strength both in the longitudinal direction and in the direction perpendicular to the longitudinal direction along the longitudinal sealing structure.

[0048] Often the gap to be sealed exhibits variable dimensions along its length and/or variable impact loading force (for example a door inertia may vary at different position of on the door) either by design or because of the tolerances. In another aspect, the sealing structure of the invention may comprise resilient sealing features **26**. By resilient sealing features it is meant structures integral to injection molded sealing lips (open lips) or resilient bulb and enabling a localized adjustment of compression sealing energy. The profile, location and dimensions of the resilient sealing features are predetermined and integrated in the design of the mold and are simultaneously overmolded with the resilient sealing member of the sealing structure to generate an integral resilient sealing member comprising the resilient sealing features that are thus made of the same material as the rest of the resilient sealing member.

[0049] The resilient sealing features can be strategically localized at positions along the sealing structure to adjust the sealing compression properties of the resilient bulb where the dimensions of the gap the dynamic compression parameters vary.

[0050] In an aspect of the invention, there is provided a method for manufacturing a sealing structure comprising a resilient sealing member and a substrate, the method comprising the steps of determining the local sealing compression dynamic properties required along a gap between two panels to generate a set of sealing requirements, determining the configuration and properties of the sealing structure based on the sealing requirements, wherein the determining of the configuration and properties of the sealing structure comprises determining the configuration and properties of the resilient sealing member and the substrate, to generate a sealing structure design, manufacturing the sealing structure according to sealing structure design wherein the manufacturing comprises overmolding the resilient sealing member on the substrate.

[0051] The determining of the configuration and properties of the sealing structure may further comprise the step of determining the configuration and properties of resilient sealing features.

[0052] Examples

[0053] Referring back to Figure 1, in one embodiment of the invention the resilient sealing bulb **10** is part of an outer belt generally shown at **80**. The bulb is coupled to the substrate **11**. The bulb comprises an upper concave portion **21** (Figure 1) that bends inwardly upon being compressed by the window **15**. The bulb provides flexible configuration design to dynamically optimize the CLD. That is to say, the design may be configured to allow the sealing compression force on the window by the resilient sealing member to be constant while the window is being closed. For example, the concave upper portion **21** may comprise a groove **22** to adjust the dynamic flexibility of the upper concave portion and can also help optimizing the compression forces throughout the resilient sealing member. This particular embodiment exemplifies how the resilient bulb of the invention can optimize the sealing energy stored in the resilient structure by distributing the sealing compression forces at more than one hinge location in the wall of the bulb as opposed to the prior art lip configuration in which all the compression force is concentrated in the lower elbow of the lip. The prior art open lip seal design requires thick lip hinge to provide sufficient rigidity to the lip to generate an adequate seal. Thus, the resilient bulb of the invention can optimize sealing properties such as the CLD. It will be appreciated that the optimization of the CLD may be achieved with different bulb configurations. For example, the upper portion of the bulb **10** may be convex.

[0054] The sealing structure may also comprise other components, other than the bulb, to provide additional sealing functionalities. For example, the outerbelt sealing structure may comprise an upper resilient member **100**, integrally coupled to (continuous with) the bulb or not and coupled to the substrate and contacting an exterior sheet metal of the vehicle to complete the seal of the gap between the sheet metal and the window. In a preferred embodiment, the upper resilient member **100** is overmolded on the substrate in the same injection as the bulb.

[0055] In an alternative embodiment, the bulb may contact the sheet metal directly to form the seal.

[0056] In the embodiment of the sealing structure shown in Figure 1, the concave upper portion may serve to reduce accumulation of water compared to prior art lip seals (between the lip and carrier) while serving as a water channel to drain any water accumulation.

[0057] In one aspect, the bulb for outer belt of the present invention is covered on at least a part of its surface that contacts the window with a friction reducing material **23**. In one embodiment this friction reducing material is flock (flock fibers).

[0058] In an embodiment, the outer belt is a hidden outer belt. By hidden outer belt it is meant that the sealing structure including the longitudinal member (bulb and substrate) is below the horizontal line defined by the top of the sheet metal **50**.

[0059] Another embodiment of the invention is shown in Figure 4 wherein the resilient sealing bulb **10** is part of a sealing structure for a lift gate. The sealing lip design of the prior art can create problems such as lip flipping which in turn causes the sealing structure to lose its functional properties. In one embodiment of the invention the resilient sealing member comprises a lower section **40** that connects a tip region **41** and upper section **42** of the bulb **10** to the attachment region **18**. In an aspect, the upper section **42** of the bulb is substantially flat in its non-compressed state, maintained in this conformation in part by the configuration of the attachment between the resilient sealing member and the substrate **11** in attachment region **18** to prevent lip flipping. The bulb is preferably overmolded on susbtrate **11**.

[0060] In another embodiment the upper section **42** may be concave to enable a flexing of the front part of the resilient sealing member upon closing (sealing compression) of a dynamic opening such as a liftgate.

[0061] In still another embodiment, the cross section of the bulb **10** is substantially oval providing two main directions or orientations, substantially perpendicular, of sealing compression forces.

[0062] In yet a further embodiment, the bulb may comprise an internal protrusion in the lower section **40** that abuts the internal part of the upper section **42** to support the sealing compression when the lift gate is closed.

[0063] The bulb **10** may comprise resilient sealing features **34**. An embodiment of a sealing structure comprising several types of resilient sealing structures is shown in Figure 5. The resilient sealing member may comprise one or several types of resilient sealing structures. Also, the resilient sealing structures may span the entire length of the sealing features or, alternatively, only a portion of the length. The contribution of a resilient sealing features to the elastomeric (sealing energy) properties of the sealing structure depends on its shape and dimension, which are predetermined based on the analysis of the sealing requirements of the gap. Examples of resilient sealing features are shown in Figure 5. In one embodiment, by way of functional explanation of a particular resilient sealing feature, ribs **35**, in sealing compression, buckle and are straightened in extension (liftgate open) but to a maximum length thereby preventing the tip of a lip or bulb from “lip-flipping”.

[0064] In some of these embodiments the bulb may comprise additional resilient sealing features to optimize the dynamic/sealing of the sealing structure such as a projecting lip or a hinge structure such as a trough to enable additional degrees of freedom during compression/extension. Two or more resilient sealing features may be combined to optimize the function of the sealing structure.

[0065] In an embodiment of the invention, the sealing structure is part of a door seal as for a door or doors having the B-pillar as a frame. A cross-section view of a B-pillar seal is shown in Figure 6. In the particular embodiment shown, the sealing structure comprises the bulb 10 which is positioned to contact front door **60** and a bulb conformation support **19** positioned to contact rear door **61**. In this case the bulb conformation support dynamically contributes to the sealing of both doors of the B-pillar. When both doors are closed the bulb conformation support provides a counter acting force to the compression of the bulb by the front door **60**.

[0066] Figure 7 shows a perspective view of a contoured sealing structure exemplified by a B-pillar sealing structure. It will be appreciated that sealing structures for other gaps such as an outer belt for example may also be contoured. Contoured sealing structures of the prior art contain residual stress in sealing lips or bulbs along the curved areas resulting in uneven sealing viscoelastic properties of the seal structure and therefore uneven sealing pressure on the door or window that result in sub-optimal sealing.

[0067] The overmolded bulb of the present invention is substantially free of residual stress in curved areas therefore providing a more uniform resiliency and sealing pressure along the length of the sealing structure. Thus, because of the advantageous characteristics described above, the resilient sealing bulb of the invention can also better adapt to the shape of the gap to be sealed such as profiled windows which may be curved or parabolic or the contour of a door.

[0068] In an aspect of the invention, the resilient sealing bulb is overmolded on a substrate. The overmolding is achieved by forming the resilient sealing bulb directly on the substrate by injection molding. In one aspect of the invention, the residual stress-free bulb enables greater flexibility in the design of sealing structures with variable sealing compression (sealing energy) requirements along the length of the sealing structure especially with sealing structures exhibiting curved or profiled or contoured shapes. Thus, the configuration of the substrate may vary along the length of the sealing structure. For example, the attachment interface **18** may be configured to optimize the properties of the sealing dynamics along the structure.

[0069] The sealing structure of the invention enables the spreading of the load from compression load deflection (CLD), tear or tensile strength and sealing pressure on a greater portion of the substrate since the sealing structure comprises more than one tension bearing point as opposed to the open lip seal design which comprises a single tension bearing point.

[0070] Advantageously, in one aspect of the invention, the resilient sealing bulb **10** has a substantially uniform diameter/hollow interior shape and/or wall thickness along the length of the sealing structure even in sealing structures presenting important radii of curvature. In another aspect the wall thickness of the resilient sealing bulb in the attachment interface **18** may differ from the wall thickness outside of the attachment region (as shown in figures 12 and 13) providing configuration options (relative thickness of bulb, shape of carrier, etc…) to optimize the dynamic sealing properties of the sealing structure.

[0071] It will be appreciated that the sealing structure of the invention is suitable for any substantially longitudinal gap associated within certain structures in a vehicle such as without being limited to, outer-belts, A, B and C pillars, cowls, doors, sky roofs and the like. The sealing structure of the invention is particularly well suited for dynamic gap involving panels that open and close.

[0072] It is to be understood that the singular forms “a”, “an” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a device” includes reference to one or more of such devices, i.e. that there is at least one device. The terms “comprising”, “having”, “including”, “entailing” and “containing”, or verb tense variants thereof, are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of examples or exemplary language (e.g. “such as”) is intended merely to better illustrate or describe embodiments of the invention and is not intended to limit the scope of the invention unless otherwise claimed.

[0073] While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods might be embodied in many other specific forms without departing from the scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

[0074] This invention has been described in terms of specific embodiments, implementations and configurations which are intended to be exemplary only. Persons of ordinary skill in the art will appreciate, having read this disclosure, that many obvious variations, modifications and refinements may be made without departing from the inventive concept(s) presented herein. The scope of the exclusive right sought by the Applicant(s) is therefore intended to be limited solely by the appended claims.

WHAT IS CLAIMED IS:

1. A sealing structure for sealing a gap between two or more panels in a vehicle, the sealing structure comprising:
a longitudinal member comprising a first component having of a resilient sealing bulb of thermoplastic elastomer coupled to a second component having of a substrate configured to be fastened to a substrate retaining structure within the vehicle, wherein the resilient sealing bulb comprises a hollow section defining a lumen extending along the longitudinal member, the hollow section comprising a wall having a cross-sectional width surrounding the lumen and wherein the TPV of the wall exhibits a gradient of anisotropy in the direction of the width.

2. The sealing structure of claim 1 wherein the bulb has a tensile strength ratio $0^{o}/90^{o}$ of between about 2.0 and 1.0 and more preferably between about 1.8 and 1.2.

3. The sealing structure of claim 1 or 2 wherein the ratio of surface area of lumen to wall thickness is between 1:1 and 80:1, more preferably between 2:1 and 60:1, more preferably between 2:1 and 40:1 and more preferably between 4:1 and 20:1.

4. The sealing structure of any one of claim 1-3 wherein the bulb is overmolded on the substrate.

5. The sealing structure of any one of claim 1-4 wherein the thermoplastic elastomer is a thermoplastic vulcanizate (TPV).

6. A sealing structure for sealing a gap between two or more panels in a vehicle, the sealing structure comprising:
a contoured longitudinal member comprising a first component consisting of a resilient sealing bulb of thermoplastic elastomer or elastomer, coupled to a second component consisting of a substrate configured to be fastened to a substrate retaining structure within

the vehicle, wherein the resilient sealing bulb comprises a hollow section defining a lumen extending along the longitudinal member and wherein the resilient sealing bulb is free of residual stress.

7. The sealing structure of claim 6 Wherein the ratio of surface area of lumen to wall thickness is between 1:1 and 80:1, more preferably between 2:1 and 60:1, more preferably between 2:1 and 40:1 and more preferably between 4:1 and 20:1.

8. The sealing structure of claim 6 or 7 wherein the sealing compression energy is substantially constant along the contoured resilient sealing bulb.

9. The sealing structure of claim 8 wherein the hollow section of the resilient sealing bulb defines a lumen wall and wherein the wall has a uniform thickness along the longitudinal direction.

10. The sealing structure of any one of claim 1-9 further comprising resilient sealing features integrated in the resilient bulb.

11. The sealing structure of claim 10 wherein the resilient sealing features are localized on the longitudinal member to optimize local sealing requirements.

12. The sealing structure of claims 10 or 11 wherein the resilient sealing features extend beyond the bulb and comprise at least a portion that is coupled to the substrate.

13. The sealing structure of any one of claim 10-12 wherein the resilient sealing features are selected from ribs, flanges, textured surface and combinations thereof.

14. The sealing structure of any one of claims 1-13 wherein the structure is part of an outerbelt.

15. The sealing structure of claim 14 wherein the outer belt is a hidden outer belt.

16. The sealing structure of claim 14 or 15 wherein the substrate comprises an upper resilient member contacting an outer sheet metal and collaborating with the resilient sealing bulb to seal the gap.

17. The sealing structure of claim 16 wherein the bulb comprises a concave groove between the window and sheet metal.

18. The sealing structure of any one of claims 1-13 wherein the structure is part of B-pillar sealing structure.

19. The sealing structure of claim 17 wherein the resilient sealing bulb comprises a bulb conformation support contacting a back door and dynamically contributing to sealing of a front door.

20. The sealing structure of any one of claims 1-13 wherein the gap is between a tail gate door and body of the vehicle.

21. A method for manufacturing a sealing structure of any one of claim 1-20, the method comprising the steps of

determining the local sealing compression energy required along a gap between two panels to generate sealing requirements;

determining the configuration and properties of the sealing structure based on the sealing requirements, comprising determining the configuration and properties of the resilient sealing bulb and the substrate, to generate a sealing structure design;

manufacturing the sealing structure according to the sealing structure design wherein the manufacturing comprises overmolding the resilient sealing bulb on the substrate.

22. The method of claim 21 wherein the step of determining the configuration and properties of the sealing structure further comprises determining the configuration and properties of resilient sealing features integrated with the resilient sealing bulb.

23. The method of claim 21 or 22 wherein the configuration and properties of the sealing structure comprise a uniform CLD along the longitudinal sealing structure.

24. The method of claim 23 wherein the uniform CLD is static CLD or dynamic CLD or a combination of both static and dynamic CLD.

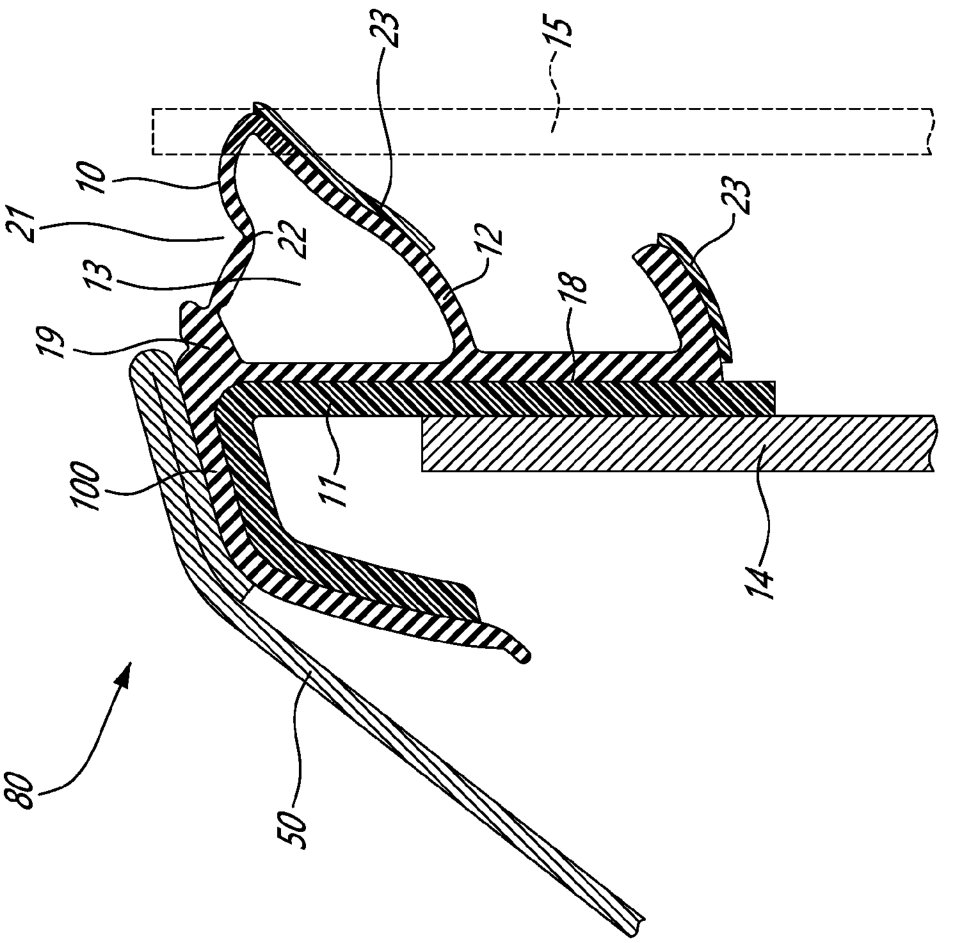

FIG-1

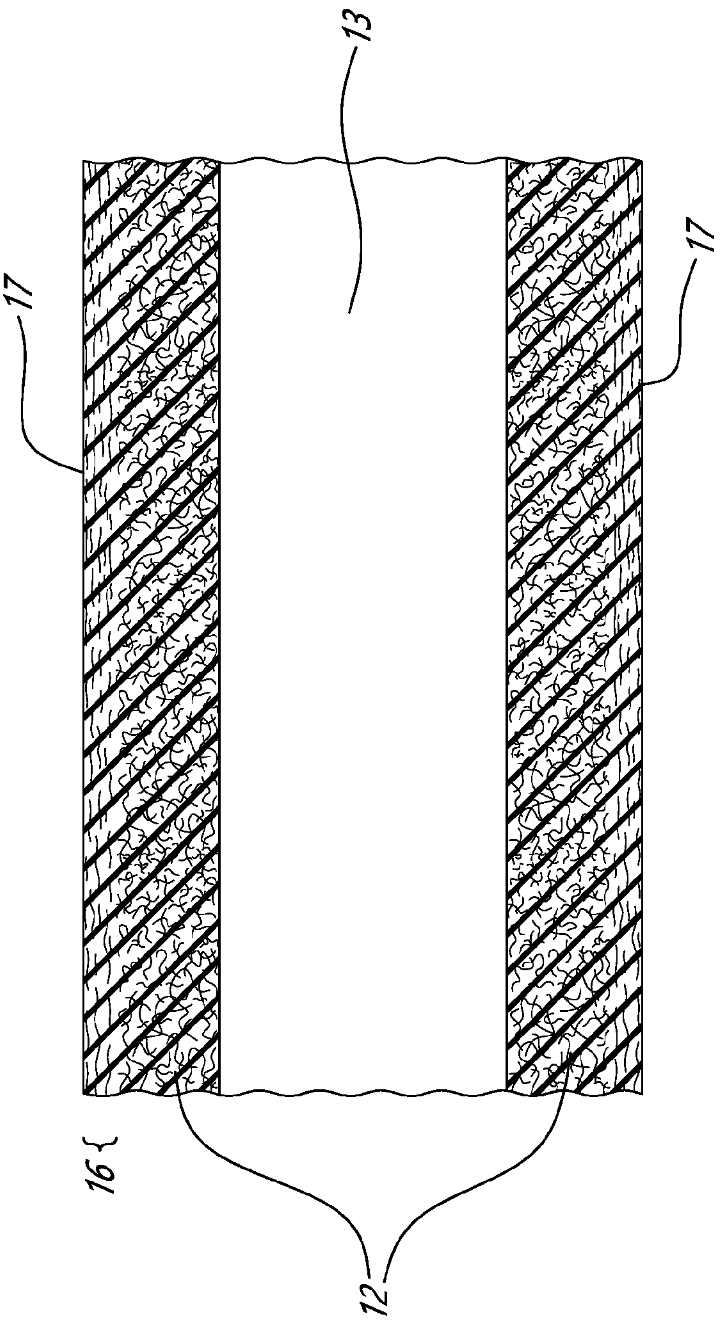

FIG-2

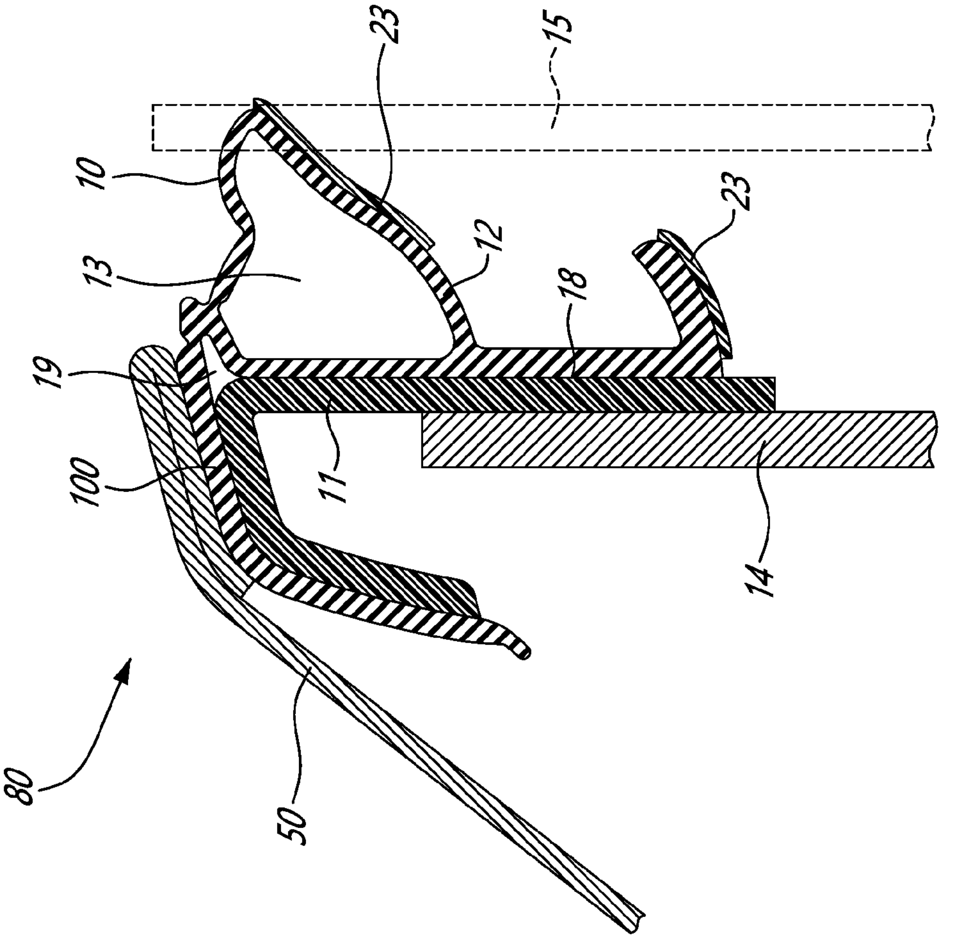

FIG. 3

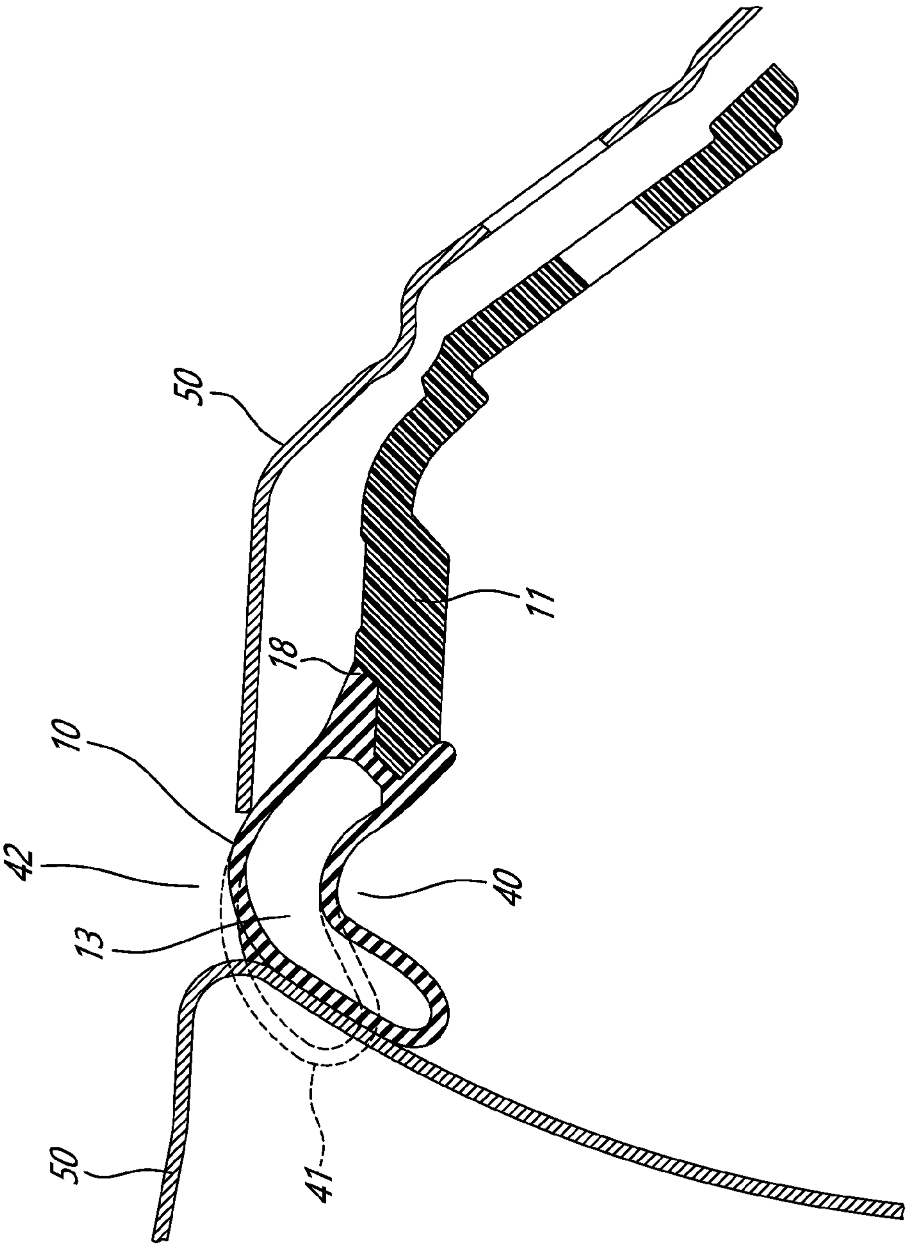

Fig. 4

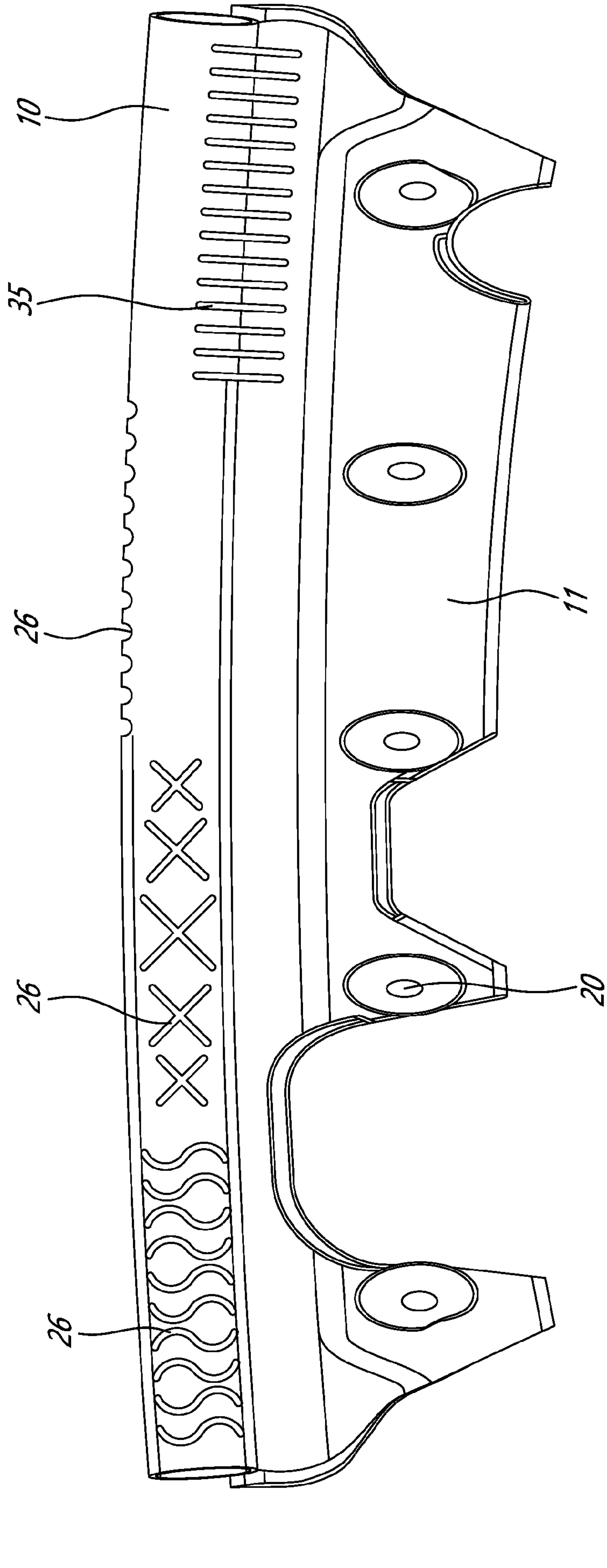

FIG - 5

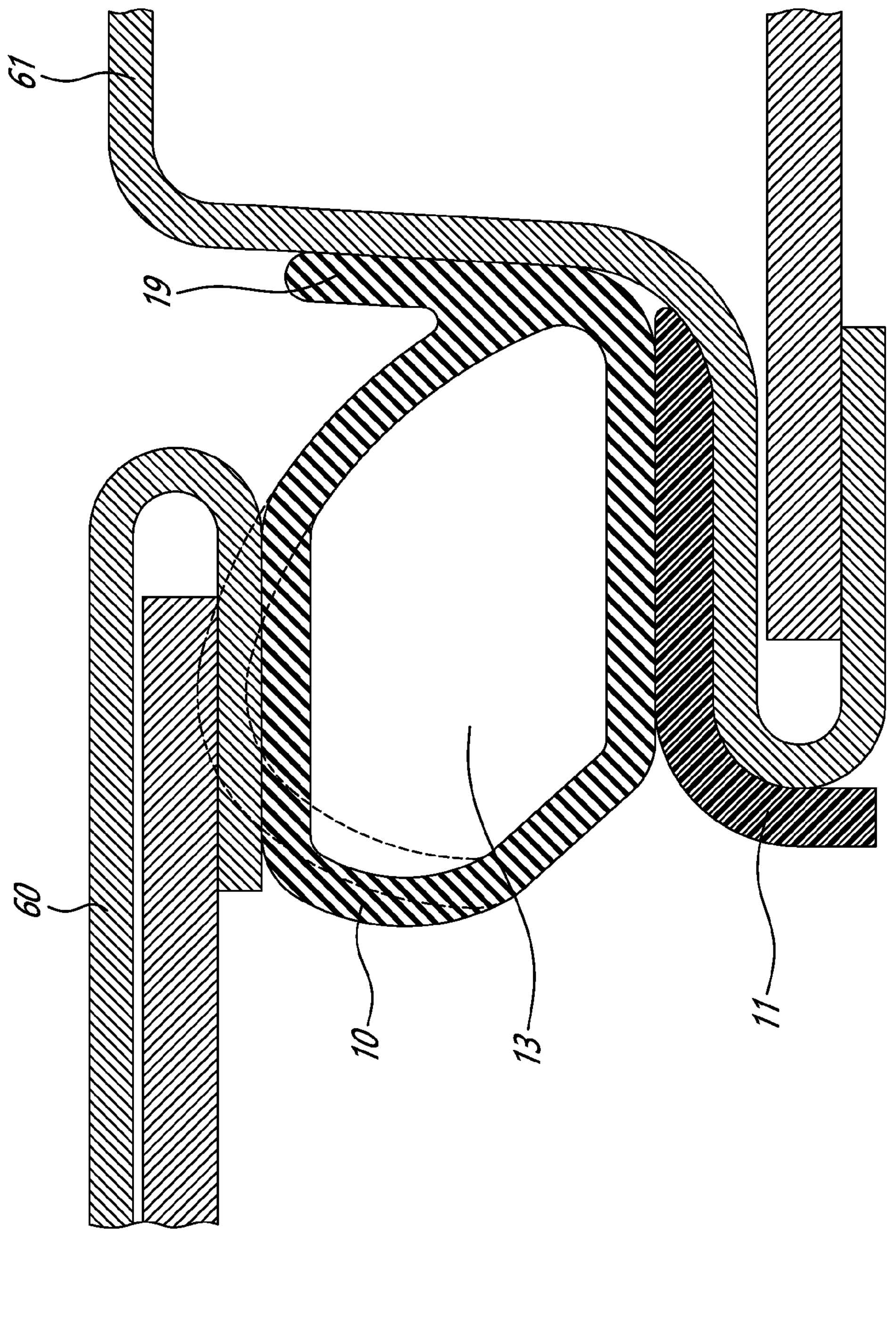

FIG-6

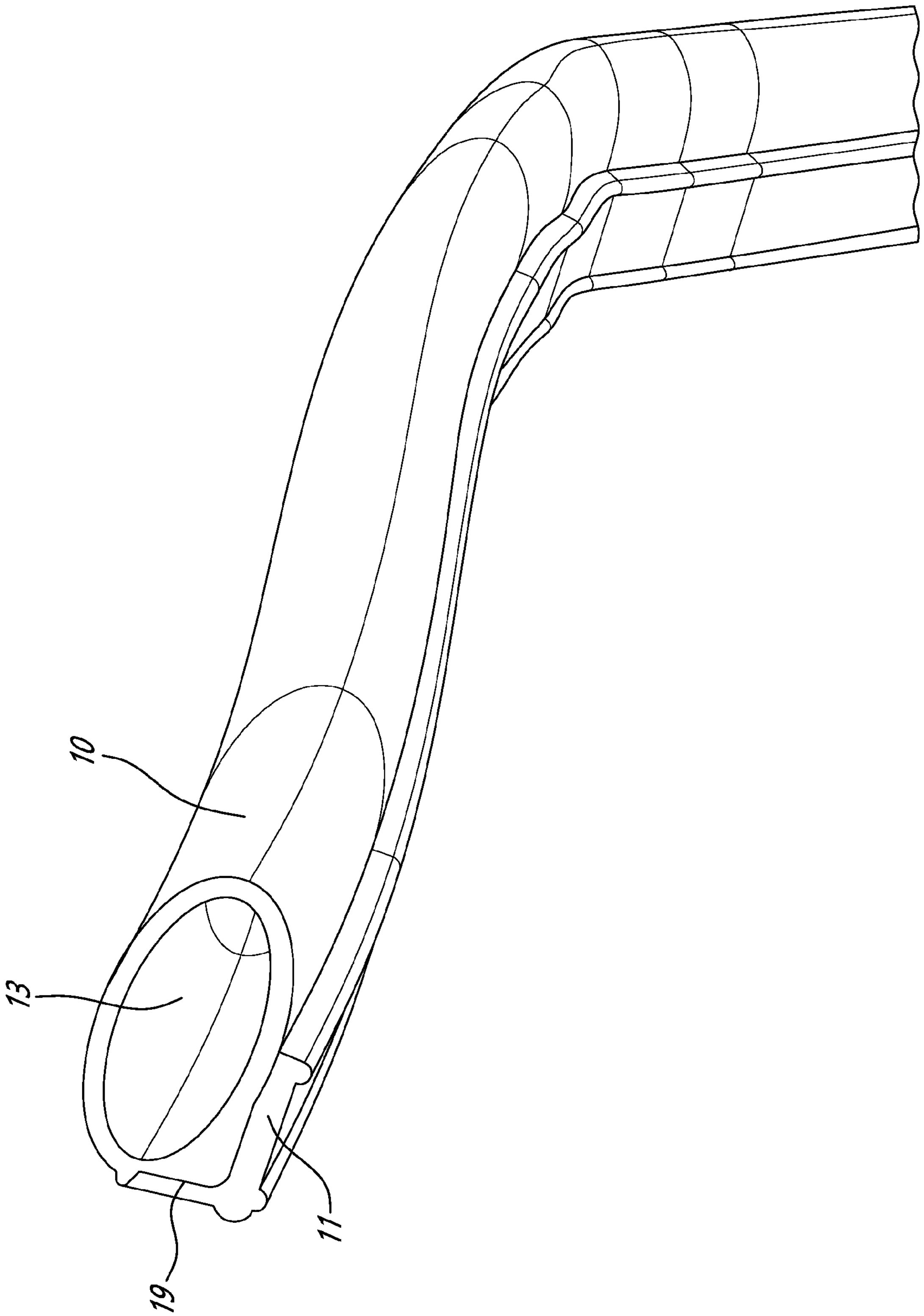

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2024/050765

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B60J 10/24*** (2016.01), ***B60J 10/27*** (2016.01), ***B60J 10/80*** (2016.01)

CPC: **B60J 10/24** (2020.01), B60J 10/27 (2020.01), B60J 10/80 (2020.01)

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)
IPC: B60J 10/24 (2016.01), B60J 10/27 (2016.01), B60J 10/80 (2016.01)
CPC: B60J 10/24 (2020.01), B60J 10/27 (2020.01), B60J 10/80 (2020.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Database: Questel Orbit
Keywords: seal+, bulb+, weatherstrip+, vehicle+, panel+, door+, frame+, thermoplastic+, elastomer+, rubber+, vulcanized, residual stress, anisotropy, gradient+, non-isotropic+, compress*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6968649 B2 (VAN DEN OORD, H.) 26 November 2005 (26-11-2005) *Fig. 1; col 1 lines 42-44, 58-60; col 2 lines 40-43; col 3 lines 19-30, 38-40; col 4 lines 1-6, 32-37 *	1-4, 14, 16, 18-22 5, 10-13
X Y	EP 0178064 A2 (COOK, J.) 16 April 1986 (16-04-1986) *Figs. 4 and 6; pg. 2 lines 1-8; pg. 3 lines 18-32; pg. 9 lines 12-15; pg. 10 lines 33-37 pg. 13 line 7; pg. 16 lines 14-20*	1-3, 6-9, 14-24 5, 10-13
Y	US 2017/0240034 A1 (GOPALAN, K. et al.) 24 August 2017 (24-08-2017) *abstract; ¶ 0030*	5
Y	US 2005/0046124 A1 (ZWOLINSKI, D. et al.) 3 March 2005 (03-03-2005) *Figs. 2-6; ¶ 0042; ¶ 0051*	10-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"D"	document cited by the applicant in the international application	"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
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"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)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 15 August 2024 (15-08-2024)	Date of mailing of the international search report 10 September 2024 (10-09-2024)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Francesca Tsimiklis (873) 354-0468

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