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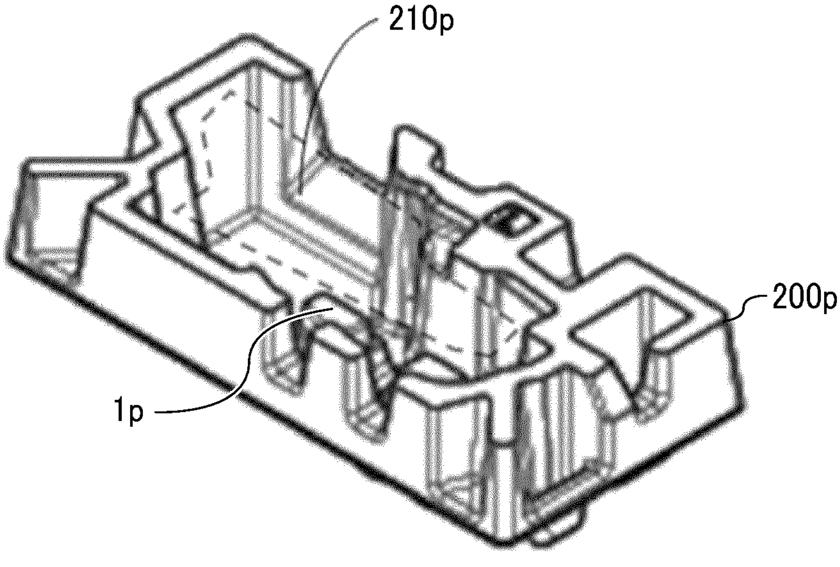
(54) IMPACT ABSORBER AND PACKAGING MATERIAL

(57) An impact absorber (1, 1a, 1x, 2) includes a three-dimensional structure. The three-dimensional structure includes a closed top surface, an open bottom, a hollow inside, and a recess (11, llx, 21). The recess is disposed within an outline of the top surface.

FIG. 1



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Description

BACKGROUND

Technical Field

[0001] Embodiments of the present disclosure relate to an impact absorber and a packaging material.

Related Art

[0002] Reduction of the use amount of single-use plastics and the marine plastic waste pollution which has been at issue in recent years have become challenges to realize a circular society aiming at a sustainable global environment. In addressing these challenges, use of plastic packaging materials derived from fossil resources is increasingly restricted. Thus, the use value of molded pulp packaging materials having excellent resource recoverability and recyclability is further increasing.

[0003] In packaging materials made of molded pulp, there is already known a technology that absorbs vibration and falling impact that an object to be packaged may receive in a distribution process by a molded pulp impact absorbing material being deformed and crushed to reduce the impact, i.e., an impact acceleration (gravitational forces (G's)) applied to the object to be packaged.

[0004] However, as an impact characteristic specific to a molded pulp packaging material known in the art, a large impact force may be instantaneously applied to an object to be package. In such a case, particularly in a packaging material that accommodates precision equipment, there is a disadvantage that many portions of the internal structure of an object to be packaged may be deformed or damaged.

[0005] In addition, in a packaging material that accommodates precision equipment using a molded pulp impact absorbing material, there has been a disadvantage that the impact-resistant strength of the object to be packaged is low and the object to be packaged may be broken.

SUMMARY

[0006] In light of the above-described disadvantages, a purpose of the present disclosure is to provide an impact absorber that prevents a high impact force from being suddenly applied to a packaged object. Another purpose of the present disclosure is to provide an impact absorber that reduces impact acceleration applied to an object to be packaged.

[0007] To solve the above-described problems, an embodiment of the present disclosure provides an impact absorber including a three-dimensional structure. The three-dimensional structure includes a closed top surface, an open bottom, a hollow inside, and a recess. The recess is disposed within an outline of the top surface.

[0008] Another embodiment of the present disclosure provides an impact absorber including a three-dimensional structure. The three-dimensional structure includes a closed top surface, an open bottom, a hollow inside, and a groove. The groove crosses the top surface. The groove has a depth equal to or greater than twice a thickness of the impact absorber and equal to or smaller than one fifth of a structural height of the impact absorber.

[0009] According to the present disclosure, it is possible to provide an impact absorber that prevents a high impact force from being suddenly applied to an object to be packaged. Further, according to the present disclosure, it is possible to provide another impact absorber that reduces impact acceleration applied to an object to be packaged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A more complete appreciation of the disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

FIG. 1 is a perspective view of a packaging material made of molded pulp, according to a control sample of the present disclosure;
FIG. 2A is a schematic perspective view of an impact absorbing rib according to a control sample of the present disclosure;
FIG. 2B is a schematic perspective view of an impact absorbing rib according to another control sample of the present disclosure;
FIG. 3 is a graph illustrating impact absorbing properties of a molded pulp impact absorbing material and a resin foam impact absorbing material, according to an embodiment of the present disclosure;
FIG. 4A is a schematic perspective view of an impact absorbing rib, according to a control sample of the present

disclosure;

FIG. 4B is a cross-sectional view of the impact absorbing rib of FIG. 4A, according to a control sample of the present disclosure;

FIG. 5 is a diagram illustrating a cross-sectional view of an impact absorbing rib and an object to be packaged that contacts the impact absorbing rib, illustrating how side walls of the impact absorbing rib is compressed or crushed, according to a control sample of the present disclosure;

FIG. 6A is a schematic perspective view of an impact absorbing rib as an impact absorber according to an embodiment of the present disclosure;

FIG. 6B is a schematic perspective view of an impact absorbing rib as an impact absorber according to another embodiment of the present disclosure;

FIG. 7 is a schematic perspective view of an impact absorbing rib illustrating an upper portion of the impact absorbing rib in which the rigidity of the upper portion is reinforced, according to an embodiment of the present disclosure;

FIG. 8A is a schematic perspective view of an impact absorbing rib according to an embodiment of the present disclosure;

FIG. 8B is a diagram illustrating a cross-sectional view of the impact absorbing rib of FIG. 8A and an object to be packaged that contacts the impact absorbing rib, and illustrating how an impact absorbing mechanism of the impact absorbing rib works when an impact is added to the impact absorbing rib, according to an embodiment of the present disclosure;

FIG. 9 is a graph illustrating a relation between an elapsed time and an impact force applied to an impact absorbing rib according to an embodiment of the present disclosure and an impact absorbing rib according to a control sample of the present disclosure;

FIG. 10 is a schematic perspective view of an impact absorbing rib in which a recess is disposed so as to connect with an outline of a top surface of the impact absorbing rib, according to an embodiment of the present disclosure;

FIG. 11 is a schematic perspective view of an impact absorbing rib according to a first embodiment of the present disclosure;

FIGS. 12A, 12B, and 12C are diagrams each illustrating a shape of a cross-section of a recess provided for an impact absorbing rib according to a second embodiment of the present disclosure;

FIGS. 13A, 13B, 13C, and 13D are top views of impact absorbing ribs each illustrating a shape of an outline of a top portion of a recess provided for a corresponding one of the impact absorbing ribs according to a third embodiment of the present disclosure;

FIG. 14A is a top view of an impact absorbing rib and a recess provided for the impact absorbing rib illustrating a shape of an outline of a top portion of the recess having a quadrangle outer shape, according to an embodiment of the present disclosure;

FIG. 14B is a top view of an impact absorbing rib and a recess provided for the impact absorbing rib illustrating a shape of an outline of a top portion of the recess having an outer shape continuous in a wave shape, according to an embodiment of the present disclosure;

FIGS. 14A and 14B illustrate a difference in rigidity between the impact absorbing rib including the recess having the quadrangle outer shape and the impact absorbing rib including the recess having the outer shape continuous in the wave shape;

FIG. 15 is a schematic side view of an impact absorbing rib illustrating an internal structure of a recess provided for the impact absorbing rib, according to a fourth embodiment of the present disclosure;

FIG. 16 is a schematic side view of an impact absorbing rib illustrating an internal structure of a recess provided for the impact absorbing rib, illustrating a disadvantage that may occur when the recess has a large depth, according to an embodiment of the present disclosure;

FIG. 17 is a schematic side view of an impact absorbing rib illustrating an internal structure of a recess provided for the impact absorbing rib, and illustrating a disadvantage that may occur when the recess contacts a bottom of the impact absorbing rib, according to an embodiment of the present disclosure;

FIG. 18 is a top view of an impact absorbing rib illustrating a shape of an outline of a top portion of the recess provided for the impact absorbing rib, according to a fifth embodiment of the present disclosure;

FIG. 19 is a schematic side view of an impact absorbing rib illustrating an internal structure of a recess provided for the impact absorbing rib, and illustrating a disadvantage that may occur when a distance between an outer shape of a top surface of the impact absorbing rib and the recess is small, according to an embodiment of the present disclosure;

FIG. 20 is a schematic side view of an impact absorbing rib illustrating an internal structure of a recess provided for the impact absorbing rib, and illustrating a disadvantage that may occur when a distance between an outer shape of a top surface of the impact absorbing rib and the recess is large, according to an embodiment of the present disclosure;

FIG. 21A is a top view of an impact absorbing rib and a recess, according to an embodiment of the present disclosure;

FIG. 21B is a schematic side view of the impact absorbing rib of FIG. 21A, illustrating a disadvantage that may occur when a portion between an outline of a top surface of the impact absorbing rib and the recess is a convex shape, according to an embodiment of the present disclosure;
FIG. 22 is a perspective view of a packaging material in which an impact absorbing rib is disposed such that a top surface of the impact absorbing rib contacts an object to be packaged, according to an embodiment of the present disclosure;
FIG. 23 is a perspective view of a packaging material in which an impact absorbing rib is disposed such that a surface of the impact absorbing rib including an opening contacts an object to be packaged, according to an embodiment of the present disclosure;
FIGS. 24A and 24B are schematic perspective views of impact absorbing ribs used in a test, according to an embodiment of the present disclosure;
FIG. 25 is a diagram illustrating how a test of a simple dynamic model is conducted, according to an embodiment of the present disclosure;
FIG. 26 is a table illustrating results of a test conducted using an impact absorbing rib according to a control sample and an impact absorbing rib according to an embodiment of the present disclosure;
FIG. 27 is a graph illustrating a relation between a distortion amount of an impact absorbing rib and impact absorption coefficient of the impact absorbing rib, according to an embodiment of the present disclosure;
FIG. 28 is a diagram illustrating how an object to be packaged is placed relative to impact absorbing materials, according to an embodiment of the present disclosure;
FIG. 29 is a schematic cross-sectional view of an impact absorbing rib and an object to be packaged illustrating how side walls of the impact absorbing rib are compressed or crushed when the impact absorbing rib receives an unbalanced load from the object to be packaged, according to a control sample of the present disclosure;
FIG. 30A is a schematic perspective view of a prismatic impact absorbing rib provided with a groove, according to an embodiment of the present disclosure;
FIG. 30B is a schematic perspective view of a cylindrical impact absorbing rib provided with a groove, according to an embodiment of the present disclosure;
FIG. 31 is a schematic side view of an impact absorbing rib illustrating a size of a groove provided for the impact absorbing rib, according to the present embodiment;
FIG. 32A is a schematic perspective view of an impact absorbing rib provided with a groove, according to an embodiment of the present disclosure;
FIG. 32B is a schematic cross-sectional view of the impact absorbing rib of FIG. 32A cut along a line B-B illustrated in FIG. 32A, according to an embodiment of the present disclosure;
FIGS. 33A, 33B, and 33C are schematic side views of an impact absorbing rib, each illustrating how a disadvantage may occur when a groove provided for the impact absorbing rib has a large depth, according to an embodiment of the present disclosure;
FIG. 34 is a schematic perspective view of an impact absorbing rib in which the rigidity of an upper portion of the impact absorbing rib is reinforced, according to an embodiment of the present disclosure;
FIG. 35 is a schematic cross-sectional view of an impact absorbing rib and an object to be packaged that is in contact with the impact absorbing rib, illustrating how side walls of the impact absorbing rib are compressed or crushed, according to an embodiment of the present disclosure;
FIG. 36A is a schematic perspective view of an impact absorbing rib according to an embodiment of the present disclosure;
FIG. 36B is a schematic cross-sectional view of the impact absorbing rib of FIG. 36A and an object to be packaged that is in contact with the impact absorbing rib cut along a line C-C illustrated in FIG. 36A, in a state in which side walls of the impact absorbing rib are compressed or crushed, according to another embodiment of the present disclosure;
FIG. 37 is a schematic cross-sectional view of an impact absorbing rib and an object to be packaged that is in contact with the impact absorbing rib in a state in which side walls of the impact absorbing rib are compressed or crushed, according to another embodiment of the present disclosure;
FIG. 38 is a schematic perspective view of an impact absorbing rib according to a seventh embodiment of the present disclosure;
FIGS. 39A, 39B, and 39C are diagrams each illustrating a cross-sectional shape of a groove provided for an impact absorbing rib, according to a nineth embodiment of the present disclosure;
FIGS. 40A, 40B, 40C, and 40D are diagrams each illustrating a schematic top view of a groove provided for an impact absorbing rib according to an eleventh embodiment of the present disclosure;
FIG. 41 is a diagram illustrating a top view of a groove provided for an impact absorbing rib, and illustrating how the rigidity of the groove having an outline continuous in a wave shape works against an impact force, according to an embodiment of the present disclosure;

FIG. 42 is a schematic side view of an impact absorbing rib and a groove provided for the impact absorbing rib, illustrating a disadvantage that may occur when the width of the groove is too large, according to an embodiment of the present disclosure;

FIG. 43 is a perspective view of a packaging material in which an impact absorbing rib is disposed such that a top surface of the impact absorbing rib contacts an object to be packaged, according to an embodiment of the present disclosure;

FIG. 44 is a perspective view of a packaging material in which an impact absorbing rib is disposed such that a surface of the impact absorbing rib including an opening contacts an object to be packaged, according to an embodiment of the present disclosure;

FIG. 45A is a schematic perspective view of an impact absorbing rib used in a test, according to a control sample of the present disclosure;

FIG. 45B is a schematic perspective view of another impact absorbing rib used in a test, according to an embodiment of the present disclosure; and

FIG. 46 is a table illustrating results of a test conducted using the impact absorbing rib of FIG. 45A according to the control sample of the present disclosure and the impact absorbing rib of FIG. 45B according to an embodiment of the present disclosure.

[0011] The accompanying drawings are intended to depict embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, like or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION

[0012] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of the present specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that have a similar function, operate in a similar manner, and achieve a similar result.

[0013] Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0014] Embodiments of the present disclosure are described below with reference to the attached drawings. In the drawings that illustrate embodiments of the present disclosure, like reference numerals are assigned as long as discrimination is possible to components such as members and component parts having a like function or shape. Thus, a description thereof is omitted once the description is provided.

[0015] A packaging material that packages an object to be packaged and an impact absorber that is disposed in the packaging material and absorbs an impact applied to the object to be packaged according to embodiments of the present disclosure are described in the following description. Further, a packaging material made of molded pulp as an example of the packaging material and an impact absorbing rib made of molded pulp as an example of the impact absorber are described as appropriate. In general, a packaging material made of molded pulp basically includes an impact absorbing rib having a cylindrical or prismatic structure to perform an impact absorbing function. In addition, an impact absorbing material made of molded pulp basically includes an impact absorbing rib having a cylindrical or prismatic structure to perform an impact absorbing function.

[0016] First, a description is given of a structure of an impact absorbing rib that reduces an impact applied to an inner structure of the object to be packaged, using a packaging material according to a control sample. FIG. 1 is a perspective view of a packaging material 200p made of molded pulp, according to a control sample of the present disclosure. FIG. 2A is a schematic perspective view of an impact absorbing rib 1p according to a control sample of the present disclosure. FIG. 2B is a schematic perspective view of an impact absorbing rib 2p according to another control sample of the present disclosure. The packaging material 200p includes the impact absorbing rib 1p made of molded pulp. The packaging material 200p includes an object accommodating space 210p indicated by a region surrounded by a broken line in FIG. 1. The impact absorbing rib 1p has a three-dimensional structure in which a top surface is closed, a bottom surface is open, and the inside of the impact absorbing rib 1b is hollow in a cylindrical or prismatic structure.

[0017] It is already known that propagation and amplification characteristics inside the structure of an object to be packaged, when the object to be packaged receives an impact from an impact absorbing material, are determined from a relation between input impact characteristics and natural vibration characteristics of each member of the internal structure of the object to be packaged. More specifically, in precision equipment, it is known that an impact response magnification in the internal structure of the precision equipment is high when a large impact force as an input impact characteristic is instantaneously applied to the precision equipment.

[0018] FIG. 3 is a graph illustrating impact absorbing properties of a molded pulp impact absorbing material and a resin-foam impact absorbing material, according to the present embodiment. As illustrated in FIG. 3, the impact characteristic applied to the object to be packaged via the molded pulp impact absorbing material has a characteristic that a large impact force is instantaneously applied to the object to be packaged. For this reason, when the object to be packaged is packaged with a molded pulp impact absorbing material, a large impact load is applied to the internal structure of the object to be packaged. Thus, there is a disadvantage that many parts of the internal structure of the object to be packaged may be deformed and broken. The resin foam impact absorbing material has a characteristic that the impact force increases relatively gradually. For this reason, the above-described disadvantage is unlikely to occur with the resin foam impact absorbing material.

[0019] The impact absorbing mechanism of the impact absorbing rib according to a control sample is described in the following description. FIG. 4A is a schematic perspective view of the impact absorbing rib 1p, according to the control sample. FIG. 4B is a cross-sectional view of the impact absorbing rib 1p cut along a line A-A illustrated in FIG. 4A. The impact absorbing rib 1p having a three-dimensional structure as illustrated in FIG. 2 is molded with a gradient of at least equal to or higher than 5 degrees for mold releasability when the impact absorbing rib 1p is fabricated.

[0020] FIG. 5 is a diagram illustrating a cross-sectional view of the impact absorbing rib 1p and the object to be packaged 300 that is in contact with the impact absorbing rib 1p, illustrating how side walls of the impact absorbing rib 1p are compressed or crushed, according to the control sample. FIG. 5 is a cross-sectional view of the impact absorbing rib 1p and the object to be packaged 300 that is in contact with the impact absorbing rib 1p, along the cut line A-A illustrated in FIG. 4A. FIG. 5 illustrates a state before the object to be packaged 300 receives an impact in a left side of FIG. 5 and another state after the object to be packaged 300 has received the impact in a right side. In FIG. 5, a package cargo is employed. The package cargo packages the object to be packaged 300 with the packaging material that includes the impact absorbing rib 1p illustrated in FIG. 4A such that the object to be packaged 300 contacts the top surface of the impact absorbing rib 1p. FIG. 5 illustrates the state in which the impact absorbing rib 1p receives a load from the object to be packaged 300 when the package cargo receives an impact.

[0021] The impact absorbing mechanism of the impact absorbing rib 1p supports a dynamic load received from the object to be packaged 300, which is generated when the object to be packaged 300 is dropped as a packaged cargo, mainly in cross-sectional areas of the side walls of the impact absorbing rib 1p. Thus, the impact absorbing mechanism of the impact absorbing rib 1p absorbs the impact by the stress generated when the side walls of the impact absorbing rib 1p are compressed or crushed, as in the compressed and crushed portion 15p illustrated in FIG. 5.

[0022] The impact absorbing rib 1p according to the control sample is a molded pulp impact absorbing material made of paper that has a characteristic such that a large stress is instantaneously generated in the impact absorbing rib 1p, as illustrated in FIG. 3 as a characteristic of the compression stress of the molded pulp impact absorbing material. Accordingly, a large impact force is instantaneously applied to the object to be packaged 300. Note that in FIGS. 4A, 4B, and 5, the prismatic impact absorbing rib 1p is used to describe the control sample. However, the control sample can also be applied to the cylindrical impact absorbing rib 2p.

[0023] As a solution to the above-described disadvantage, an impact absorber according to an embodiment of the present disclosure has a structure that prevents an impact from being applied instantaneously to an object to be packaged, as characteristics of such an impact applied to the object to be packaged via a molded pulp impact absorbing material.

[0024] Each of the impact absorbing ribs 1p and 2p as examples of an impact absorber according to an embodiment of the present disclosure has a three-dimensional structure having a closed top surface, an open bottom, and a hollow inside. The top surface of the three-dimensional structure includes at least one recess 11 within an outline (or outer line) of the top surface of the three-dimensional structure, which is an outer line of the top surface.

[0025] Further, each of the impact absorbing ribs 1p and 2p is formed by, for example, molded pulp, i.e., molded pulp impact absorbing material.

[0026] FIG. 6A is a schematic perspective view of the impact absorbing rib 1 as an impact absorber according to the present embodiment. FIG. 6B is a schematic perspective view of the impact absorbing rib 2 as another impact absorber according to another one of the embodiments. Each of the impact absorbing rib 1 and the impact absorbing rib 2 as examples of the impact absorber according to the present embodiments has a three-dimensional structure in which a top surface is closed, a bottom surface is opened, and an inside of the structure is hollow. The top surface of the structure of the impact absorbing rib 1 and the impact absorbing rib 2 includes at least one recess 11, one recess 21, respectively, each of which fits inside an outline of the top surface of the structure, which is a line outside the top surface. Further, the impact absorbing ribs 1 and 2 are formed by, for example, molded pulp, i.e., molded pulp impact absorbing material. In FIG. 6A, the prismatic impact absorbing rib 1 provided with the recess 11 is illustrated. In FIG. 6B, the cylindrical impact absorbing rib 2 provided with a recess 11a is illustrated. The impact absorbing rib 1 is mainly described in the following description. However, the impact absorbing rib 2 has like features as the impact absorbing rib 1 unless otherwise specified. FIG. 7 is a schematic perspective view of the impact absorbing rib 1 illustrating an upper portion of the impact absorbing rib 1 in which the rigidity of the upper portion is reinforced, according to the present embodiment.

[0027] Such a structure as described above allows the rigidity of the upper portion of the impact absorbing rib 1 to be reinforced by the recess 11 that fits inside the outline of the top surface of the impact absorbing rib 1. In FIG. 7, a rigidity reinforced portion 13 in which the rigidity is reinforced is indicated by oblique lines. Accordingly, due to the impact absorbing mechanism of the impact absorbing rib 1, the rigidity reinforced portion 13 allows the upper portion of the impact absorbing rib 1 to sink to a lower portion of the impact absorbing rib 1 while the upper portion having a high rigidity is not compressed and crushed and maintains a constant shape.

[0028] FIG. 8A is a schematic perspective view of the impact absorbing rib 1 according to the present embodiment. FIG. 8B is a diagram illustrating a cross-sectional view of the impact absorbing rib 1 cut along a line B-B illustrated in FIG. 8A and the object to be packaged 300 that is in contact with the impact absorbing rib 1, illustrating how the impact absorbing mechanism of the impact absorbing rib 1 works when an impact is added to the impact absorbing rib 1, according to the present embodiment. FIG. 8B illustrates a state before the impact absorbing rib 1p and the object to be packaged 300 receive an impact in a left side of FIG. 8B. FIG. 8B illustrates a state after the impact absorbing rib 1 and the object to be packaged 300 have received the impact in a right side of FIG. 8B. In FIG. 8B, a package cargo is employed. The package cargo packages the object to be packaged 300 with the packaging material that includes the impact absorbing rib 1 illustrated in FIG. 8A such that the object to be packaged 300 contacts the top surface of the impact absorbing rib 1. FIG. 8B illustrates the state in which the impact absorbing rib 1 receives a load from the object to be packaged 300 when the package cargo receives an impact. As illustrated in FIG. 8B, the impact applied to the impact absorbing rib 1 generates a compressed and crushed portion 15 and a bent and buckled portion 17. Thus, the impact absorbing rib 1 absorbs the impact.

[0029] At this time, in the impact absorbing rib 1, a stress of bending and buckling of the bent and buckled portion 17 below the rigidity reinforced portion 13 and a stress of compression and crushing of the outer walls are generated in a combined manner. Note that the stress of bending and buckling of the bent and buckled portion 17 is typically smaller than the stress of compression and crushing of the outer walls. Accordingly, occurrence of a phenomenon in which a large impact force is instantaneously applied to the impact absorbing rib 1 is reduced. FIG. 9 is a graph illustrating a relation between an elapsed time and an impact force applied to the impact absorbing rib 1 according to the present embodiment and the impact absorbing rib 1p according to the control sample. FIG. 9 indicates that the impact force applied to the impact absorbing rib 1 according to the embodiment is lower than the impact force applied to the impact absorbing rib 1p according to the control sample which absorbs the impact by compression and crushing.

[0030] As described above, the impact absorbing rib 1 as an example of the impact absorber according to the present embodiment has a structure in which the stress of bending and buckling of the bent and buckled portion 17 below the rigidity reinforced portion 13 and the stress of compression and crushing of the outer walls are generated in a combined manner. Accordingly, a large impact load inside the object to be packaged, which is generated in a packaging material known in the art when a large impact force is instantaneously applied to the object to be packaged, can be reduced. Note that, in a case in which a recess 11x of an impact absorbing rib 1x is disposed so as to connect with the outline of the top surface of the impact absorbing rib 1x (see FIG. 10), there is room for an upper portion of the impact absorbing rib 1x to be partially deformed. Accordingly, it is assumed that the upper portion of the impact absorbing rib 1x may not sink to a lower portion of the impact absorbing rib 1x while maintaining a constant shape. For this reason, preferably, the recess 11 is formed so as to fit inside the outline of the top surface of the impact absorbing rib 1. FIG. 10 is a schematic perspective view of the impact absorbing rib 1x in which the recess 11x is disposed so as to connect with the outline of the top surface of the impact absorbing rib 1x, according to the present embodiment. Each one of the embodiments of the above-described impact absorbing ribs having a corresponding one of the recess is described in the following description.

First Embodiment

[0031] In a first embodiment, an impact absorbing rib provided with more than two recesses is described. FIG. 11 is a schematic perspective view of an impact absorbing rib 1a according to the first embodiment of the present disclosure. The impact absorbing rib 1a includes two recess 11. The rigidity of the impact absorbing rib 1a can be further reinforced by increasing the number of recess 11.

Second Embodiment

[0032] In a second embodiment, modifications of the cross-sectional shape of the recess 11 are described. The cross-sectional shape of the recess 11 may be, for example, a U-shape, a C-shape, or a V-shape. The cross-sectional shape of the recess 11 is the shape of the recess of the recess 11 from the top surface of the impact absorbing rib 1 to the bottom of the recess 11. For example, the cross-sectional shape of the recess 11 is a U-shape, a C-shape formed by wall surfaces and the bottom of the recess 11 or a V-shape formed by the wall surfaces of the recess 11. Further, in the cross-sectional shape formed by the wall surfaces and the bottom of the recess 11, the wall surfaces of the recess 11 may be inclined as in a V-shape. FIGS. 12A, 12B, and 12C are diagrams each illustrating the cross-sectional shape of the impact absorbing rib 1 according to the second embodiment.

Third Embodiment

[0033] In a third embodiment, modifications of the outer shape of the recess 11 are described. The shape of the recess 11 viewed from above may be any one of a polygonal shape, a circular shape, or an outer shape in which curved lines or straight lines are continuously connected in a wave shape. In the present embodiment, the shape of the recess 11 viewed from above is a same shape as the top surface of the impact absorbing rib 1. For example, when the recess 11 deforms from the top surface of the impact absorbing rib 1 toward the bottom of the recess 11, the shape of the bottom of the recess 11 may be different from the shape of the top surface of the impact absorbing rib 1.

[0034] FIGS. 13A, 13B, 13C, and 13D are top views of the impact absorbing rib 1 each illustrating a shape of the top surface of the recess 11 provided for the impact absorbing rib 1 according to the third embodiment. In FIGS. 13A, 13C, and 13D, the outline of the top surface of the recess 11 is rectangular. In FIG. 13B, the outline of the top surface of the recess 11 is circular. Further, as a shape of the recess 11 viewed from above, FIG. 13A illustrates a quadrangle shape, FIG. 13B illustrates a circular shape, FIG. 13C illustrates an outer shape in which curved lines are continuously connected to each other in a wave shape, and FIG. 13D illustrates an outer shape in which straight lines are continuously connected to each other in a wave shape.

[0035] The shape of the recess 11 may be formed along the outline of the top surface of the impact absorbing rib 1. For example, when the outline of the top surface of the impact absorbing rib 1 is a polygon, the shape of the recess 11 may be a polygon in a similar manner. When the outline of the top surface of the impact absorbing rib 1 is an ellipse, the shape of the recess 11 may be an ellipse in a similar manner. The outer shape of the top surface of the impact absorbing rib 1 that is continuous in a wave shape as illustrated in FIGS. 13C and 13D may be a shape obtained by combining curved lines and straight lines in wave shape.

[0036] Such a configuration as described above allows to secure the rigidity of the impact absorbing rib 1 without fail. Note that, when the shape of recess 11 viewed from above is an outer shape continuous in a wave shape, the rigidity of the impact absorbing rib 1 is reinforced with respect to forces received from multiple directions. Accordingly, the rigidity of the impact absorbing rib 1 can be secured reliably. FIGS. 14A and 14B are diagrams each illustrating a top surface of the impact absorbing rib 1 and illustrating a difference in rigidity of the impact absorbing rib 1 between the impact absorbing rib 1 that includes the recess 11 having a quadrangle outer shape and the impact absorbing rib 1 that includes the recess 11 having an outer shape continuous in a wave shape, according to the present embodiment. For example, when a force is applied to the inside of the recess 11 having the outer shape continuous in the wave shape, the force is applied to protruding or curved portions of the recess 11. Accordingly, the outer shape continuous in a wave shape (see FIG. 14B) of the recess 11 is less likely to be bent than a quadrangular shape of the recess 11 (see FIG. 14A).

Fourth Embodiment

[0037] In a fourth embodiment, the depth of the recess 11 is described. FIG. 15 is a schematic side view of the impact absorbing rib 1 illustrating an internal structure of the recess 11 provided for the impact absorbing rib 1 according to the fourth embodiment. In the present embodiment, a depth hb of the recess 11 is a distance from the top surface of the impact absorbing rib 1 to the bottom of the recess 11. A height ha of the impact absorbing rib 1 is a distance, i.e., a shortest distance, from the top surface of the impact absorbing rib 1 to the bottom surface of the impact absorbing rib 1. A thickness t of the impact absorbing rib 1 is a thickness of the impact absorbing rib 1 as a three-dimensional structure having a hollow inside of the impact absorbing rib 1. In addition, in a case in which the thickness t of the impact absorbing rib 1 is different depending on positions of the impact absorbing rib 1 as the three-dimensional structure, for example, a value in a range from a minimum value inclusive to a maximum value inclusive is used, and one value may not be defined. At this time, the value in a range from equal to or greater than the minimum value to equal to or smaller than the maximum value may be limited to the thickness of the top surface of the impact absorbing rib 1 or the thickness of the rigidity reinforced portion 13 (see FIG. 7). FIG. 4B illustrates the thickness t of the impact absorbing rib 1 as an example.

[0038] In the impact absorbing rib 1, the depth hb (see FIG. 15) of the recess 11 may be approximately twice of or greater than the thickness t of the impact absorbing rib 1. Such a configuration as described above allows the degree of rigidity enhancement to be reliably ensured, and the shape of the recess 11 to be precisely formed during fabrication of the recess 11 so as to reinforce the rigidity of the impact absorbing rib 1 as intended. This is because, when the depth hb of the recess 11 is set to be approximately twice of or smaller than the thickness t of the impact absorbing rib 1, a desired shape for the recess 11 may not be formed due to, for example, variation when the impact absorbing rib 1 is fabricated.

[0039] On the other hand, in the impact absorbing rib 1, the depth hb of the recess 11 may be set to be approximately half or smaller than the height ha of the impact absorbing rib 1. When the depth hb of the recess 11 is too large, rigidity reinforced portions of the rigidity reinforced portion 13 that serve as supports of the rigidity reinforced portion 13 are long. Thus, the rigidity reinforced portion 13 is likely to fall. In the present embodiment, the rigidity reinforced portions of the rigidity reinforced portion 13 serve as side walls surrounding the periphery of the recess of the recess 11 and serve as supports for supporting the rigidity reinforced portion 13. FIG. 16 is a schematic side view of the impact absorbing rib 1 illustrating an internal structure of the recess 11, illustrating a disadvantage that may occur when the recess 11 has a large depth, according to the present embodiment.

[0040] The depth hb of the recess 11 of the impact absorbing rib 1 is set as appropriate as described above. Accordingly, the impact absorbing rib 1 avoids the above-described disadvantage and performs the intended function of reinforcing the rigidity of the impact absorbing rib 1. In addition, the impact absorbing rib 1 deforms approximately half of the height of the impact absorbing rib 1 to absorb the impact. Accordingly, when the impact absorbing rib 1 deforms, the recess 11 contacts the bottom of the impact absorbing rib 1. Thus, a disadvantage that hinders the impact absorbing function of the impact absorbing rib 1can be prevented. FIG. 17 is a schematic side view of the impact absorbing rib 1 illustrating an internal structure of the recess 11, illustrating a disadvantage that may occur when the recess contacts the bottom of the impact absorbing rib 1, according to the present embodiment.

[0041] As described above, preferably, the depth hb of the recess 11 is a length that is approximately twice or greater than the thickness t of the impact absorbing rib 1 and a length that is approximately half or smaller than the height ha of the impact absorbing rib 1.

Fifth Embodiment

[0042] In a fifth embodiment, a distance between the outline of the top surface of the impact absorbing rib 1 and the recess 11 is described. FIG. 18 is a top view of the impact absorbing rib 1 illustrating a shape of an outline of a top portion of the recess 11, according to the fifth embodiment. In the impact absorbing rib 1 according to the fifth embodiment, preferably, a distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 is set to be a length larger than twice the thickness t of the impact absorbing rib 1. Such a configuration as described above allows the rigidity reinforced portion 13 to be likely to fall in a case in which the distance db between the outer shape of the top surface of the impact absorbing rib 1 and the recess 11 is too short. Thus, the target function of the impact absorbing rib 1 can be prevented from being impaired. FIG. 19 is a schematic side view of the impact absorbing rib 1 illustrating an internal structure of the recess 11 and illustrating a disadvantage that may occur when the distance between the outer shape of the top surface of the impact absorbing rib 1 and the recess 11 is small, according to the present embodiment.

[0043] On the other hand, in the impact absorbing rib 1, the distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 may be set to be a length that is half of or smaller than the length of one side of the outline of the top surface along a same direction as the distance db. Such a configuration as described above allows the distance db between the outline of the top surface and the recess 11 to be excessively long to generate a moment. Accordingly, the recess 11 is likely to be pushed in due to an influence of the moment. Thus, a disadvantage in which the target function of rigidity reinforcement of the impact absorbing rib 1 may not performed, can be prevented. FIG. 20 is a schematic side view of the impact absorbing rib 1 illustrating an internal structure of the recess 11 and illustrating a disadvantage that may occur when a distance between the outer shape of the top surface of the impact absorbing rib 1 and the recess 11 is large compared to a case illustrated in FIG. 19, according to the present embodiment.

[0044] As described above, preferably, the distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 is a length that is approximately twice or greater than the thickness t of the impact absorbing rib 1 and a length that is smaller than approximately half of a width da of the top surface of the impact absorbing rib 1 (see FIG. 18).

[0045] Note that in a case in which the distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 changes as in the case in which the recess 11 has the outline shape with continuous wave shape as described above. In such a case, for example, the minimum value of the distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 may be set to be a length approximately twice or greater than the thickness t of the impact absorbing rib 1, and the maximum value of the distance db between the outline of the top surface of the impact absorbing rib 1 and the recess 11 may be set to a length smaller than approximately half of the width da of the top surface of the impact absorbing rib 1.

[0046] In addition, preferably, a portion between the outline of the top surface of impact absorbing rib 1 and the recess 11 is a flat surface. FIGS. 21A is a top view of an impact absorbing rib 1q illustrating a shape of an outline of the top portion of the recess 11, according to the present embodiment. FIG. 21B is a schematic side view of the impact absorbing rib 1q of FIG. 21A, illustrating a disadvantage that may occur when the portion between the outline of the top surface of the impact absorbing rib 1q and the recess 11 is a convex shape. FIG. 21 illustrates a case in which the portion between the outline of the top surface of the impact absorbing rib 1q and the recess 11 has a convex shape with a protruding tip. In FIG. 21A, the position of the tip of the convex shape is indicated by a two-dot dashed line. As illustrated in FIG. 21B, in the case in which the portion between the outline of the top surface of the impact absorbing rib 1q and the recess 11 is not a plane but a convex shape, the upper portion of the impact absorbing rib 1q is likely to fall in directions indicated by arrows illustrated in FIG. 21B due to the load received from the object to be packaged 300. Accordingly, the target function of rigidity reinforcement of the impact absorbing rib 1q cannot be performed.

Sixth Embodiment

[0047] In a sixth embodiment, outer shapes of the impact absorbing rib 1 and 2 are described with reference to FIG. 6A and 6B. The outer shape of the impact absorbing rib 1 or outer shape of the impact absorbing rib 2 as the three-dimensional structure having a hollow structure may be a prismatic shape or a columnar shape. FIG. 6A illustrates the impact absorbing rib 1 having the prismatic shape. FIG. 6B illustrates the impact absorbing rib 2 having the columnar shape.

[0048] The prismatic shape of the impact absorbing rib 1 is, for example, a truncated pyramid shape as illustrated in FIG. 6A or the prismatic shape. In addition, the shape of the top surface or the bottom surface of the impact absorbing rib 1 is the prismatic shape. The impact absorbing rib 1 may include a deformed portion such as an uneven shape formed by straight lines or curved lines in a part of the prismatic shape. The columnar shape of the impact absorbing rib 2 is, for example, a truncated cone, as illustrated in FIG. 6B or a circular column. Further, the shape of the top surface or the bottom surface of the impact absorbing rib 2 is basically a circular shape or an elliptical shape. The impact absorbing rib 2 may include a deformed portion formed by straight lines or curved lines in a part of the circular shape or the elliptical shape.

Seventh Embodiment

[0049] In a seventh embodiment, a molded pulp packaging material in which one of the impact absorbing ribs according to a corresponding one of the above embodiments is described. The packaging material according to the present embodiment includes such an impact absorbing rib at least at one position in the packaging material. Such a configuration as described above allows the above-described rigidity enhancement function of the impact absorbing rib to be attained.

[0050] In addition, in the packaging material 200, the impact absorbing rib 1 may be disposed such that the top surface of the impact absorbing rib 1 contacts the object to be packaged 300. FIG. 22 is a perspective view of a packaging material 200 in which the impact absorbing rib 1 is disposed such that the top surface of the impact absorbing rib 1 contacts the object to be packaged 300, according to the present embodiment. In the packaging material 200, when the object to be packaged 300 is accommodated in an object to be packaged accommodating space 210, the top surface of the impact absorbing rib 1 on which the recess 11 is disposed contacts the object to be packaged 300. Such a configuration as described above allows the object to be packaged 300 to be accommodated in an effective manner such that a load is applied to intended positions of the object to be packaged 300.

[0051] Further, the packaging material 200 may include the impact absorbing rib 1 such that an opening surface, i.e., the bottom surface, of the impact absorbing rib 1 contacts the object to be packaged 300. FIG. 23 is a perspective view of the packaging material 200 in which the impact absorbing rib 1 is disposed such that the opening surface, i.e., the bottom surface, of the impact absorbing rib 1 contacts the object to be packaged 300, according to the present embodiment. FIG. 23 is a perspective view of the packaging material 200 viewed from a reverse side of the object to be packaged accommodating space 210 in a state in which the top surface of the impact absorbing rib 1 on which the recess 11 is disposed in the packaging material 200. Such a configuration as described above allows a surface of the object to be packaged accommodating space 210 and a side surface of the object to be packaged 300 to surface contact each other, when the side surface of the object to be packaged 300 is flat. Thus, the object to be packaged 300, such as a product, can be stably held in the packaging material 200. In addition, the packaging material 200 described above may be used, for example, to accommodate an imaging system product.

[0052] As described in each of the above embodiments, each one of the impact absorbing ribs as an example of the impact absorber according to the corresponding one of the embodiments of the present disclosure and the packaging material 200 that includes the impact absorbing rib have a structure in which a large impact is not instantaneously applied to the object to be packaged 300. Accordingly, an effect that solves a disadvantage in which a large impact load is applied to the internal structure of the object to be packaged and many parts of the internal structure of the object to be packaged may be deformed and broken can be exhibited. In addition, due to the above-described effect, the quality as a packaging material for protecting an object to be packaged is significantly enhanced, which leads to delivery of a product to a customer without breakage. Further, solving the disadvantages that are inherent in the molded pulp impact absorbing materials known in the art allows to promote the use of materials having desirable resource recovery and recycling properties. Thus, the degree of contribution of using the above-described packaging material toward the realization of the circular society and the solving of plastic environmental disadvantages can be enhanced.

[0053] Results of a test using the impact absorbing ribs according to the above embodiments and the control sample are described in the following description.

Test Method

[0054] In the test, the spectral response acceleration of the object to be packaged 300 was measured using the packaging material that includes the impact absorbing rib according to the control sample and the packaging material that includes the impact absorbing rib according to one of the above-described embodiments of the present disclosure. FIGS. 24A and 24B each illustrate the impact absorbing rib 2p and the impact absorbing rib 1, respectively, used in the test. FIG. 25 is a diagram illustrating how the test is conducted using a simple dynamic model.

[0055] As an impact absorbing rib according to the control sample, the truncated cylindrical impact absorbing rib 2p having a basic structure known in the art was used for the test. As an impact absorbing rib according to one of the embodiments, the impact absorbing rib 1 having a truncated quadrangular pyramid shape provided with the recess 11 was used for the test. The spectral response acceleration of the impact applied to the impact absorbing rib 2p or the impact absorbing rib 1 was measured under the following test conditions.

Weight of main structure of the object to be packaged 300: m1 = 1.02 kg (aluminum)
Simulated weight of internal parts of the object to be packaged 300: m2 = 0.2 kg (aluminum)
Intermediate structure component: 0.01 kg (Gel sheet)
Natural frequency set for the simulated weight of the internal parts of the object to be packaged 300 and the intermediate constituent member: 200 Hz
Impact absorbing material: molded pulp corrugated cardboard made of wastepaper
Thickness t of the impact absorbing material = 2 mm

Test Results

[0056] FIG. 26 is a table illustrating the test results of the impact absorbing ribs 2p according to the control sample and the impact absorbing ribs 1 according to one of the embodiments of the present disclosure. Five tests from N1 to N5 (test number) were conducted to measure the spectral response accelerations (G's) of the impact applied to the product external component and the spectral response accelerations (G's) of the impact applied to internal components of a product, i.e., the object to be packaged. The spectral response accelerations (G's) of the impact applied to external components of the product were divided by the spectral response accelerations (G's) of the impact applied to the internal components of the product to calculate the internal response amplification factors, i.e., impact amplification factors, of the spectral response accelerations (G's) of the impact. The internal response amplification factor of the spectral response accelerations (G's) of the impact was 1.56 times at the maximum in the impact absorbing rib 2p according to the control sample. On the other hand, the internal response amplification factor of the spectral response accelerations (G's) of the impact was 1.23 times at the maximum in the impact absorbing rib 1 that includes the recess 11 according to one of the embodiments. Thus, it was confirmed that a large reduction of the impact can be obtained with the impact absorbing rib 1 according to the embodiment.

[0057] The impact absorbing mechanism of the impact absorbing rib 1p according to the control sample as previously illustrated in FIGS. 1 and 2A is described below. An example in which the side walls of the impact absorbing rib 1p according to the control sample are compressed or crushed is described with reference to FIGS. 4A and 5. FIG. 4A is a schematic perspective view of the impact absorbing rib 1p according to the control sample. FIG. 5 is a diagram illustrating a cross-sectional view of the impact absorbing rib 1p and the object to be packaged 300 that is in contact with the impact absorbing rib 1p, illustrating the impact absorbing rib 1p and the object to be packaged 300 in a state after the object to be packaged 300 has received the impact in a right part of FIG. 5. In FIG. 5, a package cargo that packages the object to be packaged 300 with the packaging material 200 that includes the impact absorbing rib 1p illustrated in FIG. 4A in which the impact absorbing rib 1p is disposed such that the object to be packaged 300 contacts the top surface of the impact absorbing rib 1p is used for description.

[0058] The impact absorbing mechanism of the impact absorbing rib 1p supports a dynamic load received from the object to be packaged 300, which is generated when the object to be packaged 300 is dropped as a packaged cargo, mainly in cross-sectional areas of the side walls of the impact absorbing rib 1p. Thus, the impact absorbing mechanism of the impact absorbing rib 1p absorbs the impact by the stress generated when the side walls of the impact absorbing rib 1p are compressed or crushed, as in the compressed and crushed portion 15p illustrated in FIG. 5.

[0059] In general, a basic formula below is used in designing the impact absorbing mechanism.

G (impact acceleration) = C (impact absorbing coefficient) × h (drop height) and t (impact absorbing material thickness)

[0060] FIG. 27 is a graph illustrating a relation between a distortion amount ε and an impact absorption coefficient C, according to the present embodiment. As expressed by the above-described basic formula, the value of the impact absorption coefficient C determined by the stress characteristics of the impact absorbing material is targeted to be low. On the other hand, disposing the object to be packaged 300 inside the packaged cargo such that the outer shape of the object to be packaged 300 does not contact the bottom of the packaged cargo is taken into consideration in advance. Then, the instantaneous distortion amount of the impact absorbing rib 1p is designed to be typically 0.4 to 0.6 by adjusting the above-described cross-sectional area of the side walls of the impact absorbing rib 1p as a supporting area of the load of the object to be packaged 300. FIG. 28 is a diagram illustrating how the object to be packaged 300 is placed relative to impact absorbing materials, according to the present embodiment. In designing an impact absorbing mechanism, the impact absorbing materials are arranged to generate a gap between the object to be packaged 300 and a bottom of an outer box of the package cargo which accommodates the object to be packaged 300 such that an outer shape of the object to be packaged 300 does not contact the bottom of the outer box of the package cargo when the packaged cargo that accommodates the object to be packaged 300 receives an impact.

[0061] When the above-described structure and design technology of the impact absorbing rib are employed, a reduction limit value of impact acceleration in an impact absorbing rib having a form known in the art such as the impact absorbing rib 1p according to the control sample, is determined. For this reason, desirably, a new impact absorbing rib structure having a lower impact-absorption coefficient value than the impact absorbing rib structure known in the art is found to further enhance the impact-absorbing function. In addition, in the impact absorbing rib 1p according to the control sample, the side walls of the impact absorbing rib 1p are compressed or crushed due to the natural dynamic load to generate stress to absorb the impact, when the impact absorbing rib 1p receives an unbalanced load from the object to be packaged 300. However, at this time, the structure of the impact absorbing rib 1p is likely to bend, and there is a disadvantage in which the stress to absorb the impact may be generated.

[0062] FIG. 29 is a schematic cross-sectional view of the impact absorbing rib 1p and the object to be packaged 300 illustrating how the side walls of the impact absorbing rib 1p are compressed or crushed when the impact absorbing rib 1p receives an unbalanced load from the object to be packaged 300, according to the control sample. FIG. 29 illustrates a cross section of the impact absorbing rib 1p and the object to be packaged 300 that is in contact with the impact absorbing rib 1p cut along the line A-A illustrated in FIG. 4A. FIG. 29 illustrates a state before the impact absorbing rib 1p and the object to be packaged 300 receive an impact in a left side of FIG. 29 and illustrates a state after the impact absorbing rib 1 and the object to be packaged 300 have received the impact in a right side of FIG. 29. In FIG. 29, a package cargo similar to the package cargo of FIG. 4A is used. As illustrated in FIG. 29, an energy absorption amount originally consumed by compression or crushing of the side walls of the impact absorbing rib 1p is consumed by a bending stress which consumes a relatively small energy absorption amount. Thus, impact absorption properties of the impact absorbing rib 1p are impaired. Accordingly, the structure of the impact absorbing rib 1p is excessively distorted and the impact acceleration applied to the object to be packaged 300 is increased. Note that the above-described disadvantage frequently occurs due to variations of posture of the object to be packaged 300 every time the object to be packaged 300 is dropped or variations of the position of the center of gravity of the object to be packaged 300. Thus, the impact absorption properties of the impact absorbing rib 1p are impaired. Note that the description is given using the impact absorbing rib 1p having the rectangular column shape in FIGS. 4A and 29. However, the above description applies to the impact absorbing rib 2p having the columnar shape.

[0063] The impact absorbing ribs, as examples of the impact absorber according to the embodiments of the present disclosure, have a structure that reduces impact acceleration applied to an object to be packaged in a molded pulp packaging material to solve the above-described disadvantage. Such an impact absorber has a structure in which a groove is disposed on a top surface of the impact absorber and a specific size of the groove is employed. Such a structure of the impact absorber eliminates loss of impact energy absorption amount when an impact absorber including an impact absorbing rib known in the art that has a posture for supporting a biased load and reliably exhibits a compression or crushing mechanism.

[0064] The structure and the function of the impact absorbing ribs as examples of the impact absorber according to the embodiments of the present disclosure is described in the description below. Each of the impact absorbing ribs has a three-dimensional structure in which a top surface of the structure is closed, a bottom surface of the structure is opened, and the inside of the structure is hollow, in which at least one groove is disposed on the top surface of the structure so as to connect one end and another end of an outline, i.e., a line outside the top surface, of the top surface. Further, each of the impact absorbing ribs is formed by, for example, molded pulp, i.e., molded pulp impact absorbing material. FIGS. 30A and 30B are perspective views of the impact absorbing rib 1 and the impact absorbing rib 2, respectively, each of which serves as an impact absorber according to an embodiment of the present disclosure. FIG. 30A illustrates the prismatic impact absorbing rib 1 provided with a groove 12. FIG. 30B illustrates the cylindrical impact absorbing rib 2 provided with a groove 22. The impact absorbing rib 1 is mainly described in the following description. However, the impact absorbing rib 2 has like features as the impact absorbing rib 1 unless otherwise specified.

[0065] Further, the groove 12 provided for the impact absorbing rib 1 has a specific size. FIG. 31 is a schematic side view of the impact absorbing rib 1 illustrating a size of the groove 12. FIGS. 32A and 32B are diagrams each illustrating the structure of the impact absorbing rib 1, according to an embodiment of the present disclosure. FIG. 32A is a schematic perspective view of the impact absorbing rib 1 provided with the groove 12, according to the present embodiment. FIG. 32B is a schematic cross-sectional view of the impact absorbing rib 1 of FIG. 32A cut along a line B-B illustrated in FIG. 32A.

[0066] The depth hb of the groove 12 is preferably in a range of not less than twice the thickness t of the impact absorbing rib 1 and equal to or smaller than one fifth of the height ha of the impact absorbing rib 1. In the present embodiment, distances related to the impact absorbing rib 1 and the groove 12 are set, for example, as follows.

[0067] The depth hb of the groove 12 is a distance from the top surface of the impact absorbing rib 1 to the bottom of the groove 12. A length lg of the groove 12 is a distance that connects two points on the outline of the top surface of the impact absorbing rib 1 on which the groove 12 is formed. A width bb of the groove 12 is a distance in a direction intersecting, i.e., orthogonal to, the length lg of the groove 12 on the top surface of the impact absorbing rib 1. A width ba of the top surface of the impact absorbing rib 1 is a distance obtained by connecting two points on the outline of the top surface in a same direction as the width bb of the groove 12. The width da is a longest distance, such as the length of the diameter in the case of a circle, when it is not determined to be one.

[0068] The thickness t of the impact absorbing rib 1 is the thickness of the impact absorbing rib 1 as a three-dimensional structure having a hollow inside of the impact absorbing rib 1.

[0069] In addition, in a case in which the thickness t of the impact absorbing rib 1 is different depending on positions of the impact absorbing rib 1 as the three-dimensional structure, for example, a value in a range from equal to or greater than a minimum value to equal to or smaller than a maximum value is used, and one value may not be defined. At this time, a value in a range from the minimum value to the maximum value may be used only for the thickness of the top surface or the rigidity reinforced portion 13 (see FIG. 34). In FIG. 32B, the thickness t of the impact absorbing rib 1 is illustrated as an example.

[0070] Setting the depth hb of the groove 12 to a depth that is approximately twice or greater than the thickness t of the impact absorbing rib 1 allows to ensure that the groove 12 is precisely formed at the time when the impact absorbing rib 1 is fabricated to reliably ensure the degree of rigidity enhancement and exhibit the intended effect of the rigidity enhancement. This is because, when the depth hb of the groove 12 is set to be equal to or substantially twice or smaller than the thickness t of the impact absorbing rib 1, the groove 12 may not be precisely formed due to, for example, variation when the impact absorbing rib 1 is fabricated.

[0071] In addition, setting the depth hb of the groove 12 to be approximately one fifth or smaller than the height ha of the impact absorbing rib 1 allows to prevent a disadvantage caused when the depth of the groove 12 is large. FIGS. 33A, 33B, and 33C are diagrams each illustrating a disadvantage that may occur when the groove 12 provided for the impact absorbing rib 1 has a large depth, according to an embodiment of the present disclosure. More specifically, when the depth hb of the groove 12 is larger than one fifth of the height ha of the impact absorbing rib 1 (see FIG. 33A), positions of fulcrums 111 of the groove 12 are closer to the center of the bottom of the groove 12. Thus, the rigidity reinforced portion 13 is unlikely to fall toward the groove 12, as intended as described later. On the other hand, in a case in which the depth hb of the groove 12 is extremely large (see FIG. 33B), the length of the rigidity reinforced portion 13 is large. Accordingly, the rigidity reinforced portion 13 is structurally likely to fall inward of the groove 12. Thus, the effect of stably promoting compression and crushing of the rigidity reinforced portion 13 is lost. In addition, the impact absorbing rib 1 absorbs the impact by deforming about half of the height ha of the impact absorbing rib 1. Accordingly, when the depth hb of the groove 12 is extremely large (FIG. 33C), the groove 12 contacts the bottom of the impact absorbing rib 1 at the time when the impact absorbing rib 1 deforms. Thus, the impact absorbing function of the impact absorbing rib 1 may be impaired.

[0072] Further, as illustrated in FIG. 34, the impact absorbing rib 1 includes the rigidity reinforced portion 13 which are rigidity reinforced portions in an upper portion of the impact absorbing rib 1 from the bottom of the groove 12 to the top surface of the impact absorbing rib 1. FIG. 34 is a schematic perspective view of the impact absorbing rib 1 in which the rigidity of an upper portion of the impact absorbing rib 1 is reinforced, according to the present embodiment. The groove 12 is disposed between both sides of the rigidity reinforced portion 13, thus each of the sides of the rigidity reinforced portion 13 includes an increased number of side walls. Accordingly, the rigidity reinforced portion 13 is unlikely to bend in directions indicated by two arrows in FIG. 34 due to, for example, the increased number of the side walls. The direction in which the rigidity reinforced portion 13 is unlikely to bend differs depending on the shape of the groove 12. However, in FIG. 34, the direction is, for example, a circular arc direction along the length direction of the groove 12 or a direction along the length direction of the groove 12.

[0073] Such a configuration as described above allows the rigidity reinforced portion 13 to moderately fall toward the groove 12 and the dynamic load of the object to be packaged 300 to be applied perpendicularly to the cross section of the outer walls of the lower part of the impact absorbing rib 1, while the upper portion of the impact absorbing rib 1 of which the rigidity is high is not deformed in the impact absorbing mechanism. Accordingly, the impact absorbing rib 1 can sufficiently absorb the impact energy of the object to be packaged 300, and the impact absorbing properties of the impact absorbing rib 1 can be enhanced. Note that, setting the size of the groove 12 to the size described above allows the rigidity of the upper portion of the impact absorbing rib 1 to be reinforced and prevents an effect gained by an action in which the rigidity reinforced portion 13 moderately fall toward the groove 12 to be lost when the depth of the groove 12 is too large. Such a configuration as described above prevents the loss of the impact energy absorption amount of the impact absorbing rib 1 due to the biased load support posture of the impact absorbing rib 1 and allows the impact absorbing rib 1 to have a structure that reliably exhibits a compression or crush mechanism. Thus, the rigidity of the upper portion of the impact absorbing rib 1 around the top surface can be reinforced.

[0074] In addition, when the impact absorbing rib 1 receives an unbalanced load, the upper portion of the impact absorbing rib 1 having high rigidity is unlikely to fall and bend, and the unbalanced load is stably applied to the cross section of the side walls of the impact absorbing rib 1 in the vertical direction while the impact absorbing rib 1 is not inclined. Thus, a target compression or crushing stress of the impact absorbing rib 1 can be exhibited. FIG. 35 is a schematic cross-sectional view of the impact absorbing rib 1 and the object to be packaged 300 that is in contact with the impact absorbing rib 1 cut along the line B-B illustrated in FIG. 32A, illustrating how side walls of the impact absorbing rib 1 are compressed or crushed, according to the present embodiment. FIG. 35 illustrates a state before the impact absorbing rib 1 and the object to be packaged 300 receive an impact in a left side of FIG. 35 and illustrates a state after the impact absorbing rib 1 and the object to be packaged 300 have received the impact in a right side of FIG. 35. FIG. 35 illustrates the impact absorbing rib 1p and the object to be packaged 300 in a state in which the object to be packaged 300 is packaged with a packaging material provided with the impact absorbing rib 1 illustrated in FIG. 32A, such that the object to be packaged 300 is in contact with the top surface of the impact absorbing rib 1, in a package cargo. FIG. 35 illustrates a state in which the impact absorbing rib 1 receives an unbalanced load from the object to be packaged 300 when the package cargo receives an impact in a right side of FIG. 35. When the impact absorbing rib 1 that includes the groove 12 is disposed in the packaging material, even when the impact absorbing rib 1 receives the unbalanced load from the object to be packaged 300, only the compressed and crushed portion 15 is generated. Accordingly, the bent and crushed portion 15p as illustrated in FIG. 29 is not generated. Accordingly, the loss of the impact energy absorption amount of the impact absorbing rib 1 can be eliminated, and the impact acceleration applied to the object to be packaged 300 can be reduced.

[0075] Note that the impact absorbing rib 1 includes an upward tapering degree α, for example, 5 degrees, for fabrication purpose, as illustrated in FIG. 32B. Accordingly, there is a concern that a region having high rigidity sinks between the side walls of the impact absorbing rib 1 as compression or crushing proceeds from the rigidity reinforced portion 13 as starting points, as illustrated, for example, in FIG. 36B. FIG. 36A is a schematic perspective view of the impact absorbing rib 1 according to the present embodiment. FIG. 36B is a schematic cross-sectional view of the impact absorbing rib of FIG. 36A and the object to be packaged 300 that is in contact with the impact absorbing rib 1 cut along a line C-C illustrated in FIG. 36A, in a state in which the compressed and crushed portion 15 and a bent and buckled portion 17 are generated, according to another one of the embodiments of the present disclosure. In FIG. 36, a package cargo similar to the package cargo used in FIG. 35 is used.

[0076] FIG. 37 is a schematic cross-sectional view of the impact absorbing rib 1 and the object to be packaged 300 that is in contact with the impact absorbing rib 1 cut along a line C-C illustrated in FIG. 36A, in a state in which side walls of the impact absorbing rib 1 are compressed or crushed, according to still another one of the embodiments of the present disclosure. In FIG. 37, a package cargo similar to the package cargo used in FIG. 35 is used. As illustrated in FIG. 37, support portions 113 of the groove 12 fall into a void area of the opened groove 12 such that the posture of the impact absorbing rib 1 is naturally corrected and a load can be applied to the side walls of the impact absorbing rib 1. Accordingly, in the impact absorbing mechanism, a dynamic load of the object to be packaged 300 is applied vertically to the cross sections of the outer walls of the lower portion of the impact absorbing rib 1 while the support portions 113 of the groove 12 fall moderately toward the groove 12 without the upper portion of the impact absorbing rib 1 having high rigidity being deformed. Accordingly, the impact absorbing rib 1 can be reliably compressed and crushed. Thus, the loss of impact energy absorption of the impact absorbing rib 1 can be prevented, and the impact acceleration applied to the object to be packaged 300 can be reduced. Embodiments of the present disclosure of the impact absorbing rib 1 that includes the above-described groove 12 are described below.

Eighth Embodiment

[0077] In an eighth embodiment, an impact absorbing rib 1a that includes two or more grooves is described. FIG. 38 is a schematic perspective view of the impact absorbing rib 1a according to the eighth embodiment. The impact absorbing rib 1a includes the two grooves 12. The rigidity of the impact absorbing rib 1a is further reinforced by increasing the number of grooves 12. Further, preferably that the two grooves 12 are disposed so as to intersect with each other. More specifically, preferably that the two grooves 12 are disposed so as to be orthogonal to each other. Such a configuration as described above allows the rigidity of the upper portion of the impact absorbing rib 1a to be reinforced and allows the impact absorbing rib 1a to perform the rigidity enhancement function reliably as intended. In addition, support portions of the groove 12 can fall flexibly in the void area of the opened groove 12 in a plurality of directions. Thus, the rigidity enhancement function of the impact absorbing rib 1a can be achieved to the maximum as intended. Such a configuration as described above causes the rigidity reinforced portion 13 to be enlarged in the upper part of the impact absorbing rib 1a. Accordingly, the rigidity enhancement function of the impact absorbing rib 1a can be achieved to the maximum as intended.

[0078] Each one of the grooves 12 is formed, for example, so as to connect two positions on the outline of the top surface of the impact absorbing rib 1a and divide the top surface into two regions. Further, the grooves 12 may be formed so as to divide the top surface of the impact absorbing rib 1a substantially equally. As an impact absorbing rib that includes the two or more grooves 12, the impact absorbing rib 1a may include the grooves 12 that may be formed, for example, so as to connect three or more positions on the outline of the top surface of the impact absorbing rib 1a and divide the top surface into three or more regions. The shape of the multiple grooves 12 are not limited to the shape that intersects each other. For example, the shape of the multiple grooves 12 may be a shape such that the multiple grooves 12 divide the top surface of the impact absorbing rib 1a into three regions while the groove 12 connecting two positions of the four positions on the outline of the top surface and the groove 12 connecting the other two positions of the four positions on the outline of the top surface do not intersect with each other.

Nineth Embodiment

[0079] In a nineth embodiment, modifications of the cross-sectional shape of the groove 12 are described. The cross-sectional shape of the groove 12 according to the ninth embodiment may be, for example, a U-shape, a C-shape, or a V-shape. The cross-sectional shape of the groove 12 is a shape of a recess of the groove 12 from the top surface of the impact absorbing rib 1 to the bottom of the groove 12, and is, for example, a shape formed by the wall surfaces and the bottom of the groove 12, such as the U-shape or a shape formed by the wall surfaces of the groove 12, such as the V-shape. Further, in the shape formed by the wall surfaces and the bottom of the groove 12, the wall surfaces of the groove 12 may be inclined as in the case of the V-shape. FIGS. 39A, 39B, and 39C are diagrams each illustrating cross-sectional shapes of the groove 12 of the impact absorbing rib 1 according to the nineth embodiment of the present disclosure.

Tenth Embodiment

[0080] In a tenth embodiment of the present disclosure, the outer shapes of the impact absorbing rib 1 and the impact absorbing rib 2 are described with reference to FIGS. 30A and 30B, respectively. The outer shape of the impact absorbing ribs according to the tenth embodiment as the three-dimensional structure having a hollow interior may be a prismatic shape or a columnar shape. FIG. 30A is a perspective view of the prismatic impact absorbing rib 1 having the prismatic shape. FIG. 30B is a perspective view of the impact absorbing rib 2 having the columnar shape.

[0081] The prismatic shape of the impact absorbing rib 1 is, for example, a truncated pyramid shape as illustrated in FIG. 30A or a prism shape. In addition, the shape of the top surface or the bottom surface of the impact absorbing rib 1 is a prismatic shape. A part of the prismatic shape may include a deformed portion such as an uneven shape formed by straight lines or curved lines. The columnar shape of the impact absorbing rib 1 is, for example, a truncated cone, for example as illustrated in FIG. 30B or a column. Further, the shape of the top surface or the bottom surface of the impact absorbing rib 2 is basically a circular shape or an elliptical shape. A part of the circular shape or the elliptical shape may include a deformed portion formed by straight lines or curved lines.

Eleventh Embodiment

[0082] In an eleventh embodiment, modifications of the groove 12 are described. Shapes of the groove 12 viewed from above may be formed by an outer shape in which at least one of straight lines or curved lines are continuously connected to each other or any one of the straight lines or the curved lines are continuously connected to each other in a wave-shape. The shape of the outline formed as described above may be an I-shape or a cross shape. In the present embodiment, the shape of the groove 12 viewed from above may be a same shape as the top surface of the impact absorbing rib 1. For example, when the groove 12 is deformed from the top surface of the impact absorbing rib toward the bottom of the groove 12, the shape of the bottom of the groove 12 may be different from the shape of the top surface of the groove 12.

[0083] FIGS. 40A, 40B, 40C, and 40D are diagrams each illustrating a cross-sectional shape of the groove 12 provided for the impact absorbing rib 1 according to the eleventh embodiment. FIG. 40A, 40B, 40C, and 40D illustrate shapes of the top surface of the groove 12 provided for the impact absorbing rib 1 having a truncated quadrangular pyramid shape. FIG. 40A illustrate the top surface of the groove 12 having an I-shape formed by straight lines. FIG. 40B illustrates the top surface of the groove 12 having a cross-shape formed by straight lines. FIG. 40C illustrates the top surface of the groove 12 having a cross-shape formed by straight lines and curved lines. FIG. 40D illustrates the top surface of the groove 12 having a cross-shape formed by straight lines and curved lines. The groove 12 having the shapes as described above allows the impact absorbing rib 1 to secure the effect of rigidity enhancement function of the impact absorbing rib 1. Note that in the shapes of the groove 12 illustrated in FIGS. 40C and 40D, when the outer shape of the top surface of the impact absorbing rib 1 is a truncated cone, end portions of the groove 12 are curved lines. Thus, the shape of the groove 12 is an outline continuous in a wave shape formed by connected curved lines.

[0084] FIG. 41 is a diagram illustrating a top view of the groove 12 provided for the impact absorbing rib 1 in which the groove 12 has an outline continuous in a wave shape, illustrating how the rigidity of the outline of the groove 12 works against an applied force, according to the present embodiment. As illustrated in FIG. 41, when the groove 12 has the outline continuous in the wave shape, the rigidity of the impact absorbing rib 1 is reinforced with respect to the force received from multiple directions. Accordingly, the rigidity enhancement function of the impact absorbing rib 1 can be performed more reliably as intended.

Twelfth Embodiment

[0085] In a twelfth embodiment, the width of the groove 12 is described. The dimensions of the impact absorbing rib 1 and the groove 12 are illustrated in FIGS. 31 and 32B. A width bb of the groove 12 may be a length that is approximately twice or greater than the thickness t of the impact absorbing rib 1. The impact absorbing rib 1 exhibits the effect of rigidity enhancement when the rigidity reinforced portion 13 moderately fall into the groove 12 (see, for example, FIGS. 33A, 33B, 33C, and 37). For this reason, desirably the rigidity reinforced portion 13 located on both sides along the wall surfaces of the groove 12 do not interfere with each other even if the rigidity reinforced portion 13 fall toward the groove 12. Accordingly, for the groove 12 located between the rigidity reinforced portion 13, the width bb of the groove 12 has, preferably, a sufficient distance.

[0086] On the other hand, the width bb of the groove 12 is preferably set to be smaller than approximately one third of the width ba of the top surface of the impact absorbing rib 1. FIG. 42 is a schematic side view of the impact absorbing rib 1 and the groove 12, illustrating a disadvantage that may occur when the width of the groove 12 is too large, according to the present embodiment. Desirably, the impact absorbing rib 1 prevents the rigidity reinforced portion 13 to be likely to fall toward the groove 12, when each side of the rigidity reinforced portion 13 located on both sides along the wall surfaces of the groove 12 have a small width. Accordingly, setting the width bb of the groove 12 to an appropriate length allows to prevent a disadvantage that impairs the rigidity enhancement effect of the impact absorbing rib 1.

[0087] As described above, preferably, the width bb of the groove 12 is a length that is approximately twice or greater than the thickness t of the impact absorbing rib 1 and a length that is less than approximately one third of the width ba of the top surface of the impact absorbing rib 1.

Thirteenth Embodiment

[0088] In a thirteenth embodiment, a molded pulp packaging material provided with an impact absorbing rib according to one of the above embodiments of the present disclosure is described. The packaging material according to the present embodiment includes the impact absorbing rib at least at one position in the packaging material. Such a configuration as described above allows the above-described rigidity enhancement function of the impact absorbing rib to be attained.

[0089] In addition, in the packaging material, the impact absorbing rib may be disposed such that a top surface of the impact absorbing rib contacts the object to be packaged. FIG. 43 is a perspective view of the packaging material 200 in which the impact absorbing rib 1 is disposed such that the top surface of the impact absorbing rib 1 contacts an object to be packaged, according to the present embodiment. In the packaging material 200, the top surface of the impact absorbing rib 1 provided with the groove 12 contacts the object to be packaged when the object to be packaged is accommodated in the object to be packaged accommodating space 210. Such a configuration as described above allows the object to be packaged to be accommodated in an effective manner such that a load is applied to intended positions of the object to be packaged.

[0090] In addition, in the packaging material 200, the impact absorbing rib 1 may be disposed such that a surface of the impact absorbing rib 1 that includes an opening, i.e., a bottom surface of the impact absorbing rib 1, contacts the object to be packaged. FIG. 44 is a perspective view of the packaging material 200 in which the impact absorbing rib 1 is disposed such that the surface of the impact absorbing rib 1 that includes the opening contacts the object to be packaged, according to the present embodiment. FIG. 44 is a perspective view of the packaging material 200 viewed from a reverse side from the accommodation space of the packaging material 200 in which the object to be packaged is accommodated and illustrates the packaging material 200 in a state in which the top surface of the impact absorbing rib 1 provided with the groove 12 is disposed. Such a configuration as described above allows a surface of the object to be packaged accommodating space 210 and a side surface of the object to be packaged to surface contact each other, when the side surface of the object to be packaged is flat. Thus, the object to be packaged, such as a product, can be stably held in the packaging material 200. In addition, the packaging material 200 described above may be used, for example, to accommodate an imaging system product.

[0091] As described in each of the above embodiments, each of the impact absorbing ribs as examples of the impact absorber according to the embodiments of the present disclosure and each of the packaging materials provided with the corresponding one of the impact absorbing ribs form a structure in which a large impact force is not applied to the object to be packaged. Accordingly, a disadvantage in which the object to be packaged may break can be solved. In addition, the above-described configuration according to the embodiments allows the quality of the packaging material as a packaging material for protecting an object to be packaged to be significantly enhanced, which leads to delivery of a product to a customer without breakage. Further, solving the disadvantages that are inherent in the comparative molded pulp impact absorbing materials allows to promote the use of materials having desirable resource recovery and recycling properties. Thus, the degree of contribution of using the above-described packaging material toward the realization of a circular society and the solving of plastic environmental disadvantages can be enhanced.

[0092] Results of a test using the impact absorbing ribs according to the above embodiments and the control sample of the present disclosure are described in the following description. Test Method In the test, the spectral response acceleration of the object to be packaged was measured using the packaging material that includes the impact absorbing rib according to the control sample and the packaging material that includes the impact absorbing rib according to one of the above-described embodiments of the present disclosure. FIGS. 45A and 45B are diagrams each illustrating the impact absorbing rib 1p and the impact absorbing rib 1 used in the test, respectively. FIG. 45A is a diagram illustrating the impact absorbing rib 1p according to the control sample. FIG. 45B is a diagram illustrating the impact absorbing rib 1 according to the embodiment of the present disclosure.

[0093] As the control sample, the impact absorbing rib 1p that has a basic structure of a truncated quadrangular pyramid shape known in the art was used. As the impact absorbing rib according to the embodiment, the impact absorbing rib 1 that has a truncated quadrangular pyramid shape, provided with the groove 12, is used. A drop test was conducted under following conditions to measure the impact response acceleration of the object to be packaged.

Weight: m1 = 1.02 kg (aluminum)
Impact absorbing material: corrugated cardboard wastepaper
Thickness t of molded pulp impact absorbing material = 2 mm
Test conditions: 80 cm free fall

Test Results

[0094] FIG. 46 is a table illustrating test results of the drop test using impact absorbing rib 1p and the impact absorbing rib 1. Five tests from test number N1 to N5 were conducted to measure the impact response accelerations (G's) of an external component of a product to calculate the average accelerations (G's) and the standard deviation of measured values (1δ). The impact response accelerations of the impact absorbing rib 1p according to the control sample were 43.79 G's as the average accelerations. In comparison, the impact response accelerations of the impact absorbing rib 1 according to the embodiment were 50.76 G's. Further, the standard deviation of the measured values that indicates variations was reduced by half to 3.16 of the impact absorbing rib 1 according to the embodiment as compared with 6.97 of the impact absorbing rib 1p according to the control sample. As described above, relatively excellent results were obtained.

[0095] Other embodiments and each of the above-described embodiments are described with reference to the packaging materials made of molded pulp and the impact absorbing ribs made of molded pulp. However, the packaging materials and the impact absorbing ribs are not limited to molded pulp packaging materials and the molded pulp impact absorbing ribs. For example, another material such as a non-resin plastic impact absorbing material may be used for the impact absorbing rib and the packaging material.

[0096] Note that embodiments of the present disclosure are not limited to the embodiments described above. Within the scope of the present disclosure, it is possible to modify, add, and convert each element of the above-described embodiments to contents that can be easily considered, and combine the above-described embodiments as needed by those skilled in the art.

Claims

1. An impact absorber (1, 1a, 1x, 2) comprising a three-dimensional structure, the three-dimensional structure including:

a closed top surface;
an open bottom;
a hollow inside; and

a recess (11, 11x, 21) within an outline of the top surface.

2. The impact absorber (1, 2) according to claim 1, further comprising another recess (12, 22) within the outline of the top surface.

3. The impact absorber (1) according to claim 1 or 2,

wherein the recess (12, 22) has a U-shape, a C-shape, or a V-shape in cross section, and
wherein the impact absorber (1, 1p, 2) is a prismatic outer shape or a cylindrical outer shape.

4. The impact absorber (1) according to any one of claims 1 to 3,
wherein the recess (11) has, in top view, a polygonal shape, a circular shape, or an outer shape in which curved lines or straight lines are connected with each other in a wave shape.

5. The impact absorber (1) according to any one of claims 1 to 4,
wherein a depth of the recess (11) is equal to or greater than twice a thickness of the impact absorber (1) and equal to or smaller than half of a height of the impact absorber (1).

6. The impact absorber (1) according to any one of claims 1 to 5,
wherein a distance between the outline of the top surface and the recess (11) is greater than twice a thickness of the impact absorber (1) and equal to or less than half of a length of the outline of the top surface along a same direction as the distance.

7. A packaging material (200) comprising the impact absorber (1, 1a, 1x, 2) according to any one of claims 1 to 6 at at least one position,
wherein the impact absorber (1, 1a, 1x, 2) comprises molded pulp.

8. The packaging material (200) according to claim 7,
wherein the top surface of the impact absorber (1, 1a, 1x, 2) is disposed at a position to contact on an object to be packaged.

9. An impact absorber (1) comprising a three-dimensional structure, the three-dimensional structure including:

a closed top surface;
an open bottom;
a hollow inside; and
a groove (12, 22) crossing the top surface, the groove having a depth equal to or greater than twice a thickness of the impact absorber and equal to or smaller than one fifth of a structural height of the impact absorber.

10. The impact absorber (1a) according to claim 9, further comprising another groove (11) crossing the top face,

wherein said another groove (11) has the depth equal to or greater than twice the thickness of the impact absorber and equal to or smaller than one fifth of the structural height of the impact absorber, and
wherein the groove (11) is orthogonal to said another groove (11).

11. The impact absorber (1) according to claim 9 or 10,

wherein the groove (11) has a U-shape, a C-shape, or a V-shape in cross section, and
wherein the impact absorber (1, 2) has a prismatic outer shape or a cylindrical outer shape.

12. The impact absorber (1) according to any one of claims 9 to 11,
wherein the groove (12) has, in top view, an I-shape or a cross-shape including a continuous line connecting straight lines, a continuous line connecting curved lines, or a continuous line connecting a straight line and a curved line.

13. The impact absorber (1) according to any one of claims 9 to 12,
wherein a width of the groove (12) is equal to or more than twice a thickness of the impact absorber and less than one third of a width of the top surface of the impact absorber.

14. A packaging material (200) comprising the impact absorber (1) according to any one of claims 9 to 13 at at least one position,
wherein the impact absorber (1, 1a, 1x, 2) comprises molded pulp.

15. The packaging material (200) according to claim 14,
wherein a top surface of the impact absorber (1) is disposed at a position to contact on an object to be packaged.

FIG. 1

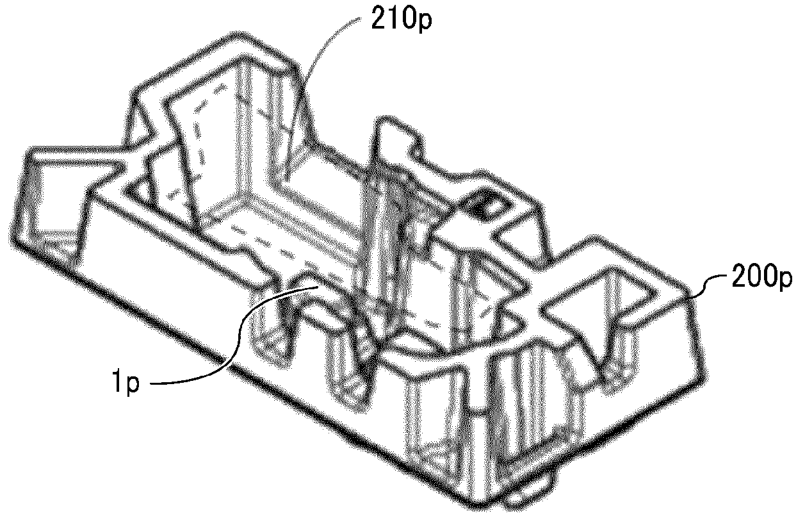


FIG. 2A

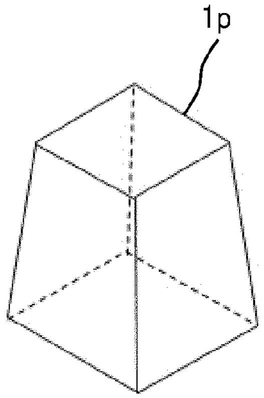


FIG. 2B

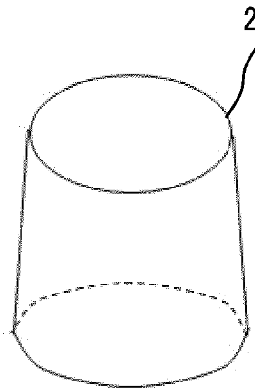


FIG. 3

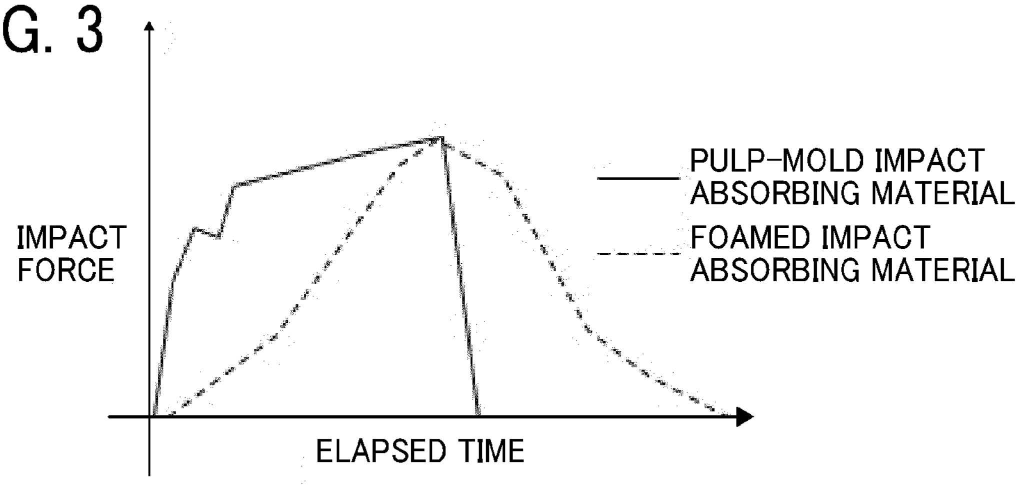


FIG. 4A

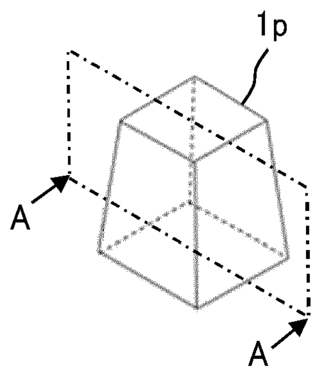


FIG. 4B

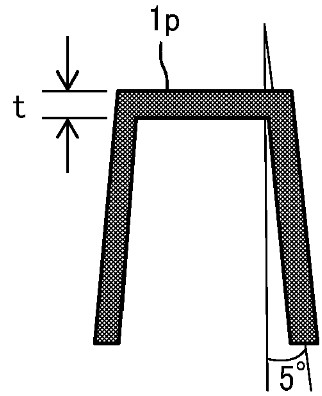


FIG. 5

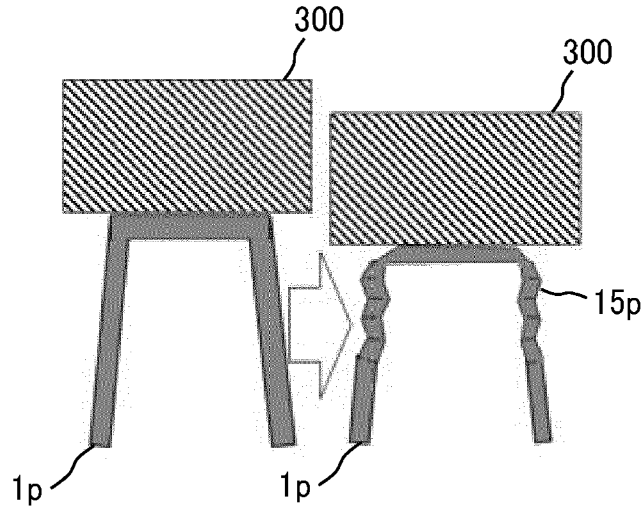


FIG. 6A

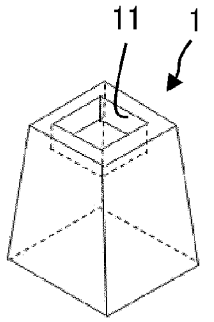


FIG. 6B

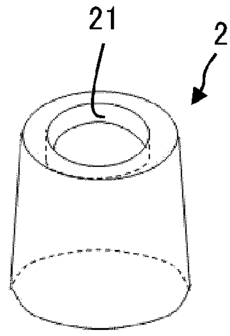


FIG. 7

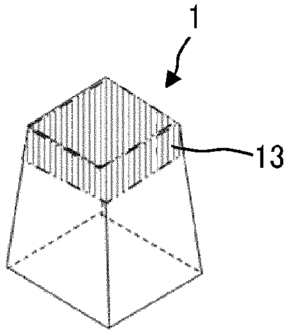


FIG. 8A

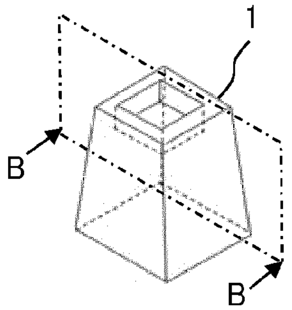


FIG. 8B

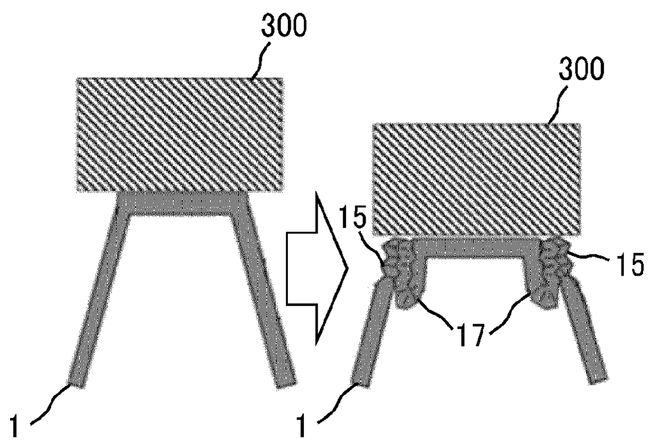


FIG. 9

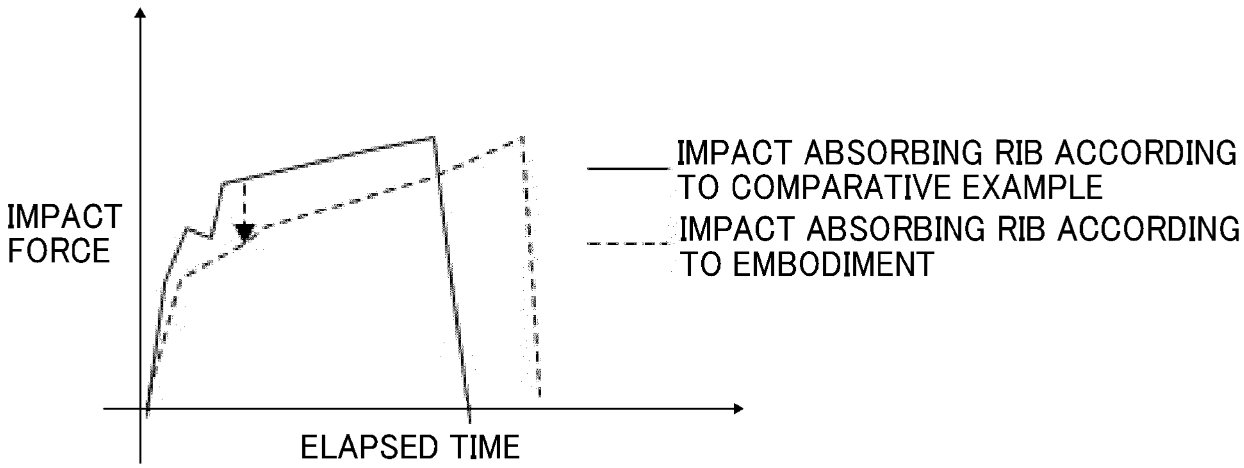


FIG. 10

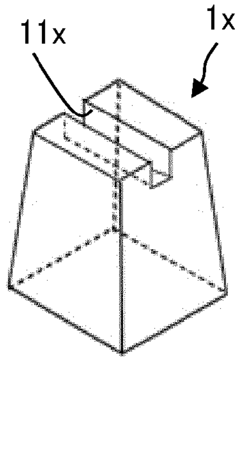


FIG. 11

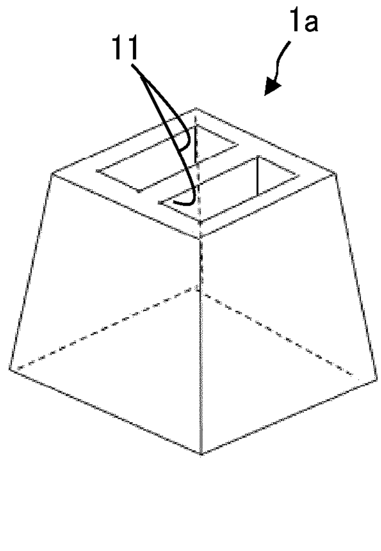


FIG. 12A

FIG. 12B

FIG. 12C

FIG. 13A

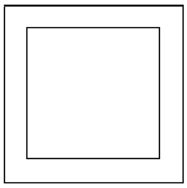


FIG. 13B

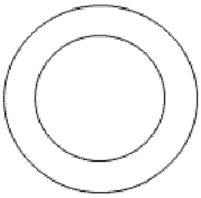


FIG. 13C

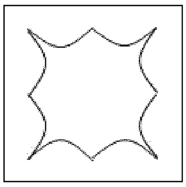


FIG. 13D

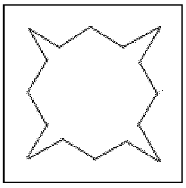


FIG. 14A

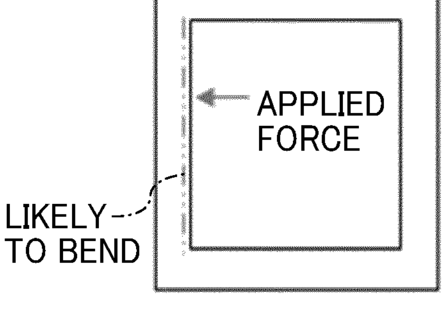


FIG. 14B

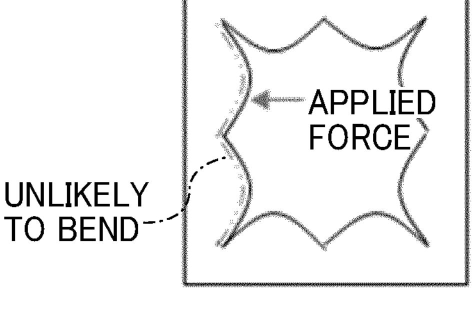


FIG. 15

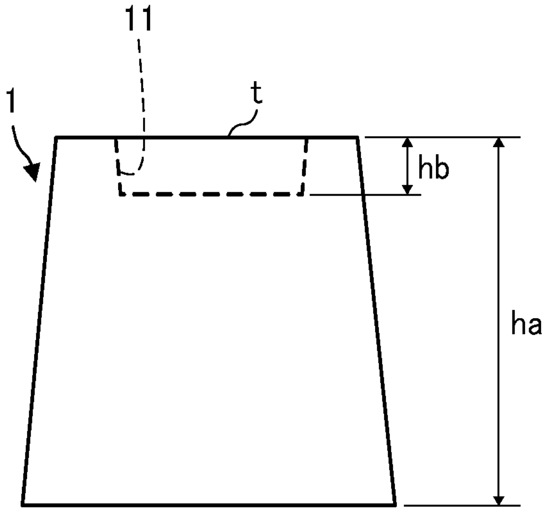

11
1
t
hb
ha

FIG. 16

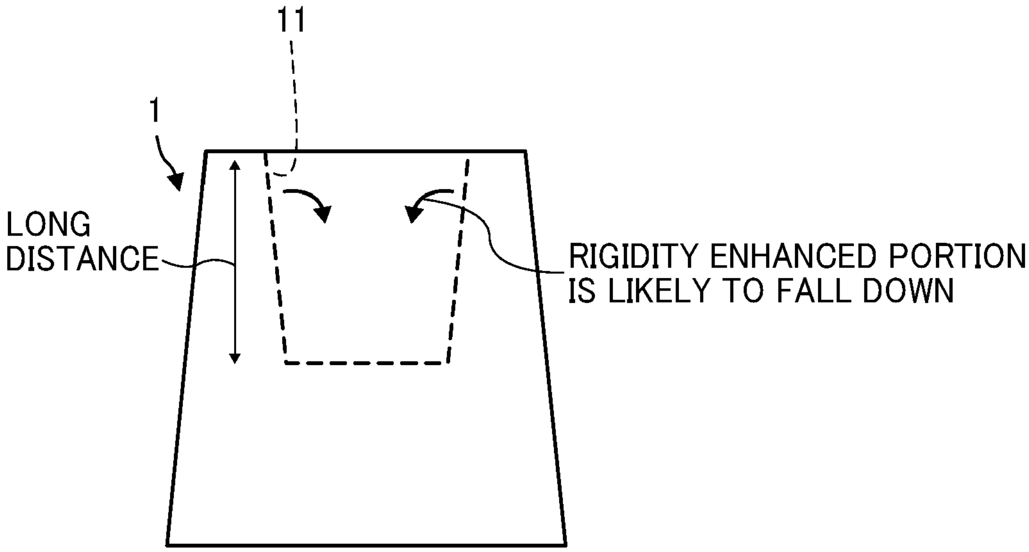

11
1
LONG
DISTANCE
RIGIDITY ENHANCED PORTION
IS LIKELY TO FALL DOWN

FIG. 17

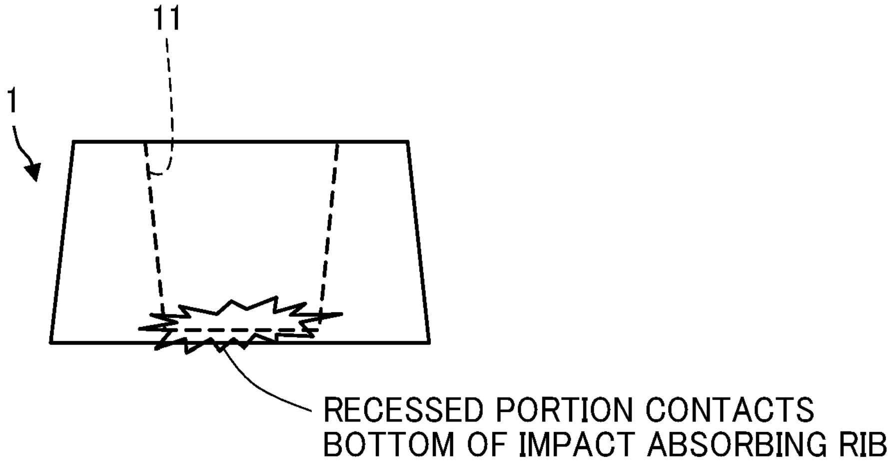

11
1
RECESSED PORTION CONTACTS
BOTTOM OF IMPACT ABSORBING RIB

FIG. 18

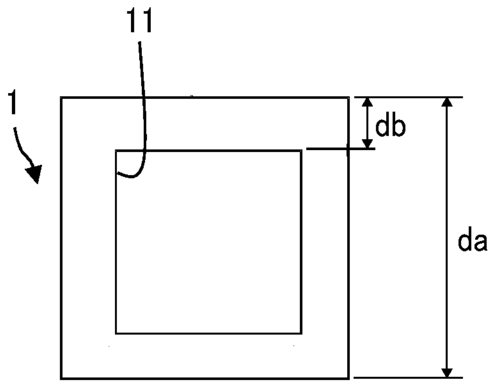

11
1
db
da

FIG. 19

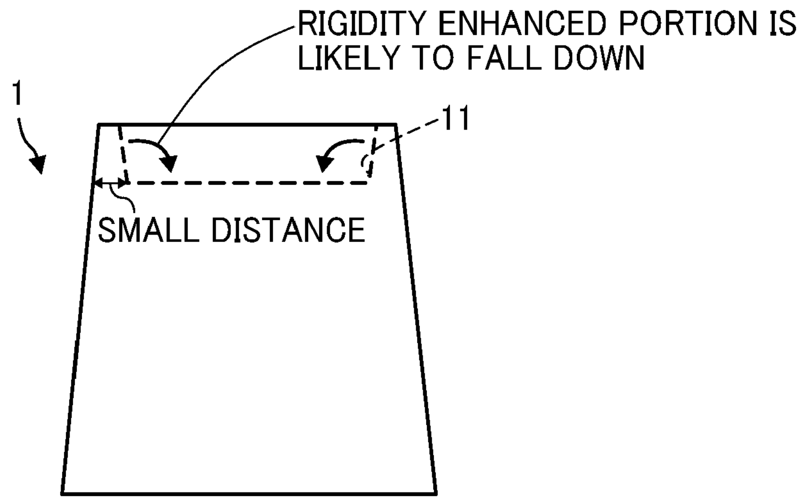
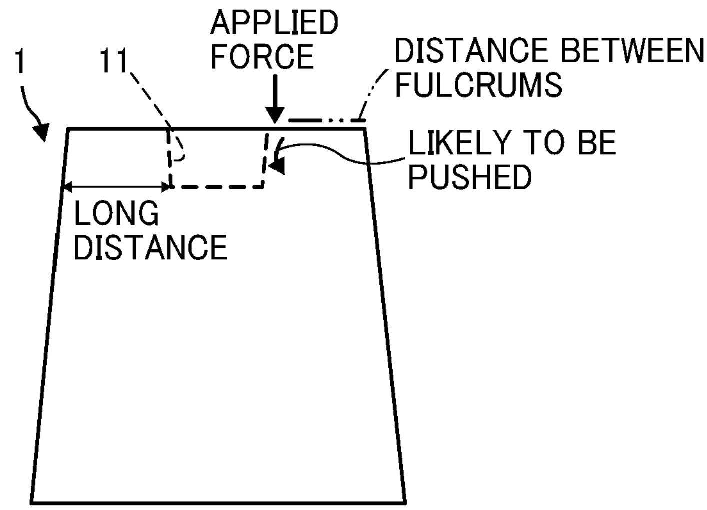

RIGIDITY ENHANCED PORTION IS
LIKELY TO FALL DOWN
1
11
SMALL DISTANCE

FIG. 20


APPLIED
FORCE
1
11
DISTANCE BETWEEN
FULCRUMS
LIKELY TO BE
PUSHED
LONG
DISTANCE

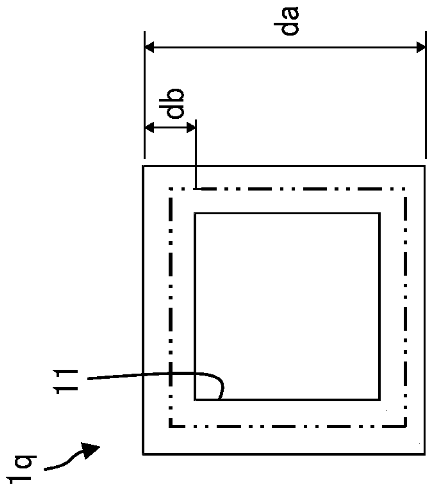


FIG. 21A

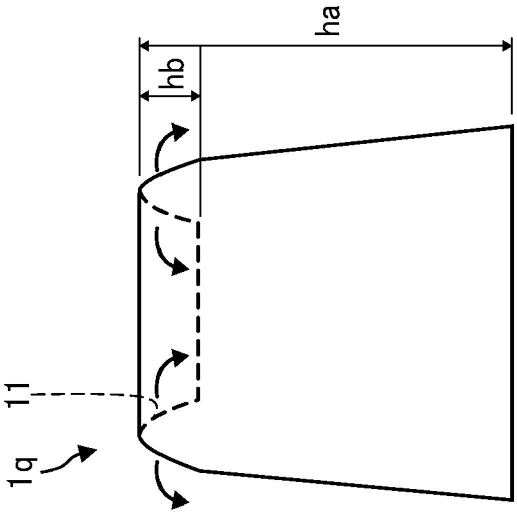


FIG. 21B

FIG. 22

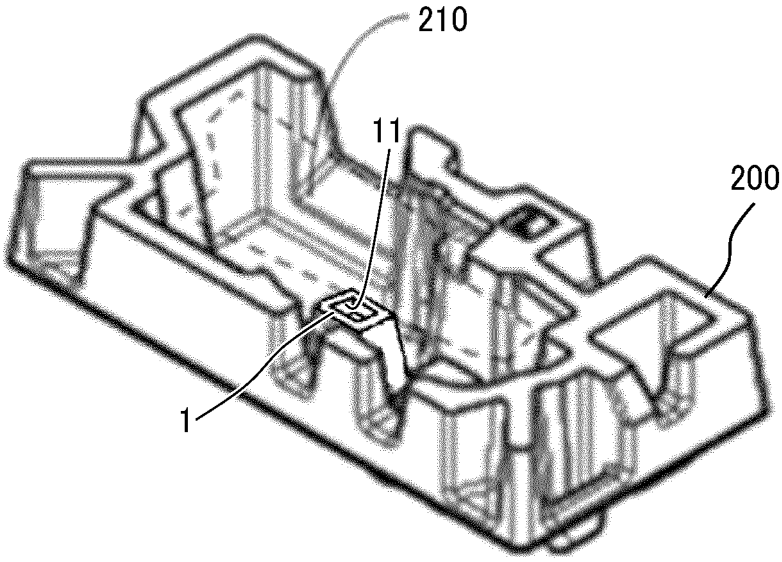


FIG. 23

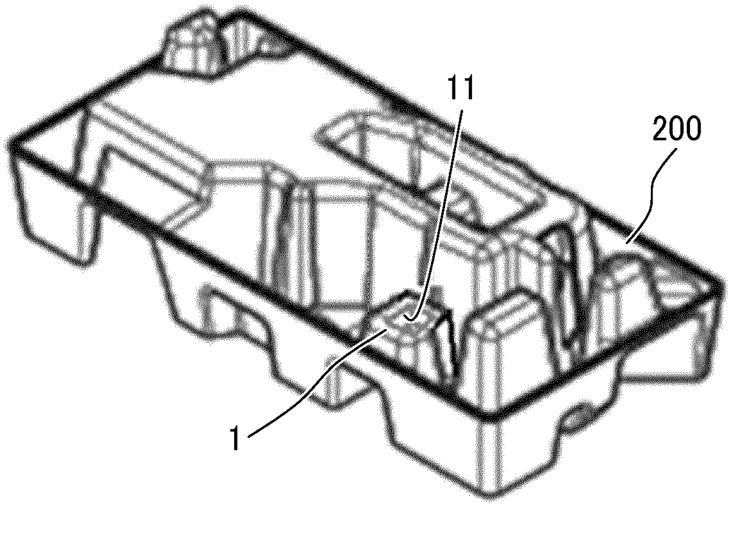


FIG. 24A

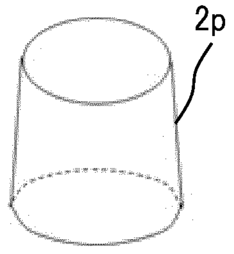


FIG. 24B

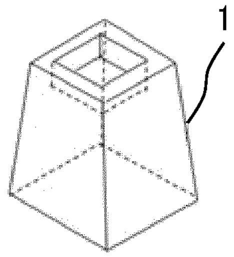


FIG. 25

NATURAL FREQUENCY: 200 Hz

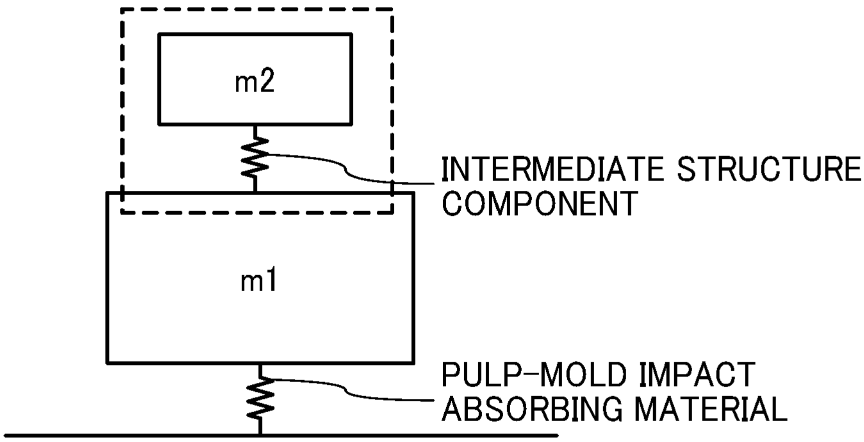


FIG. 26

EXPERIMENT TYPE	EXPER-IMENT NO.	EXTERNAL COMPONENT IMPACT RESPONSE ACCELERATION (G's)	INTERNAL COMPONENT IMPACT RESPONSE ACCELERATION (G's)	IMPACT AMPLIFI-CATION FACTOR
CONTROL SAMPLE	N1	47.79	73.11	1.53
	N2	50.28	69.19	1.38
	N3	47.46	73.88	1.56
	N4	52.97	71.77	1.35
	N5	55.85	74.06	1.33
EMBODIMENT	N1	44.99	52.76	1.17
	N2	54.62	55.24	1.01
	N3	49.46	56.40	1.14
	N4	51.19	54.47	1.06
	N5	53.45	65.62	1.23

FIG. 27

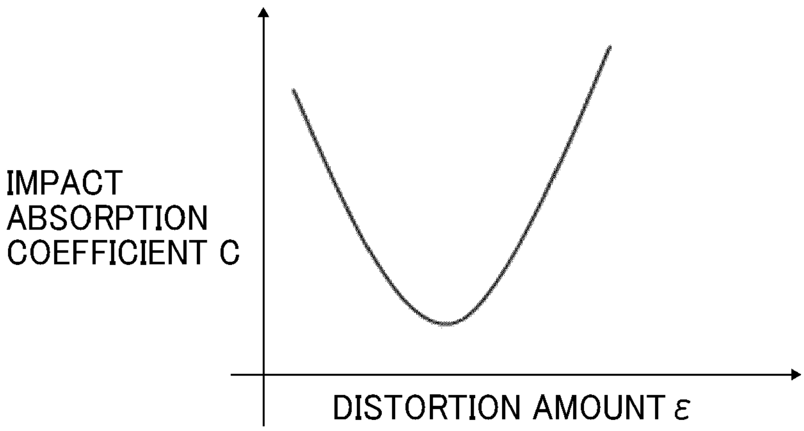

IMPACT
ABSORPTION
COEFFICIENT C
DISTORTION AMOUNT ε

FIG. 28

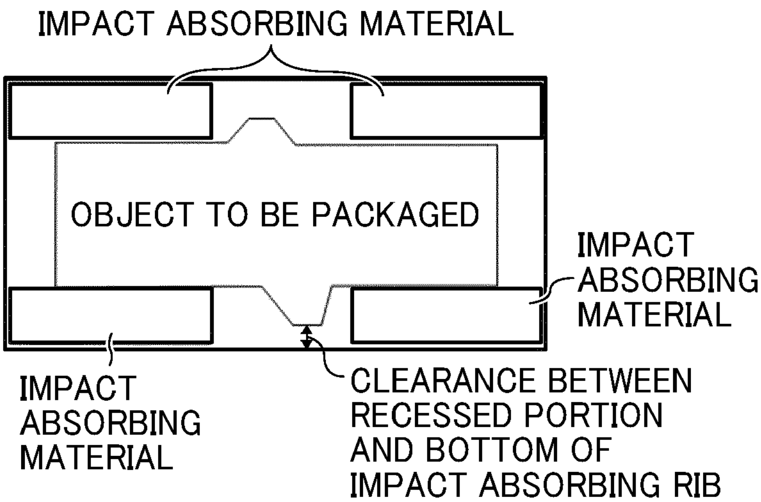

IMPACT ABSORBING MATERIAL
OBJECT TO BE PACKAGED
IMPACT
ABSORBING
MATERIAL
IMPACT
ABSORBING
MATERIAL
CLEARANCE BETWEEN
RECESSED PORTION
AND BOTTOM OF
IMPACT ABSORBING RIB

FIG. 29

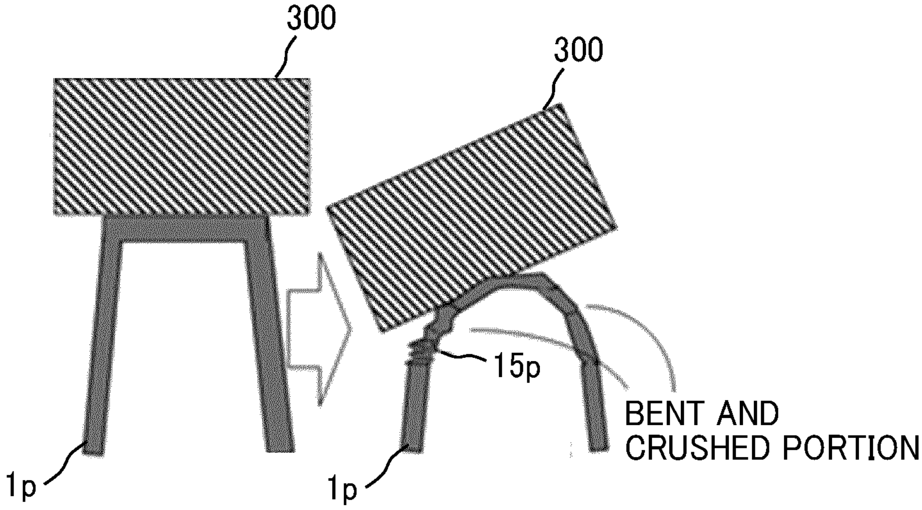


FIG. 30A FIG. 30B

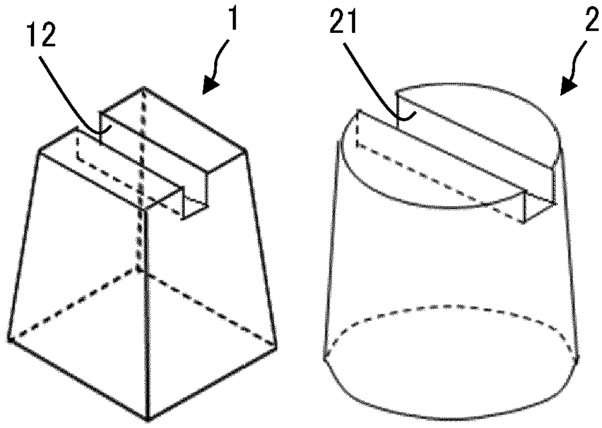


FIG. 31

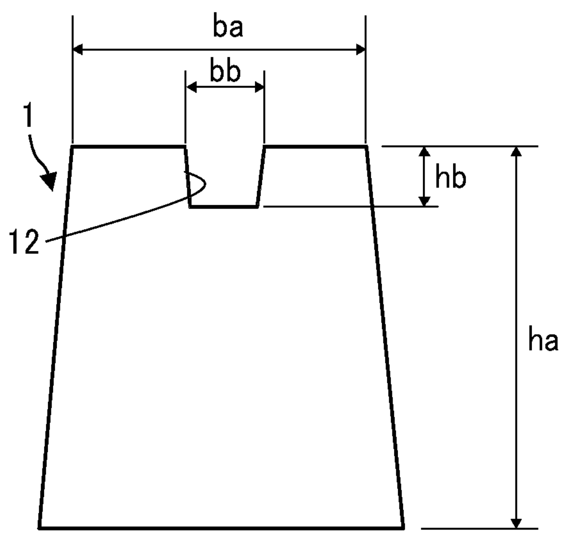


FIG. 32A

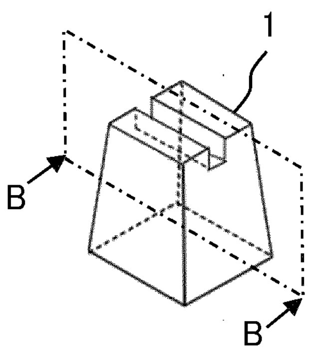


FIG. 32B

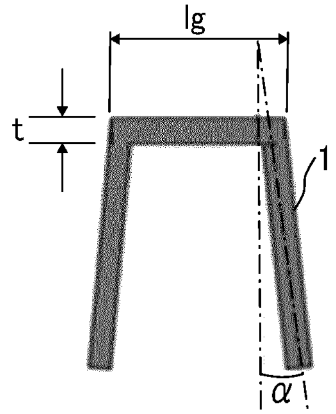


FIG. 33A

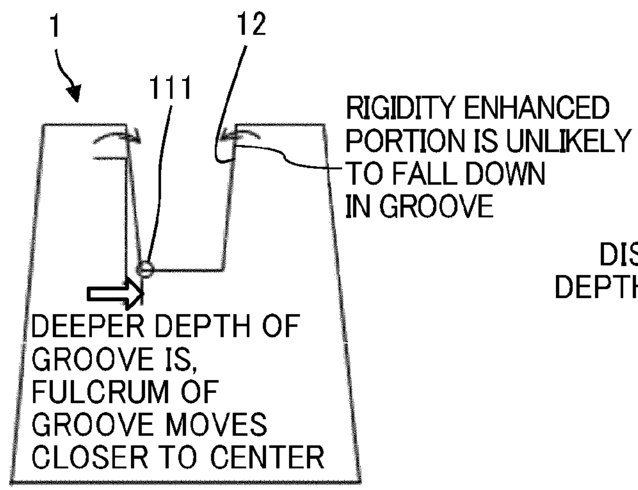


FIG. 33B

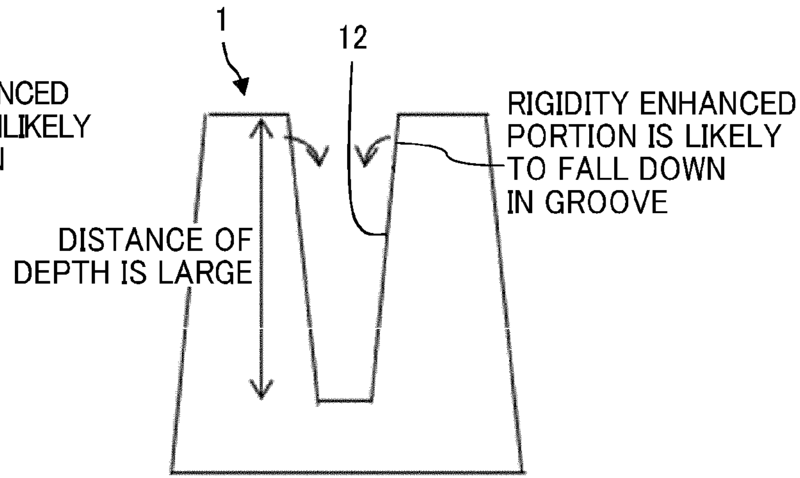


FIG. 33C

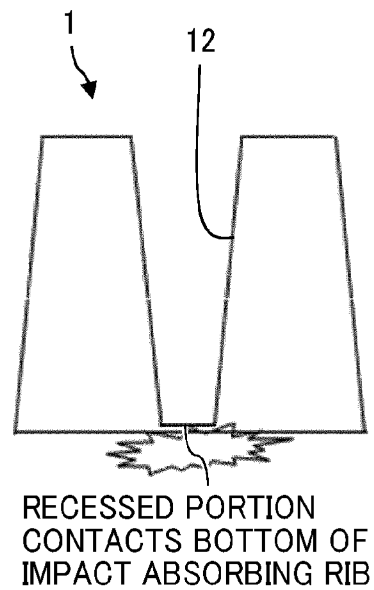


FIG. 34

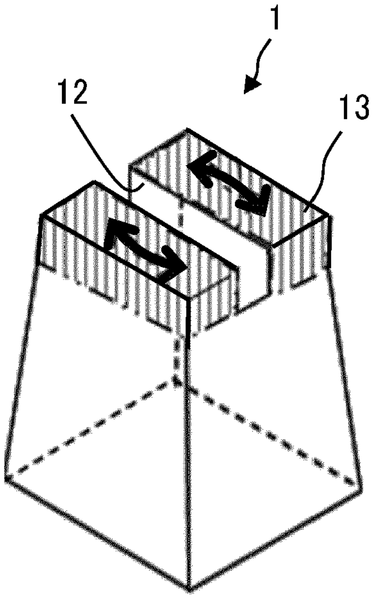


FIG. 35

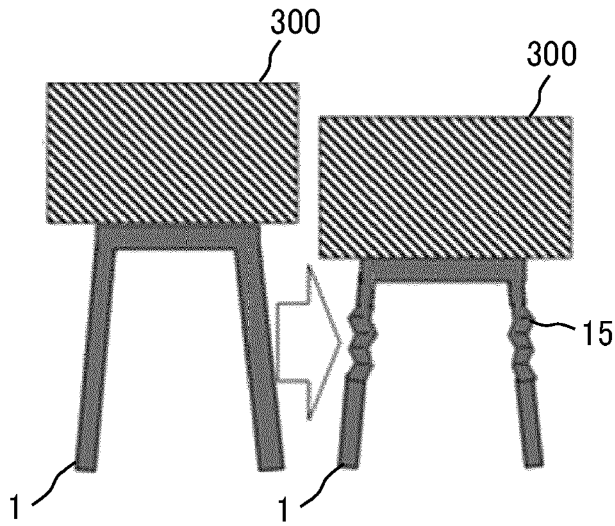


FIG. 36A

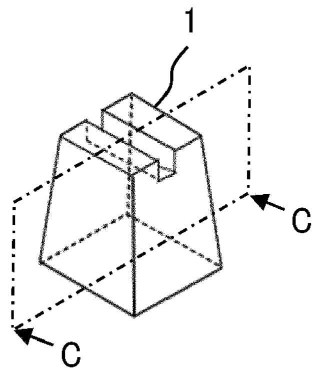


FIG. 36B

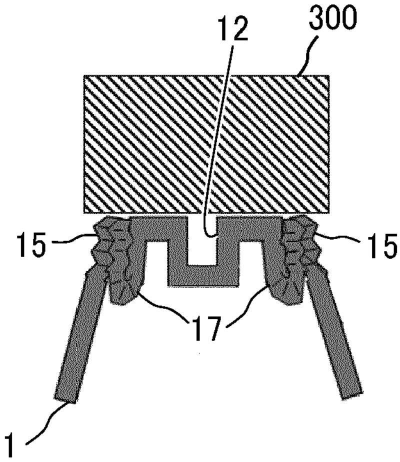


FIG. 37

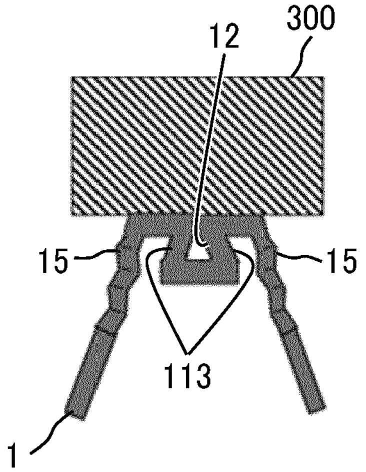


FIG. 38

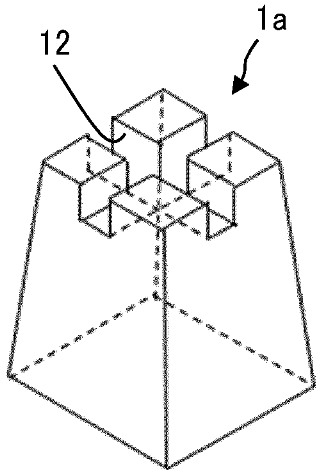


FIG. 39A FIG. 39B FIG. 39C

FIG. 40A FIG. 40B FIG. 40C FIG. 40D

FIG. 41

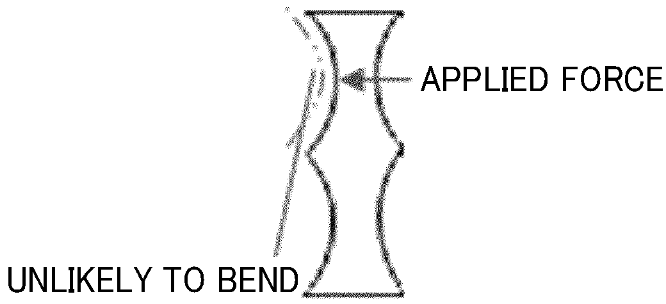


FIG. 42

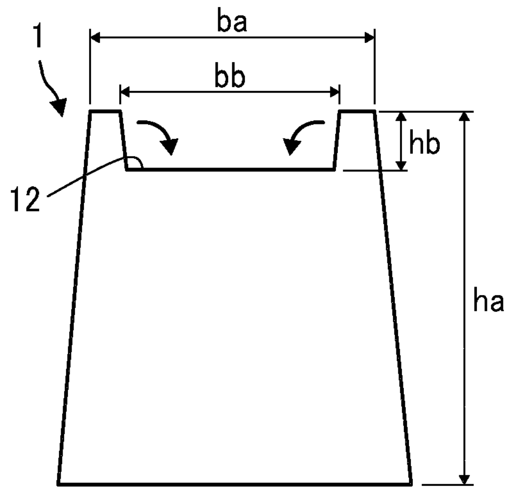


FIG. 43

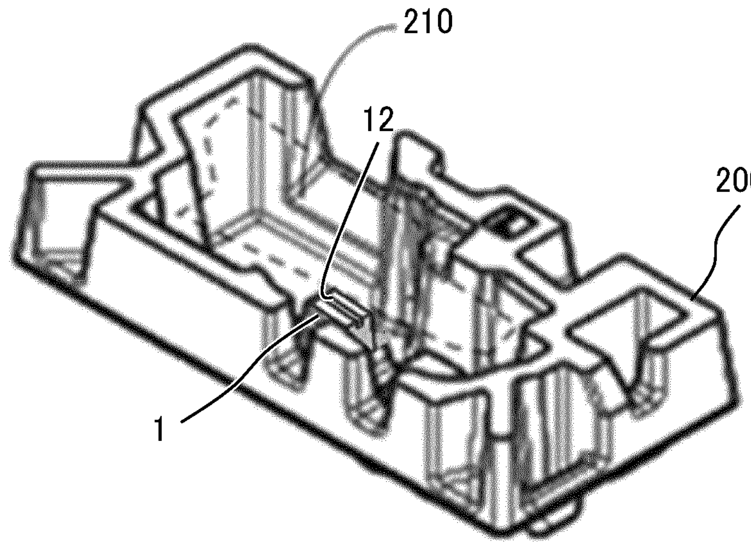


FIG. 44

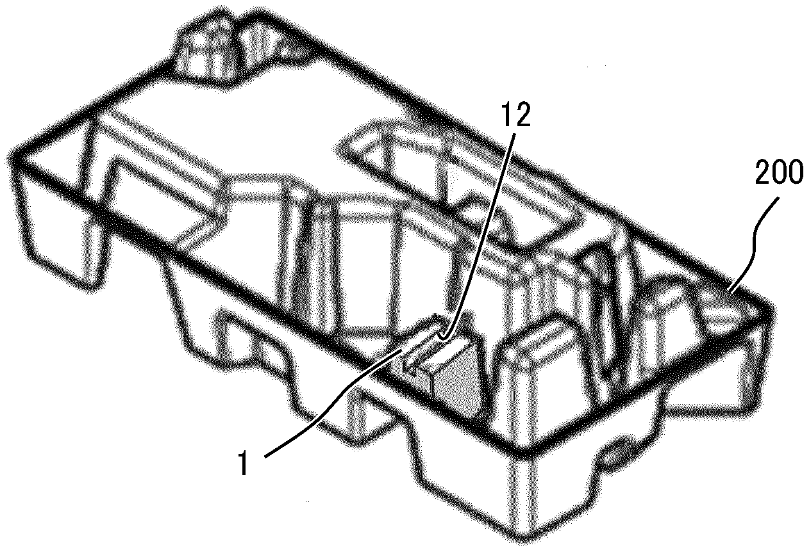
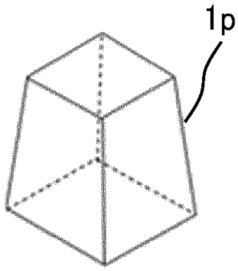


FIG. 45A

FIG. 45B



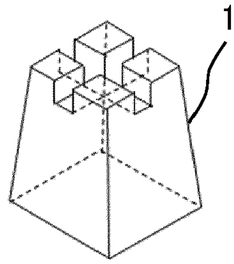


FIG. 46

EXPERIMENT TYPE	EXPER-IMENT NO.	EXTERNAL COMPONENT IMPACT RESPONSE ACCELERATION (G's)	AVERAGE ACCELER-ATION(G's)	STANDARD DEVIATION OF MEASURED VALUES(1 σ)
CONTROL SAMPLE	N1	48.17	50.76	6.97
	N2	54.00		
	N3	59.58		
	N4	51.24		
	N5	40.80		
EMBODIMENT	N1	40.31	43.79	3.16
	N2	47.35		
	N3	46.94		
	N4	42.24		
	N5	42.13		