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Packing material and method of manufacturing the packing material

Abstract

A packing material including a plurality of discrete cushioning elements and methods for making the same. The discrete cushioning elements may be cellulosic cushioning elements. A flexible linkage may connect the plurality of discrete cushioning elements in the packing material. The packing material may also include a bottom cellulosic sheet connected to a top cellulosic sheet with the plurality of cellulosic cushioning elements positioned between the top cellulosic sheet and the bottom cellulosic sheet. The packing material may also be a molded packing material that includes bonds comprising adhesive and cellulosic fibers. The adhesive and cellulosic fibers of the bonds may be dispersed between the folds of each of the cellulosic cushioning elements.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of International Patent Application No. PCT/US21/42719, filed Jul. 22, 2021, which claims priority to U.S. patent application Ser. No. 17/197,837, filed Mar. 10, 2021, U.S. patent application Ser. No. 17/197,889, filed Mar. 10, 2021, and U.S. Provisional Patent Application No. 63/054,853, filed Jul. 22, 2020, and titled "PACKING MATERIAL AND METHOD OF MANUFACTURING THE PACKING MATERIAL," the entirety of which are incorporated herein by reference.

FIELD OF THE INVENTION
(1) The invention relates to packing material, particularly packing material that includes a plurality of discrete cushioning elements made from paper. The invention is also related to methods of manufacturing the same.
BACKGROUND OF THE INVENTION
(2) Various packing materials are used to secure items in shipping containers, including cardboard boxes, to thereby prevent damage to these items if they move within the shipping container during shipment or other impacts during shipping, such as being dropped or hit. Such packing materials include bubble wrap, expanded polystyrene (polystyrene foam), and other plastic foam packing, which may be molded into blocks or into other shapes, peanuts, and inflated plastic bags (also known as air pillows). These plastic products may be discarded as waste after they have been used during shipping. Plastic waste takes a long time to decompose and produces carbon dioxide in the decomposition process. In addition, polystyrene foam does not readily biodegrade, and may take many, many years to break down. With an increased awareness of the negative effects of plastics and polystyrene foam on the environment, however, consumers are increasingly seeking to use

environmentally-friendly, recyclable, and biodegradable products as a packing material. There are desired environmentally-friendly, recyclable, and biodegradable products that provide sufficient cushioning effects at an affordable cost.

SUMMARY OF THE INVENTION

(3) In one aspect, the invention relates to a packing material including a plurality of cellulosic cushioning elements, a top cellulosic sheet arranged one side of the plurality of cellulosic cushioning elements, and a bottom cellulosic sheet arranged on an opposite side of the plurality of cellulosic cushioning elements. Each cellulosic cushioning element of the plurality of cellulosic cushioning elements have a plurality of folds and are formed into a shape. The bottom cellulosic sheet is connected to the top cellulosic sheet with the plurality of cellulosic cushioning elements positioned between the top cellulosic sheet and the bottom cellulosic sheet.

(4) In another aspect, the invention relates to a packing material including a plurality of discrete cushioning elements and a flexible linkage connecting the plurality of discrete cushioning elements. The plurality of discrete cushioning elements is arrayed in a first direction and have an order with each cushioning element of the plurality of discrete cushioning elements is adjacent to at least one other cushioning element of the plurality of discrete cushioning elements. The at least one other cushioning element of the plurality of discrete cushioning elements is a first adjacent cushioning element, and each cushioning element is spaced apart from a respective first adjacent cushioning element with a first gap formed between each cushioning element and the respective first adjacent cushioning element. Each cushioning element is connected to the respective first adjacent cushioning element by the flexible linkage. The flexible linkage spans the first gap between each cushioning element and the respective first adjacent cushioning element.

(5) In a further aspect, the invention relates to a method of manufacturing packing material. The method includes filling a plurality of pockets of a first cellulosic sheet with a plurality of cellulosic cushioning elements. Each pocket has an opening through which the pocket is filled. The method further includes applying an aqueous slurry of cellulosic fibers and adhesive to the plurality of cellulosic cushioning elements in each pocket of the first cellulosic sheet, drying the aqueous slurry and the plurality of cellulosic cushioning elements, and bonding a second cellulosic sheet to the first cellulosic sheet to cover the openings of the plurality of pockets in the first cellulosic sheet.

(6) In yet another aspect, the invention relates to a packing material including a plurality of cellulosic cushioning elements and bonds bonding the plurality of cellulosic cushioning elements to each other. Each cellulosic cushioning element of the plurality of cellulosic cushioning elements has a plurality of folds and is formed into a shape. The bonds comprise adhesive and cellulosic fibers. The adhesive and cellulosic fibers of the bonds are dispersed between the folds of each of the cellulosic cushioning elements.

(7) In still another aspect, the invention relates to a method of manufacturing molded packing material. The method includes filling a mold with a plurality of cellulosic cushioning elements; applying an aqueous slurry of cellulosic fibers and adhesive to the plurality of cellulosic cushioning elements in the mold; drying the aqueous slurry and the plurality of cellulosic cushioning elements to form a molded packing material; and removing the molded packing material from the mold.

(8) In yet a further aspect, the invention relates to a method of manufacturing packing material. The method includes providing a cellulosic sheet. The cellulosic sheet has a thickness and a face surface. The face surface has a surface area. The cellulosic sheet has a thickness direction and an orthogonal direction that is orthogonal to the thickness direction. The method also includes compressing the cellulosic sheet to form a compressed cellulosic sheet; and twisting the compressed cellulosic sheet to form a crumpled cellulosic sheet.

(9) These and other aspects of the invention will become apparent from the following disclosure.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1**A shows a cellulosic cushioning element that can be used as a packing material according to a preferred embodiment of the invention. FIG. **1**B shows an alternative cellulosic cushioning element that can be used as the packing material.

(2) FIG. **2** is a shipping box containing an item and a plurality of the cellulosic cushioning elements in FIG. **1**A.

(3) FIGS. **3**A-**3**D show a method and machine used to manufacture the cellulosic cushioning element shown in FIG. **1**A. FIG. **3**A shows a first step, FIG. **3**B shows a second step, FIG. **3**C shows a third step, and FIG. **3**D shows a fourth step.

(4) FIGS. **4**A-**4**D show an alternate method and machine used to manufacture the cellulosic cushioning element shown in FIG. **1**A. FIG. **4**A shows a first step, FIG. **4**B shows a second step, FIG. **4**C shows a third step, and FIG. **4**D shows a fourth step.

(5) FIG. **5** is a perspective view of feeding rollers that may be used with the method and apparatus shown in FIGS. **4**A-**4**D.

(6) FIGS. **6**A and **6**B are cellulosic cushioning elements that may be produced by the method and apparatus shown in FIGS. **4**A-**4**D. FIG. **6**A is a cellulosic cushioning element that is produced without shaping by the feeding rollers, and FIG. **6**B is a cellulosic cushioning element that is produced with the feeding rollers shown in FIG. **5**.

(7) FIGS. **7**A and **7**B each show a packing material with linkages connecting discrete cushioning elements. The packing material in FIGS. **7**A and **7**B use the cellulosic cushioning elements shown in FIG. **1**A as discrete cushioning elements. FIG. **7**A shows one way the linkage is attached to the cellulosic cushioning elements, and FIG. **7**B shows another way the linkage is attached to the cellulosic cushioning elements.

(8) FIG. **8** shows the packing material of FIG. **7**B with alternative discrete cushioning elements.

(9) FIG. **9** shows the packing material of FIG. **7**A with alternative linkages.

(10) FIG. **10** shows another packing material with linkages connecting discrete cushioning elements. The packing material in FIG. **10** uses the cellulosic cushioning elements shown in FIG. **1**A as discrete cushioning elements.

(11) FIG. **11** shows the packing material of FIG. **10** used on a bottle.

(12) FIG. **12** shows a method of manufacturing the packing material shown in FIG. **9**.

(13) FIG. **13** shows another packing material using the cellulosic cushioning elements shown in FIG. **1**A as discrete cushioning elements.

(14) FIG. **14** shows further packing material using the cellulosic cushioning elements shown in FIG. **1**A as discrete cushioning elements.

(15) FIG. **15** is a cross-sectional view of the packing material shown in FIG. **14** taken along line **15**-**15** in FIG. **14**.

(16) FIG. **16** is an alternate cross-sectional view of the packing material shown in FIG. **14** taken along line **15**-**15** in FIG. **14**.

(17) FIG. **17** shows a variation of the packing material shown in FIG. **14**.

(18) FIG. **18** shows another variation of the packing material shown in FIG. **14**.

(19) FIG. **19** shows a method and machine used to manufacture the packing material shown in FIG. **14**.

(20) FIG. **20** shows a further packing material using the cellulosic cushioning elements shown in FIG. **1**A.

(21) FIG. **21** is a cross-sectional view of the packing material shown in FIG. **20** taken along line **21**-**21** in FIG. **20**.

(22) FIG. **22** shows a method and machine used to manufacture the packing material shown in FIG. **20**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(23) The packing materials disclosed herein utilize a cushioning element **100** as a base material. FIG. **1**A shows a preferred cushioning element **100** that may be used in the packing materials discussed further below. This cushioning element **100** is preferably a cellulosic cushioning element **110**, being formed from paper composed of cellulosic fibers. Other suitable cushioning elements **100**, as will be described in certain embodiments below, may also be used in the packing materials discussed herein. Paper is a preferred material used for the cellulosic cushioning element **110**, as paper is biodegradable. The paper used herein is preferably recycled paper (e.g., previously-used paper). Various suitable basis weights and thicknesses may be used for the cellulosic cushioning elements **110** discussed herein and they may be varied depending upon application. As will be described further below, the paper is preferably crumpled into a shape that is preferably ball-like or sphere-like or cylindrical. The cellulosic cushioning element **110** may be relatively small in size, such as approximately 0.25 inch in diameter, or relatively large in size, such as approximately one inch in diameter. But such sizes are exemplary, and various other suitable diameters may be used. The crumpled cellulosic cushioning element **110** thus includes a plurality of folds and crevices or air pockets formed between the folds of the cellulosic cushioning element **110**.
(24) An alternative cellulosic cushioning element **111** is shown in FIG. **1**B. The paper used to form the alternative cellulosic cushioning element **111** may be cut into thin strips (for example, 0.25 inch in width) and then folded a plurality of times into a shape to form the alternative cellulosic cushioning element **111**. The alternative cellulosic cushioning element **111** is thus folded to form a geometric shape, such as the square, shown in FIG. **1**B. But other suitable geometric shapes may be formed. As with the cellulosic cushioning element **110**, the alternative cellulosic cushioning element **111** includes a plurality of folds and air pockets formed between the folds and strips of paper.
(25) The invention is not limited, however, to the sizes and shapes described above and shown in FIGS. **1**A and **1**B. The cellulosic cushioning element **110** and alternative cellulosic cushioning element **111** may also be crumpled or folded to form elements having other shapes or forms including, for example, the form shown in FIG. **6**A, below. The alternative cellulosic cushioning element **111** may be used in place of the crumpled cellulosic cushioning element **110** in each of the packing materials discussed further below.
(26) These cellulosic cushioning elements **110** may be used on their own as packing material. FIG. **2** shows, for example, a shipping box **102** that has an item-to-be-shipped **104** placed therein. The shipping box **102** may be any suitable shipping box including a cardboard box. The cellulosic cushioning element **110** may be placed in the shipping box **102** to surround the item-to-be-shipped **104**. The cellulosic cushioning element **110** is elastically deformable to absorb energy and protect the item-to-be-shipped **104** but, even when crushed, provides additional energy (shock) absorbing to protect the item-to-be-shipped **104**. Factors impacting the amount of energy absorbed that may be modified for the desired protection include the weight of the paper, the volume or size (e.g., diameter) of the cellulosic cushioning element **110**, and the density of the cellulosic cushioning element **110**.
(27) A method of forming the cellulosic cushioning element **110** and a machine assembly **200** used in this method will be described with reference to FIGS. **3**A-**3**D. Initially a sheet **112** of paper is fed on top of a die **210** and, in this embodiment, between a cover plate **212** and the die **210**. The sheet **112** includes a face surface **114** with a surface area. The sheet **112** also has a thickness, which as discussed above, can be any suitable thickness. The sheet has a thickness direction and an orthogonal direction that is orthogonal to the thickness direction. In FIG. **3**A, the sheet **112** is fed in the orthogonal direction of the sheet **112**. The sheet **112** is nipped and fed by a feed roller **202**. The feed roller **202** forms a nip with a nip forming member, which in this embodiment is a feed plate **204**, but any suitable nip forming member may be used such as another roller. In this embodiment, the sheet **112** is a continuous sheet from a roll **116**. However, the sheet **112** may be provided in other suitable forms such a stack of sheets **112** that cut to size and fed one-by-one to the die **210**.

(28) The die **210** has a cylindrical hole **214** with a taper **216** at the entrance of the die **210** forming a funnel shape. The sheet **112** is pressed through the die **210** with a plunger **220**. The plunger **220** has a shape that corresponds to the shape of the die **210**. In this embodiment, the plunger **220** is cylindrical with a spherical tip **222**, but any suitable shape may be used. The cylindrical hole **214** of the die **210** has a diameter, and the diameter of the plunger **220** is smaller than the diameter of the cylindrical hole **214** so that the plunger **220** can be inserted into the cylindrical hole **214**. The plunger **220** is lowered moving through a hole **218** in the cover plate **212** to press the sheet **112** in a direction crossing the orthogonal direction of the sheet **112**, which is the thickness direction in this embodiment. The tip **222** of the plunger **220** contacts the face surface **114** of the sheet **112** and pushes the sheet **112** into the cylindrical hole **214** of the die **210**. The sheet **112** has a surface area that is greater than the surface area of the cylindrical hole **214** at the exit of the die **210**. As the plunger **220** pushes presses the sheet **112** into the taper **216** and the cylindrical hole **214** of the die **210**, the sheet **112** conforms to the shape of the die **210** and the plunger **220** to form a shaped cellulosic sheet **118**. Thus, in this embodiment, the shaped cellulosic sheet **118** has a hollow, cylindrical shape with a spherical tip. The plunger **220** is inserted into the cylindrical hole **214** of the die **210** such that the plunger **220** discharges the shaped cellulosic sheet **118** from the exit (bottom) of the die **210**.

(29) When the sheet **112** is supplied by the roll **116** a cutter **224** may be used to cut the sheet **112** to the appropriate length. In this embodiment, the cutter **224** is configured to move with the plunger **220** between the top of the die **210** and the feed plate **204**. The cutter **224** cuts the sheet **112** just before or as the tip **222** contacts the face surface **114** of the sheet **112** to push the sheet **112** into the die **210**.

(30) After the shaped cellulosic sheet **118** exits the die **210**, the shaped cellulosic sheet **118** passes between a first portion **230**A and a second portion **230**B of a form **230** as shown in FIG. **3**B. The first portion **230**A and the second portion **230**B of the form **230** are then brought into contact with each other to compress the shaped cellulosic sheet **118** within a cavity **232** of the form **230** as shown in FIG. **3**C. Each of the first portion **230**A and the second portion **230**B of the form **230** have a concavity **234** formed therein that, when the first portion **230**A and the second portion **230**B are brought together, form a spherical cavity **232**. In this embodiment each concavity **234** is hemispherical to form the cavity **232**.

(31) The form **230** also includes a catcher **240** to help catch the shaped cellulosic sheet **118** as it passes between the first portion **230**A and the second portion **230**B of the form **230**. The catcher **240** of this embodiment includes a plurality of teeth **242** that are splayed outward from contacting portions of the first portion **230**A and the second portion **230**B of the form **230**. The diverging angles of the teeth **242** help compress and guide the shaped cellulosic sheet **118** into the cavity **232** as the first portion **230**A and the second portion **230**B are brought together. In this embodiment, the teeth **242** are interlocking teeth **242** such that the teeth **242** of the first portion **230**A mesh with the teeth **242** of the second portion **230**B.

(32) With the shaped cellulosic sheet **118** compressed within the cavity **232** the first portion **230**A and the second portion **230**B may be rotated about an axis extending in the direction in which the first portion **230**A and the second portion **230**B are brought together (or separated). Rotating the first portion **230**A and the second portion **230**B of the form **230** twists the shaped cellulosic sheet **118** and may help create additional folds and pockets in the resulting the cellulosic cushioning element **110**. To facilitate this process, each concavity **234** includes an outer surface **236** that is serrated. Compressing and twisting the shaped cellulosic sheet **118** forms the cellulosic cushioning element **110**. After the first portion **230**A and the second portion **230**B are rotated, the first portion **230**A and the second portion **230**B are separated by being moved in a direction opposite to the direction in which they were brought together. The cellulosic cushioning element **110** is ejected from the form **230** as the first portion **230**A and the second portion **230**B are separated as shown in FIG. **3**D. These steps are repeated to form additional cellulosic cushioning elements **110**.

(33) FIGS. **4**A-**4**D show an alternate method for forming the cellulosic cushioning element **110** and a machine assembly **300** used in this method. As in the method and machine assembly **200** described above, a sheet **112** of paper is used to form the cellulosic cushioning element **110**. Although the sheet **112** may be similar to those discussed above, the sheet **112** of this embodiment is preferably a strip of paper having a length (as will be further discussed below) longer than its width. The sheet **112** is nipped and fed by a pair of feed rollers (a first feed roller **302** and a second feed roller **304**) and fed into an arcuate-shaped cylinder **310** (herein arcuate cylinder **310**), as shown in FIG. **4**A. FIG. **5** is a perspective view of the first feed roller **302**, the second feed roller **304**, and the arcuate cylinder **310**.

(34) The first feed roller **302** and the second feed roller **304** may have smooth outer surfaces, but they also may be configured to shape the sheet **112** in the thickness direction as the sheet **112** is fed. As shown in FIG. **5**, for example, the first feed roller **302** includes a groove **306**. The groove **306** of this embodiment is v-shaped, but any suitable shape may be used, including, for example a u-shape or a w-shape. The second feed roller **304** has a corresponding surface, which in this embodiment is a v-shaped protrusion **308**. The protrusion **308** presses the sheet **112** into the groove **306** to impart a shape corresponding to the groove **306** and protrusion **308** to the sheet. FIG. **6**A shows the cellulosic cushioning element **110** produced using this method and machine assembly **300** when the sheet **112** is fed with the first feed roller **302** and the second feed roller **304** having smooth outer surfaces. The cellulosic cushioning element **110** sheet shown in FIG. **6**A has a plurality of folds with gaps therebetween. FIG. **6**B shows the cellulosic cushioning element **110** produced using this method and machine assembly **300** when the sheet **112** is fed with the first feed roller **302** and the second feed roller **304** shown in FIG. **5**. The cellulosic cushioning element **110** sheet shown in FIG. **6**B is similar to the cellulosic cushioning element **110** shown in FIG. **1**A, having a plurality of folds, but with a more cylindrical shape instead of spherical.

(35) As shown in FIG. **4**A, the arcuate cylinder **310** has a channel **312** formed therein with an inlet **314** and an outlet **316**. The sheet **112** is fed into the channel **312** through the inlet **314** and then slides through the channel **312** until it contacts a ram **322** located at the outlet **316**. In this embodiment, the sheet **112** (strip of paper) is fed into the channel **312** to have a length longer than the length of the channel **312** and the sheet **112** waves back and forth within the channel **312**. However, the length of the sheet **112** is not so limited and it may be shorter, for example.

(36) When the sheet **112** reaches the desired length, it is cut with a cutter **324**. In this embedment, the cutter **324** is formed between an edge of the inlet **314** of the arcuate cylinder **310** and a plunger **326**. The plunger **326** is connected to a rotor **328** to rotate in a circle. As shown in FIG. **4**B, the plunger **326** enters the inlet **314** of the arcuate cylinder **310** and cuts the sheet **112** as it does so. The plunger **326** rotates as it moves along the channel **312** compressing the sheet against the ram **322** the plunger **326**. The ram **322** and the plunger **326** of this embodiment are similar to the first portion **230**A of the form **230** and second portion **230**B of the form **230** discussed above. The ram **322** and the plunger **326** each include a hemispherical concavity **234** and, when brought together as shown in FIG. **4**C, form a cavity **232** to compress the sheet **112** and form the cellulosic cushioning element **110**. As the plunger **326** continues to rotate, the ram **322** pivots to open the cavity **232** and eject the cellulosic cushioning element **110** as shown in FIG. **4**D.

(37) The process shown in FIGS. **4**A-**4**D repeats to form additional cellulosic cushioning elements **110**. As can be seen in FIG. **4**C, the next sheet **112** is fed into the inlet **314** of the arcuate cylinder **310** after the plunger **326** passes the inlet **314**. Accordingly, the next sheet **112** is being fed as the previous sheet **112** is being compressed (FIG. **4**C) and ejected as the cellulosic cushioning element **110** (FIG. **4**D).

(38) While the plurality of cellulosic cushioning elements **110** are used in a shipping box **102** (as discussed above with reference to in FIG. **2**), such a configuration can be messy. When packing or unpacking the item-to-be-shipped **104** the individual cellulosic cushioning elements **110** can easily spill and scatter, requiring the need to clean up. To avoid this issue, each cellulosic cushioning

element **110** of a plurality of cellulosic cushioning elements **110** can be connected to one another as shown in FIGS. **7**A and **7**B. FIGS. **7**A and **7**B show a packing material according to a preferred embodiment of the invention. For clarity with the other packing materials discussed herein, the packing material of this embodiment is referred to as a rope-like packing material **120**.

(39) The rope-like packing material **120** includes a plurality of discrete cushioning elements **100** that are arrayed in a length direction A. Each discrete cushioning element **100** of this embodiment is the cellulosic cushioning element **110** discussed above, but they are not so limited. Instead, each discrete cushioning element **100** may be, for example, a packing peanut **106** as shown in FIG. **8**. The packing peanut **106** may be a foamed polymer resin material such as the s-shaped polystyrene foam. Other packing peanuts **106** may be used including biodegradable packing peanuts that are made from resin material of a starch such as corn.

(40) The rope-like packing material **120** will be further described with reference to FIGS. **7**A and **7**B, but it also applies to the other cushioning elements **100** shown in FIG. **8**. The cellulosic cushioning element **110** is arrayed in length direction A in an order. FIGS. **7**A and **7**B show five cellulosic cushioning elements **110** each appended with a different letter (a-e). Each cellulosic cushioning element **110** is adjacent to at least one other cellulosic cushioning element **110**. For example, cellulosic cushioning element **110***a* is adjacent to cellulosic cushioning element **110***b*, and cellulosic cushioning element **110***b* is adjacent to both cellulosic cushioning element **110***a* and cellulosic cushioning element **110***c*. In this embodiment, the adjacent cellulosic cushioning elements **110** are spaced apart from each other with a gap (referred to as a first gap **122**, herein) formed between the adjacent cellulosic cushioning elements **110**, although other suitable embodiments may be possible where, for example, adjacent cellulosic cushioning elements **110** contact one another.

(41) The adjacent cellulosic cushioning elements **110** are connected to each other by a flexible linkage **124**. The flexible linkage **124** is connected to each cellulosic cushioning element **110** and spans the first gap **122** between adjacent cellulosic cushioning element **110**. In this embodiment the flexible linkage **124** is a string. The cellulosic cushioning elements **110** may be attached to the flexible linkage **124** using any suitable method, for example an adhesive. In FIG. **7**A, the flexible linkage **124** (string) is wrapped around each cellulosic cushioning element **110** at least one time. In FIG. **7**B, each cellulosic cushioning element **110** has a hole **126** formed through the diameter (central portion) of the cellulosic cushioning element **110**, and the flexible linkage **124** (string) runs through the hole **126**.

(42) Other suitable flexible linkages **124** may be used. FIG. **9** shows an example of the rope-like packing material **120** with an alternative flexible linkage **124**. The flexible linkage **124** of this embodiment includes an upper tape **132** and a lower tape **134**. Although any suitable tape can be used, each of the upper tape **132** and lower tape **134** is preferably a paper (or cellulosic) strip that has a length much greater than its width (see FIG. **10**). Paper is preferred, particularly when used with the cellulosic cushioning element **110** so that the entire rope-like packing material **120** can be biodegradable and recyclable. In this embodiment, the upper tape **132** and the lower tape **134** are aligned with each other and sandwich the cellulosic cushioning element **110** therebetween. An adhesive **136** is preferably applied to the inner sides of each of the upper tape **132** and the lower tape **134** to bond the upper tape **132** and the lower tape **134** to each other and to the cellulosic cushioning element **110**. Any suitable adhesive **136** may be used, but in this embodiment, it is preferably a biodegradable adhesive.

(43) In this embodiment, both the upper tape **132** and the lower tape **134** are used, but it is not so limited and the cellulosic cushioning element **110** may be connected by a single tape (e.g., either the upper tape **132** or the lower tape **134**). In such a case, it is preferable to omit or remove the adhesive **136** from the portion of the tape in the first gap **122**.

(44) The flexible linkage **124** discussed above may be used with the discrete cushioning elements **100** to form other packing materials. FIG. **10** shows another packing material using the flexible

linkage **124** discusses above. For clarity with the other packing materials discussed herein, the packing material of this embodiment is referred to as a net-like packing material **140**. As with the other embodiments the cushioning element **100** elements may be any suitable cushioning element, but in this embodiment, the cushioning element **100** is cellulosic cushioning element **110**.

(45) The cellulosic cushioning elements **110** of the net-like packing material **140** are arrayed in two directions. The cellulosic cushioning elements **110** are arrayed in the length direction A, as discussed above, and also are arrayed in a width direction B in an order. For example, the cellulosic cushioning element **110***b* is adjacent to the cellulosic cushioning element **110***y* and the cellulosic cushioning element **110***z* in the width direction B, in addition to the cellulosic cushioning element **110***a* and the cellulosic cushioning element **110***c* in the length direction A. The width direction B is a direction crossing the length direction A, and in this embodiment, the width direction B is perpendicular to the length direction A.

(46) The cellulosic cushioning elements **110** are also spaced apart with a gap (a second gap **142**) formed between adjacent cellulosic cushioning elements **110** in the width direction B. One flexible linkage **124**, a first flexible linkage **144** connects the cellulosic cushioning elements **110** in the length direction A and another flexible linkage **124**, a second flexible linkage **146**) connects the cellulosic cushioning elements **110** in the width direction B. In this embodiment, there are a plurality of first flexible linkages **144** and a plurality of second flexible linkages **146** that are connected together to form the net-like structure of the net-like packing material **140**. FIG. **10** shows the first flexible linkage **144** and the second flexible linkage **146** with constructed using the tape (e.g., the upper tape **132** and the lower tape **134**), but other suitable flexible linkages **124**, such as string, may be used as discussed above.

(47) The net-like packing material **140** may be used to pack an item-to-be-shipped **104** in the manner shown above in FIG. **1**A, but it may also be used in other suitable packing arrangements. For example, the net-like packing material **140** may be used similarly to bubble wrap and be wrapped around an item-to-be-shipped **104** such as a bottle **108**, as shown in FIG. **11**.

(48) A method of forming the rope-like packing material **120** is shown in FIG. **9**, and a machine assembly **400** used in this method will be described with reference to FIG. **12**. The cellulosic cushioning element **110** may be formed using any suitable method or machine including the machine assembly **200** and machine assembly **300** discussed above. The machine assembly **200** is shown in FIG. **12**, for example. The machine assembly **400** shown in FIG. **12** includes a first roll **402** of a strip of paper which will become the upper tape **132** and a second roll **404** of a strip of paper which will become the lower tape **134**.

(49) The upper tape **132** is stretched between the first roll **402** and a first laminating roller **412**, and the lower tape **134** is stretched between the second roll **404** and a second laminating roller **414**. Each of the first laminating roller **412** and the second laminating roller **414** have a plurality of recesses **416** formed in their exterior surface. Between the recesses **416** is a land **418**. The first laminating roller **412** and the second laminating roller **414** are posited to form a bonding nip therebetween in which the recesses **416** of each laminating roller oppose each other in the bonding nip and the lands **418** of each laminating roller oppose each other in the bonding nip.

(50) The adhesive **136** is applied to at least one of the upper tape **132** and the lower tape **134**. In this embodiment, the adhesive **136** is applied to the upper tape **132** by an adhesive application unit **420**. Alternatively, another adhesive application unit **420** may be used to also apply adhesive **136** to the lower tape **134**. The adhesive application unit **420** includes a reservoir **422** holding the adhesive **136**. The adhesive **136** is transferred from the reservoir **422** to an outer surface of applicating roller **424**. The adhesive application unit **420** also includes a backing roller **426**, which forms an adhesive application nip with the applicating roller **424**. The upper tape **132** passes through the adhesive application nip and the adhesive **136** is applied by the applicating roller **424** to a surface (which will become an inner surface) of the upper tape **132**. Other suitable adhesive application units **420** may be used including, for example, spray adhesive applicators.

(51) After the cellulosic cushioning element **110** is formed and discharged from the form **230**, the cellulosic cushioning element **110** is guided to the entrance of the nip by, for example, a chute **406**. The cellulosic cushioning element **110** is then located in a cavity formed by two opposing recesses **416** and separated from adjacent cellulosic cushioning element **110** by opposing lands **418**. The upper tape **132** is sandwiched between the first roll **402** and the cellulosic cushioning element **110**, and the lower tape **134** is sandwiched between the second roll **404** and the cellulosic cushioning element **110**. As the upper tape **132** and the lower tape **134** pass through the bonding nip without a cellulosic cushioning element **110** between them, the upper tape **132** and the lower tape **134** are bonded to each other to form the first gap **122**.

(52) Another packing material is shown in FIG. **13**. For clarity with the other packing materials discussed herein, the packing material of this embodiment is referred to as a sandwich wrap **150**. The sandwich wrap **150** includes a top sheet **152** and a bottom sheet **154**. Although any suitable sheet may be used, the top sheet **152** and the bottom sheet **154** are preferably paper (cellulosic) sheets. The top sheet **152** is connected to the bottom sheet **154** with a plurality of discrete cushioning elements **100** positioned therebetween. As shown in FIG. **13**, the discrete cushioning elements **100** of this embodiment are cellulosic cushioning elements **110**. In this embodiment, the cellulosic cushioning element **110** are arrayed in the length direction A and in the width direction B. Although gaps may be present between adjacent cellulosic cushioning elements **110**. The adjacent cellulosic cushioning elements **110** of this embodiment contact each other. Each of the top sheet **152** and the bottom sheet **154** include an inner surface **156**. An adhesive **136** is applied to the inner surface **156** of each of the top sheet **152** and the bottom sheet **154** to attach the cellulosic cushioning element **110** to the top sheet **152** and the bottom sheet **154** and connect the top sheet **152** and the bottom sheet **154** to each other.

(53) As noted above, the cushioning elements **100** may be positioned between the top sheet **152** and the bottom sheet **154** with the cushioning elements **100** spaced apart from each other. One such packing material is shown in FIGS. **14** and **15**. For clarity with the other packing materials discussed herein, the packing material of this embodiment is referred to as a wrap-like packing material **160**. FIG. **15** is a cross-sectional view of the wrap-like packing material **160** taken along line **15-15** in FIG. **14**. The wrap-like packing material **160** of this embodiment has similarities to the sandwich wrap **150**. For example, the wrap-like packing material **160** includes a top sheet **152** connected to a bottom sheet **154** with cellulosic cushioning elements **110** positioned therebetween. At least one of the top sheet **152** and the bottom sheet **154** includes a plurality of pockets **162**. In this embodiment, both the top sheet **152** and the bottom sheet **154** include a plurality of pockets **162**. Each of the pockets **162** includes an opening **164**. In the wrap-like packing material **160** shown in FIG. **15**, each opening **164** of the top sheet **152** opposes a corresponding opening **164** of the bottom sheet **154**, forming a combined pocket. An area sounding each pocket **162** or combined pocket is referred to herein as webbing area **166**. The top sheet **152** and bottom sheet **154** are adhered to each other using, for example, the adhesive **136** discussed above in the webbing area **166**.

(54) At least one cellulosic cushioning element **110** is located in each combined pocket. In this embodiment, each pocket **162** includes a plurality of cellulosic cushioning elements **110**. The plurality of cellulosic cushioning elements **110** in each pocket **162** or combined pocket may be bonded to each other with bonds comprising adhesive and cellulosic fibers, as will be described further below. Instead of both the top sheet **152** and the bottom sheet **154** having a plurality of pockets **162**, pockets **162** may be formed in one of the top sheet **152** and the bottom sheet **154**. FIG. **16** is a cross-sectional view of the wrap-like packing material **160** taken along line **15-15** in FIG. **14**, where a plurality of pockets **162** are formed in the bottom sheet **154** but not the top sheet **152**. In this embodiment, the top sheet **152** is bonded to the bottom sheet **154** such that the top sheet **152** covers the openings **164** of the plurality of pockets **162** in the bottom sheet **154**.

(55) To increase the flexibility of the wrap-like packing material **160**, a plurality of holes **168** may

be formed through both the top sheet **152** and the bottom sheet **154**, as shown in FIGS. **17** and **18**. The wrap-like packing material **160** shown in FIG. **17** has the holes **168** located between each pocket **162** in the length direction A and in the width direction B. Another configuration for the wrap-like packing material **160** with holes **168** is shown in FIG. **18** in which the holes **168** are formed in interstitial portions between the pockets **162**.

(56) When a single cellulosic cushioning element **110** is located in each combined pocket of the wrap-like packing material **160**, a modified method and machine assembly **400** shown and discussed above with reference to FIG. **12** may be used. The first laminating roller **412** and the second laminating roller **414** may be longer and the machine assembly **200** is configured to place a plurality of cellulosic cushioning elements **110** along the length of the first laminating roller **412** and the second laminating roller **414**. Instead of the first roll **402** and the second roll **404** being tape, they may be rolls of paper used to form the top sheet **152** and the bottom sheet **154**.

(57) A method of forming the wrap-like packing material **160** shown in FIG. **16** and a machine assembly **500** used in this method will be described with reference to FIG. **19**. The bottom sheet **154** is provided with the plurality of pockets **162** formed therein. At a first station **502**, the plurality of cellulosic cushioning elements **110** are filled in each pocket **162**. Optionally, at a second station **504**, the cellulosic cushioning elements **110** in each pocket **162** may be bonded together. The cellulosic cushioning elements **110** may be bonded together by an adhesive, which is preferably a biodegradable adhesive. Even more preferably, an emulsion of water, adhesive, and cellulosic (paper) fibers are sprayed into each pocket **162** at the second station **504**. Each pocket **162** is conveyed and supported by a backing member, such as by the first laminating roller **412** discussed above, through a bonding nip formed between the first laminating roller **412** and a press roller **512**. The top sheet **152** may be conveyed by the press roller **512** into the bonding nip and the top sheet **152** is bonded to the bottom sheet **154**. Where the emulsion is used, the emulsion may then be dried resulting in a plurality of cellulosic cushioning elements **110** that are bonded by bonds comprising cellulosic fibers and the adhesive and/or a matrix of cellulosic fibers and the adhesive, as discussed further below in connection with the molded packing material **170**.

(58) Instead of using a sheet of paper alone as top sheet **152**, a top sheet **152** with pockets **162** filled with cellulosic cushioning elements **110** and optionally bonded may formed in a manner similar to the bottom sheet **154**, as discussed above. This top sheet **152** with pockets may then be brought together with the bottom sheet **154** in the bonding nip to form the wrap like packing material shown in FIG. **15**. Alternatively, two of the wrap-like packing materials **160** shown in FIG. **16** may be brought together to form the wrap-like packing material **160** shown in FIG. **15**. In any of these cases, the top sheet **152** and the bottom sheet **154** may be bonded together with an adhesive, which is preferably a biodegradable adhesive.

(59) The cellulosic cushioning elements **110** discussed herein may also be suitable to make a polystyrene foam (or other plastic foam) replacement. FIGS. **20** and **21** show such a packing material according to a preferred embodiment of the invention. For clarity with the other packing materials discussed herein, the packing material of this embodiment is referred to as a molded packing material **170**. The molded packing material **170** is shown in FIG. **20**, and FIG. **21** is a cross section of the molded packing material **170** shown in FIG. **20** taken along line **21-21** in FIG. **20**.

(60) The molded packing material **170** will be formed into a shape in order to pack the item-to-be-shipped **104**. Such molded shape may include recesses and protrusions. For example, the molded packing material **170** shown in FIG. **20** includes a hemispherical cavity **172** in which a portion of the item-to-be-shipped **104** can be placed. The molded packing material **170** of this embodiment includes a plurality of cellulosic cushioning elements **110** that are formed into the desired shape and then joined together. The plurality of cellulosic cushioning elements **110** may be joined together by bonds comprising adhesive and cellulosic (paper) fibers. In some embodiments, the plurality of cellulosic cushioning elements **110** may be joined together by a matrix of cellulosic fibers, and in a preferred embodiment, a matrix of cellulosic (paper) fibers and an adhesive.

Additional features of the bonds and matrix will be discussed below in connection with the method of manufacturing the molded packing material **170**. Optionally, the outer surfaces of the molded packing material **170** may be covered with an outer sheet **174**. The outer sheet **174** is preferably a cellulosic (paper) sheet.

(61) A method of manufacturing the molded packing material **170** shown in FIG. **20** will be described with reference to FIG. **22**. First, a mold **520** having the desired shape is provided. The mold **520** may preferably be silicon. If an outer sheet **174** is used, the outer sheet **174** is placed into the mold. The mold **520** is then filled with the cellulosic cushioning elements **110**. Next, an emulsion of water, cellulosic (paper) fibers, and preferably adhesive is sprayed into the mold **520** with the cellulosic cushioning elements **110**. The emulsion flows around and between the cellulosic cushioning elements **110**. In addition, the emulsion may also flow at least a portion of the way into crevices exposed on the outer surfaces of the plurality of cellulosic cushioning elements **110**. If the outer sheet **174** is used, the outer sheet **174** may be placed on top of an exposed surface **176** of the cellulosic cushioning elements **110**. The cellulosic cushioning elements **110** with the emulsion is then removed from the mold **520**, such as by turning the mold **520** upside down, and then dried to form the molded packing material **170**. The drying step may also take place before removing the cellulosic cushioning elements **110** from the mold **520**.

(62) As the cellulosic cushioning elements **110** with the emulsion is dried bonds form between the folds of each of the cellulosic cushioning elements **110** and also between the cellulosic cushioning elements **110**. The emulsion may also form, as it is dried, a matrix around the cellulosic cushioning elements **110**, and the cellulosic cushioning elements **110** may be connected to each other by the cellulosic fibers and, when used, the adhesive of the matrix. The molded packing material **170** may thus include a plurality of cellulosic cushioning elements **110** that are interconnected to each other by cellulosic fibers. The cellulosic cushioning elements **110** may retain some of the air pockets therein, and the molded packing material **170** may also be described as having discrete groupings of air (gas) pockets interspersed within a cellulosic (paper) mass.

(63) As discussed above, factors impacting the amount of energy absorbed include the weight of the paper, the volume or size (e.g., diameter) of the cellulosic cushioning element **110**, and the density of the cellulosic cushioning element **110**. In this embodiment, the amount of emulsion and the amount of the cellulosic fibers and the amount of adhesive in the emulsion may also be modified to create a packing material with the desired strength and energy absorbing properties. The emulsions discussed herein may be referred to herein as an aqueous slurry of cellulosic fibers and adhesive. In the emulsions discussed herein the cellulosic fibers are preferably the same fibers as are used in the paper for the cellulosic cushioning element **110**. In addition, the adhesive of the emulsion is preferably a biodegradable emulsion.

(64) Although this invention has been described with respect to certain specific exemplary embodiments, many additional modifications and variations will be apparent to those skilled in the art, in light of this disclosure. It is, therefore, to be understood that this invention may be practiced otherwise than as specifically described. Thus, the exemplary embodiments of the invention should be considered in all respects to be illustrative and not restrictive, and the scope of the invention to be determined by any claims supportable by this application and the equivalents thereof, rather than by the foregoing description.

Claims

1. A molded packing material comprising: a plurality of cellulosic cushioning elements; and a matrix comprising adhesive and cellulosic fibers bonding the plurality of cellulosic cushioning elements to each other, wherein the plurality of cellulosic cushioning elements and matrix form a mass that has been molded into a shape having exterior surfaces and an interior with some of the plurality of cellulosic cushioning elements being on the exterior surfaces of the mass and the

remainder of the plurality of cellulosic cushioning elements being in the interior of the mass.
2. The molded packing material according to claim 1, further comprising at least one cellulosic sheet bonded to at least one of the exterior surfaces of the mass.
3. The molded packing material according to claim 1, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is a crumpled cellulosic sheet.
4. The molded packing material according to claim 1, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is a cellulosic material formed into a geometric shape with at least one pocket of air formed therein.
5. The molded packing material according to claim 1, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements has a sphere-like shape.
6. The molded packing material according to claim 1, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is cylindrical.
7. The molded packing material according to claim 1, wherein the cellulosic cushioning elements comprise cellulosic fibers, and the cellulosic cushioning elements are the same as the cellulosic fibers of the matrix.
8. The molded packing material according to claim 1, wherein the adhesive of the matrix is a biodegradable adhesive.
9. The molded packing material according to claim 1, wherein the mass has been molded into a shape including at least one recess.
10. The molded packing material according to claim 9, further comprising at least one cellulosic sheet bonded to at least one of the exterior surfaces of the mass forming the recess.
11. A molded packing material comprising: a plurality of cellulosic cushioning elements; and a matrix comprising cellulosic fibers bonding the plurality of cellulosic cushioning elements to each other, wherein the plurality of cellulosic cushioning elements and matrix form a mass that has been molded into a shape having exterior surfaces and an interior with some of the plurality of cellulosic cushioning elements being on the exterior surfaces of the mass and the remainder of the plurality of cellulosic cushioning elements being in the interior of the mass.
12. The molded packing material according to claim 11, further comprising at least one cellulosic sheet bonded to at least one of the exterior surfaces of the mass.
13. The molded packing material according to claim 11, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is a crumpled cellulosic sheet.
14. The molded packing material according to claim 11, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is a cellulosic material formed into a geometric shape with at least one pocket of air formed therein.
15. The molded packing material according to claim 11, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements has a sphere-like shape.
16. The molded packing material according to claim 11, wherein each cellulosic cushioning element of the plurality of the cellulosic cushioning elements is cylindrical.
17. The molded packing material according to claim 11, wherein the cellulosic cushioning elements comprise cellulosic fibers, and the cellulosic cushioning elements are the same as the cellulosic fibers of the matrix.
18. The molded packing material according to claim 11, wherein the mass has been molded into a shape including at least one recess.
19. The molded packing material according to claim 18, further comprising at least one cellulosic sheet bonded to at least one of the exterior surfaces of the mass forming the recess.