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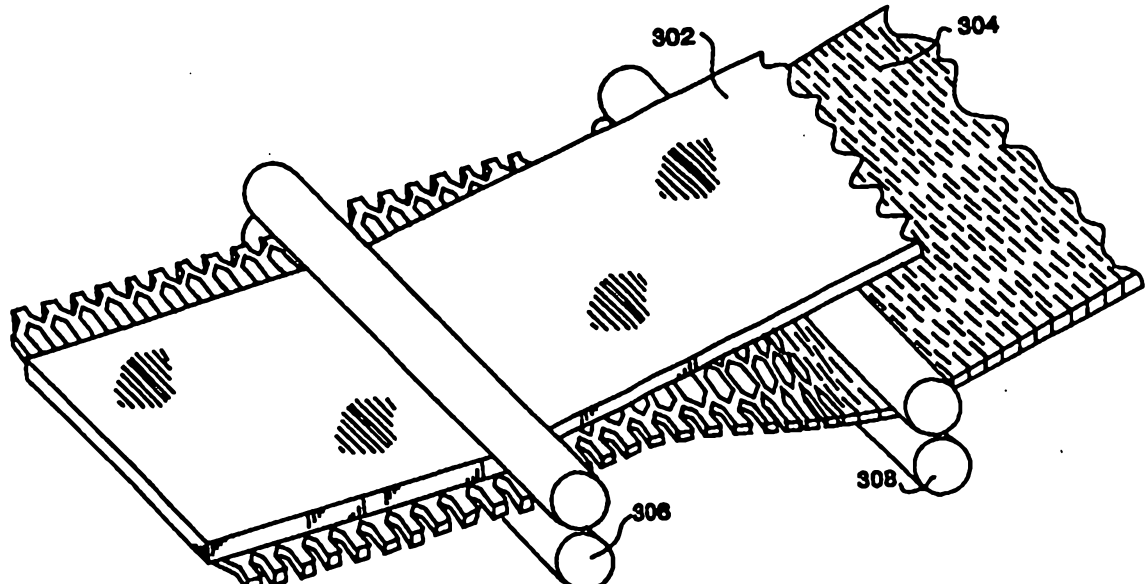
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(54) Title: APPARATUS FOR MANUFACTURING OF COMPOSITE CUSHIONING PRODUCT		
		
(57) Abstract The invention relates to a composite cushioning system for protecting articles, packaged within a box, from damage while being transported in the box. The composite structure includes at least one expanded slit sheet (304), in combination with a separator sheet (302). The expanded sheet has a slit pattern which produces open cells, preferably of a hexagonal configuration. The separator sheet precludes the nesting of the slit sheet. A variety of combinations of separator sheets and expansion sheets can be used, such as a pair of expansion sheets with a separator sheet between the pair of expansion sheets, or two such pairs of expansion sheets, with or without a separator sheet between the pairs. The separator sheet can be unslit, or tear-perforated or slit to accommodate expansion.		

APPARATUS FOR MANUFACTURING OF COMPOSITE CUSHIONING PRODUCT

BACKGROUND OF THE INVENTION

Field of the Invention

- 5 The present invention relates in general to the methods and apparatus to automatically produce a composite packaging material, from an expanded slit paper and a separator sheet and to the articles produced.

Brief Description of the Prior Art

- 10 The performance and ecological disadvantages of cellular foam styrene and/or styrofoam peanuts as a void fill material is well known. Starch products have been used, but tend to be excessively dusty and frangible, while products made from corn husks and other vegetation, are prone to attracting vermin. Paper products tend to be low in bulk and thus have a high cost per cubic foot of void fill.

- 15 Expanded paper can be used to wrap articles and as void fill for packages. Although the expanded paper product is more expensive, on a volume basis than the commonly used void fill materials, its performance as a protective cushioning material is substantially greater.

- 20 It is thus an aim of the invention to address the cost, on a volume basis, of expanded paper packaging material. It is another aim of the invention to address the production of a void fill product which can be shipped in an unexpanded form, and expanded at the user's site, at a cost competitive with that of styrene and/or styrofoam void fill.

SUMMARY OF THE INVENTION

- 25 According to one aspect, the present invention provides a composite cushioning material, such as a wrap, comprising a combination of at least one sheet of slit, expanded paper sheet material and a layer of substantially unexpanded sheet material, juxtaposed so that adjacent layers of expanded sheet material are separated by a separator sheet of said substantially unexpanded sheet material.

- 30 In a preferred form of the invention, the cushioning material further comprises the combination of two layers of expanded paper sheet material separated by said separator sheet. Preferably, the width of the separator sheet is substantially less than the width of the two layers of expanded paper sheet material when fully expanded, whereby the regions of the expanded paper sheet material which extend beyond the separator sheet are in contact with adjacent layers of expanded sheet material in a nesting



engagement and the separator sheet prevents nesting of the two layers of expanded paper sheet material in the region separated by the separator sheet.

According to another aspect, the present invention also provides a method of making a roll of the composite cushioning material described above, comprising the

5 steps of:

applying expansion pressure to at least one sheet of slit, expandable sheet paper material to form a sheet of expanded material, which is expanded in length and thickness and reduced in width,

10 drawing a separator sheet of flexible material along with said expandable sheet, wrapping said composite of said at least one sheet of expanded material and separator sheet around itself to form a roll in which all adjacent layers of expanded material have a separator sheet between them.

According to a further aspect, the present invention provides an apparatus for producing the composite cushioning material described above, comprising:

15 at least one roll of flexible separator sheet material;
first and second rolls of expandable paper slit material in unexpanded form;
a first pair of guide rollers;
gripping means on said guide rollers for engaging said expandable material;
a first pair of expansion rollers;

20 said expandable material extending from said first roll of expandable paper slit material to said first pair of guide rollers, and from said first pair of guide rollers to said first pair of expansion rollers;

at least one of said expansion rollers in the first pair of expansion rollers having slit material gripping means on its surface, said slit material gripping means having an

25 effective peripheral rotational speed greater than the effective peripheral rotational speed of said first pair of guide rollers, whereby rotation of said first pair of guide rollers draws slit material from said first roll of slit material and rotation of said first pair of expansion rollers at a rotational speed greater than the rotational speed of said first pair of guide rollers expands said slit material in length and loft;

30 a second pair of guide rollers;
gripping means on said guide rollers for engaging said expandable material; a second pair of expansion rollers;



said expandable material extending from said second roll of expandable paper slit material to said second pair of guide rollers, and from said second pair of guide rollers to said second pair of expansion rollers;

at least one of said expansion rollers in the second pair of expansion rollers
 5 having slit material gripping means on its surface, said slit material gripping means having an effective peripheral rotational speed greater than the effective peripheral rotational speed of said second pair of guide rollers, whereby rotation of said second pair of guide rollers draws slit material from said second roll of slit material and rotation of said second pair of expansion rollers at a rotational speed greater than the rotational
 10 speed of said second pair of guide rollers expands said slit material in length and loft; and,

packaging material delivery means for delivering said first expanded material in juxtaposition with at least the first surface of the unexpanded separator material and the second expanded material in juxtaposition with the second surface of said unexpanded
 15 separator material.

At least one second separator sheet may be included to produce a composite having at least two layers of expanded sheet material separated by a separator sheet and at least one outer layer separator sheet. Two outer layers of unslit sheet material can be bound together longitudinally along their edges to form a bound composite packaging
 20 material having at least two layers of expanded sheet material separated by a separator sheet enclosed within two outer layers.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further features and advantages of the present invention will become more apparent from the following detailed description of preferred
 25 embodiments of the invention with reference to the accompanying drawings, in which:

Figure 1 is a side view of a multi-layer expander for production of a three layer product;

Figure 2 is a schematic of a multi-layer expander for product of a seven
 layer product;

30 Figure 3 is a schematic of a multi-layer expander for product of pads and envelopes;

Figure 4 is a perspective view of the protective envelope produced from the product produced by the expander of Figure 3;

Figure 5 is a perspective view of the completed envelope of Figure 4;



Figure 6 is a side view of the expanded paper and separator paper combination;

Figure 7 is side view of two sheets of expanded paper having reverse inclines in combination with a separator paper;

5 Figure 8 is a perspective view of a slit paper, separator paper combination;

Figure 9 is a perspective view of an article wrapped in the combination of Figure 8; and

10 Figure 10 is a end view of expanded and separator paper rolled into a cylinder.

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DETAILED DESCRIPTION OF THE INVENTION

The term expanding, as used herein, refers to a three-dimensional expansion, or a volume expansion, as disclosed in PCT/US93/02369, WO 93/18911 published 30 September 1993.

While any slit pattern for expanding the paper can produce an effective packaging material, when used in combination with an unexpanded sheet, the use of a pattern which produces hexagonal cells is preferred due to the high rigidity of the hexagonal cells. Hexagonal cells are rigidly self-supporting as compared to oval cells which close readily under load.

Positioning an unexpanded sheet of material between each layer of expanded hexagonal sheets results in a final thickness which is equal to the full thickness of the sum of the thickness of each individual unexpanded and expanded sheet. To retain the biodegradability of the material, paper or biodegradable plastic should be used, although any flexible material can be substituted. Economically it is advantageous to use lightweight kraft or tissue paper as a separator sheet, keeping the paper weight at the minimum required for the desired cushioning. The resultant cushioning is different from the highly resilient cushioning which is produced by the interaction of nested sheets. The highly resilient, high loft, stiff cushioning, is highly suited to void fill applications due at least in part, to the very thick product having spongy cushioning which is produced when the expanded sheet layers is interlayered with an unexpanded sheet.

The multi-layer, separator sheet structure's stiffness and resiliency results in it's being exceptionally suited for use with lighter weight paper than it's single-ply counterpart, thereby increasing the volume yield per gram and reducing the price per cubic meter. A greater amount of energy is required to collapse the multi-ply structure than is required to collapse the single ply counterpart.

The separator sheet does not nest with the lands and/or legs of the expanded sheet, but rather, distributes impact from the expanded sheets to from the legs and/or lands to at least cell sized regions of the next layer of expanded sheet. The separator sheet causes each leg and land to

operate independently, rather than in nested groups. The change in effect is not a loss of impact absorption capacity, but a change in the type of impact absorption which the cushioning material is undergoing.

The separator sheet can be a simple sheet of paper freely fed along with one or more expanded slit sheets. By unwinding along with the wrapping motion, the separator sheet can accommodate and keep up with the rate at which the expanded sheet is being fed. The separator sheet can be coupled to a single expanded sheet, or placed between expanded sheets. When drawing on the expanded sheets during the wrapping operation, the expanded sheet is elongated beyond the initial expansion produced by a powered expander, requiring the separator sheet to accommodate a feed rate greater than that of the expansion rollers. Where the separator sheet is between expanded sheets, it is preferred to simultaneously feed the composite through a single pair of expansion rolls. Since the feed rate of the separator sheet is limited to that of the expanded sheets, the separator sheet restricts the further expansion required to wrap with an interlocking action. To accommodate this, the separator sheet can have a tear line formed by a line of perforations, such as small, closely spaced holes, large holes or elongated slits, transverse to the machine direction of the paper.

Alternatively, the separator sheet can be provided with a narrow region of slit patterns transverse to the machine direction of the paper. The expansion region is designed to provide the same degree of expansion from region to region, as is obtained from the pulling of the expanded sheet taut during the wrapping operation. The additional expansion used to spring load the expanded sheet, is less than 25% of the length of the region, and generally is on the order of five to ten percent. The slit pattern to produce this criteria can vary dependent upon manufacturing preferabilities. The slits can be longer than those used for cushioning expansion at intervals along the length of the sheet rather than uniformly distributed along the sheet. If the resultant cells are twice as large as those for the expanded cushioning layer, half as many cell should be used, with the critical factor being the achievement of equal expansion for the slit and functionally "unslit" layer. The expansion region of the separator sheet can be conveniently spaced at one or two foot

intervals to provide from about one to four inches of expansion. Expansion of about one inch per foot generally provides sufficient extension to permit the required pulling of the expansion sheet to the taut condition. Obviously, providing for more expansion than necessary is not detrimental, though providing insufficient expansion is undesirable and can interfere with the interlocking feature. Where the composite is used to produce a pad or envelope, the expanded slit sheet is not pulled taut and an expansion or tear region is unnecessary.

The slit pattern ratio in the separator sheet cannot be the equivalent to the slits pattern as disclosed for the slit paper, as this would result in nesting. If the slit pattern is used, the slit size and ratios must be different from those used in the expanded paper. It is preferable that any slit pattern used does not form the resilient hexagons, thereby providing the firmer support provided by unslit paper.

The weight of the expanded sheet material can be selected based on the required performance, generally in the 40 to 50 pound range. The weight of the separator sheet need not be greater than 30 or 40 pound kraft paper, since its function is strictly as a separator.

The expansion is preferably performed in a modified expander of the type disclosed in copending patent application, Serial Number PCT/US94/10209, WO-95/07225, published 16 March 1995, used for producing single or dual webs of expanded sheet material. This basic expander is redesigned herein to allow for the production of the multi-layer combination. The expansion process, as well as hardware, is disclosed in detail in the foregoing PCT application.

Two layers of expandable sheet material separated by a light weight, unslit separator sheet, can be processed in a single pair of rollers. By offsetting the hook and loop fabric windings of the two rollers, crushing of the expanded material is precluded, even when multiple expandable sheets are separated by a separator sheet. The thickness of material passing between the expansion rollers is about 50% greater when two pairs of unseparated slit sheets are simultaneously processed. The hook filaments must be positioned close enough to one another to apply sufficient pressure to the double webs to grip unexpanded lead material and transform it into expanded material.

The expander is preferably provided with the ability to automatically readjust on the other of the thickness of one or more layers of expanded sheet material. This provides the ability to have a closer position at start-up to provide substantial gripping of the unexpanded paper and a further apart position after a momentary, start-up period. The rollers are preferably provided with high and low settings for optimum performance. The displacement can be adjusted as required, to adjust to different slit row spacing and can be adjusted downwardly to compensate for nesting or upwardly to compensate for the use of a separator sheet.

Where multi-layer or webs of expanded sheet material having 20.3 centimeter slit row spacing, are fed through a single pair of expansion rollers, the spacing between the expansion roller is increased about 4.8 centimeters per expanded sheet. The expansion rollers are preferably powered for parallel movement, in order to regulate the spacing between the rollers. Where expanded sheets are not separated, the spacing of the pair of parallel expansion rolls will be less than where the expanded sheets have a separator between them to prevent nesting. Thus, where two sheets of expanded paper and two outer sheets of kraft paper are fed through the expansion rollers, the roller spacing is less than where a separator sheet is used between the pair of expanded sheets.

In Figure 1 the tri-layer expander 10 positions slit rolls 12 and 14 above and below the separator roll 16. The slit rolls 12 and 14 are each expanded through dual pairs of expansion rollers. As the expansion rollers used are identical, only one set will be described. The separator paper 20 is fed from the separator roll 16 located between the slit rolls 12 and 14. The separator roll 16 is free floating on the roller support 28 allowing the separator paper 20 to freely unroll as it is pulled. To prevent the separator paper 20 from continuing to unroll due to momentum, any restraining method, such as a friction fit between the roller support 28 and the core of the separator roll 16, can be used.

Figure 2 illustrates one example of an alternate expander 50 with multiple delivery areas which comprises slit paper rolls 52 and 56 and separator roll 54. The rolls are placed to allow for the separator roll 54 to be delivered between the slit paper rolls 52 and 56. The separator paper 72 is removed from the roll 54 and held in position for delivery by positioning bar 58. One or more

positioning bars can be provided to place the paper in the position required for smooth entry into the guide rollers 60 and 62. The slit paper 68 and 70 passes through the guide rollers 60 and 62 and expansion rollers 64 and 66, expanding as described in the aforementioned PCT application. The separator paper 72 also runs through the guide rollers 60 and 62 and expansion rollers 64 and 66, subjecting the separator paper 72 to the same physical pulling as the slit paper 68 and 70. In order to prevent the separator paper 72 from tearing during the expansion stage, the separator paper 72 is provided with slits. The second delivery area is the center separator roll 74 which separates the first and third delivery areas. The center separator sheet 76 prevents the expanded paper 70 from nesting with the expanded paper 78. The third delivery area is the same as the first delivery area, although the positioning of the rolls may differ. This configuration provides cushioning in a more bulky, rigid form and is preferable for wrapping larger objects. It should be noted that any number of delivery areas can be combined in the same manner as disclosed in this Figure.

The expander 100 of Figure 3 has the delivery systems arranged to provide the capability of producing envelopes. The rolls 102 and 106 are unslit kraft paper, at least one of which has a weight sufficient to provide exterior envelope protection. The exterior paper 104 and 108 is placed through dual guide rollers 110 and 112 which are utilized to maintain alignment of the paper 104 and 108. The expanded paper rolls 114 and 116 are positioned to deliver expanded paper adjacent to the exterior paper 104 and 108. The slit paper 118 and 120 is expanded through use of dual guide rollers 122 and 124 and expansion rollers 126 and 128. A center separator sheet 132, fed off a center separator roll 130, is used to prevent the expanded paper 118 and 120 from nesting. The center separator sheet 132 can be provided with one or more positioning rollers 134 to maintain the positioning of the center separator sheet 132. The multi-layer combination 152 can be used for either wrapping, a cushioning pad or envelope.

The combination produced by the expander 100 is ideal for use as a protective envelope. The combination 152 is cut at a predetermined length, approximately two and 1/4 the length of the desired size envelope 150 as illustrated in Figures 4 and 5. In Figure 4 the multi-layer combination 152 has been folded over onto itself, leaving closure flap 154 as a single layer of the

multi-layer combination 152. The envelope 150 is sealed along the peripheral edges 158 and 160 by means known in the art. Alternatively, the cut pad of combination 152 can be folded to produce an envelope which does not incorporate the closure flap 154 and is sealed through stapling. The advantage to using the exterior weight kraft paper for the exterior paper 104 and 108 is in the ability to fold the combination 154 to either expose exterior paper 104 or exterior paper 108. Alternatively, either paper 104 or 108 can be replaced with a lighter weight paper, however the direction of folding must correspond accordingly.

The cushioning pad can consist of the output from two or more pairs of rollers combined to form a unity structure. The final structure can consist of four layers of expanded sheet material separated by light weight separator sheets and covered top and bottom, by outer layers of unslit kraft paper, providing extreme loft as a result of the separation of the sheets of expanded paper. The two inner layers of expanded sheet material can be unseparated to provide greater resiliency, or separated by a separator sheet to provide greater stiffness. The structural demands of the separator sheets is so minimal that paper weights normally unsuited to producing a cushioning material can be used.

The above disclosed multi-layer combination can be folded in the standard flag fold as known in the art. The folding of the triangle back on itself, diagonally, is repeated until the desired thickness of material is produced. The cell pattern is rotated forty-five degrees between layers, thus producing reduced nesting in multi-layer combination where the expanded paper comes in contact with itself. However, even with the ninety degree rotations of the cell pattern, nesting does occur.

Figure 6 illustrates, from a side view, how the separator sheets 250 and 252 prevent the expanded sheets 254 and 256 from nesting. The peaks of the expanded paper 256 and 254 rest on the separator sheet 250 and 252 thereby causing impact to be transmitted through the separator sheets 250 and 252 as described heretofore.

Decreased nesting can also be obtained by reversing the incline of the lands of the cells as shown in Figure 7. Separator sheet 270 is used in this Figure in combination with the expanded sheets 274 and 272, however the incline reversing can be used without the separator sheet 270. If the inclines are about 60 degrees, reversing the direction of the inclines of each layer of expanded sheets 272 and 274, reduces the nesting. Ten sheets of expanded paper having an individual expanded thickness of about 4 mm, will have a combined, nested thickness of about 63.5 mm. Nesting can also be substantially negated by wrapping the expanded paper in the flag fold.

Figure 8 illustrates the ratio between the separator sheet 302 and the expanded sheet 304 for use in wrapping bottles and the like. The separator sheet 302 preferably has a width less than that of the expanded sheet 304 to allow the cells to interlock when wrapped about an article as shown in Figure 9. The wrap extends beyond both ends of the article being wrapped and is fully stretched, or necked down, remaining that way due to the interlocking action. In this format, a single layer of expanded sheet material can be interleaved with a single layer of unslit sheet material, with the outer end regions of the slit sheet providing the desired interlocking effect. It may be necessary to use glue or tape in some instances to preclude unwrapping of the cushioning material, since the separator sheet precludes interlocking along the "body" of the article. Where the article is wider than the paper, the wrapping starts with the article inwardly of one edge of the paper and the composite is wrapped with a spiral action progressing toward the other side, until composite overhangs both sides of the article. The final product is similar to that achieved where the article is narrower than the composite. By allowing for the cells to interlock, the use of tape or other means to secure the wrap around the article is eliminated. Figure 8 also illustrates how the paper is expanded between the guide rollers 308 and the expansion rollers 306. In the expansion process of Figure 8, only the slit paper 304 is fed off the roll (not shown) through the guide rollers 308. The separator paper 302 is brought in from another roll (not shown) and fed only through the expansion rollers 306. This method eliminates separator sheet 302 from being exposed to the pulling force which expands the slit paper 304 and the need for any type of slit pattern in the separator paper 302. Additionally, an expander can contain a second sheet of slit

paper (not shown) that can be fed through its own set of guide rollers into the expansion rollers 306, thereby producing a multi-layer combination having a separator sheet 302 sandwiched between two expanded sheets 304. In the event two expanded sheets are used, the separator sheet 302 can have the same width as the expanded sheet 304. Other combinations of separator sheets and expanded sheets can be used, as disclosed heretofore, with each expanded sheet having its own set of guide rollers.

To form a cylinder from the multi-layer combination, as illustrated in Figure 10, the slit paper is expanded in combination with a separator paper, as disclosed heretofore, and rolled into a cylindrical spiral. The raised cells of the expanded paper interlock with cells in adjacent layers of slit paper as the paper spirals outward. The use of a separator sheet 1244 prevents the cells from interlocking with one another, thereby limiting locking to adjacent expanded sheets and requiring tape to maintain the cylinder 1200 in a closed position. The spiral cylinder 1200 of Figure 10 is an illustration of an end view showing the expanded paper 1242 in combination with the separator sheet 1244. By combining the separator sheet 1244 with the expanded sheet 1242, the cylinder 1200 has substantially greater bulk than cylinders made from only a single sheet of expanded paper. The tighter the cylinder is wound, the greater the amount of sheet material required to form a cylinder. Although the tighter the cylinder, the firmer the cushion effect which is achieved, winding the cylinder too tightly will have the effect of removing air from the cylinders and lessening their cushioning qualities. Hence, winding forces on the slit paper material and the quantity of slit paper material used to produce a cylinder are critical. The cylinders can be customized to meet specific system requirements.

Whereas hexagonal cells are preferred for the expansion sheets, oval cells are preferred for the separator sheet. Hexagonal cells facilitate nesting, even where the cells of adjacent layers are of substantially unequal size, or the incline pattern is rotated 45 or 90 degrees. Oval cells will flatten readily, collapsing rather than nesting. It should be apparent, that the novel use of dissimilar layers, provides a wide range of potential cushioning characteristics for the composite structure. The degree of thickening, or loft can be varied, as well as the stiffness, and the relationship be-

tween deflection and load. The response to high impact, as measured by G-force test equipment, can be customized through the selection of the combination of slit patterns, total absence of slits for the separator sheets and weights of the expansion sheets and separator sheets.

The variables are as follows:

- 1 Paper weight for expansion sheet
- 2 Paper weight for separator sheet
- 3 Slit pattern for expansion sheet
 - A- Absence of slit pattern
 - B- Perforated to provide discrete sections
 - C- Slit to provide expansion equal to expansion sheet
 - a- Slits periodic to provide expansion
 - b- Slits uniform, but of different pattern from expansion sheet to preclude nesting.
- 4 Ratio of number of expansion sheets to separator sheets.
- 5 Number of expansion sheets nested with an adjacent expansion sheet.

The system thus provides customization comparable to that which is attainable with cellular foam plastics. The compression characteristics of the multi-layer structure differ from that of multiple layers of single-ply expanded wrap.

The structures can take the following forms:

- A- A single layer of expanded slit sheet material with a single layer of a separator sheet;
- B- separator sheet is narrower than necked down width of expanded slit sheet;
- C- separator sheet has spaced apart tear lines;
- D- separator sheet is manually fed, unrestricted;
- E- separator sheet has expansion slits is able to permit expansion equal to that of expanded sheet;
- F- separator sheet is slit, but with a longer slit than slits of expanded slit sheet and greater space between rows of slits, to provide fewer cells, but larger cells than in the expanded sheet;

- G- single layer sheet of thin, flexible material such as tissue, with expanded material to keep all layers of expanded material from nesting;
- H- pairs of expanded sheet separated by separator sheet;
- I- separator sheet between expanded sheet and outer unslit sheets;
- J- separator sheet between expanded sheet and outer unslit sheets folded and sealed into envelope form;
- K- a plurality of pairs of expanded sheet separated by separator sheet, where each set of pairs is separated by a separator sheet;
- L- single layer expanded sheet and single layer separator sheet rolled into cylinder form, as a void fill, either end glued and/or separator sheet is narrower than expanded sheet;
- M- pair of expanded sheets separated by separator sheet and rolled into cylinder form for use as void fill; or
- N- expanded sheet preferably with hexagonal cells for optimum rigidity.

Since other modifications and changes varied to fit particular operating requirements and environments will be apparent to those skilled in the art, the invention is not considered limited to the example chosen for the purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

Throughout the description and claims of this specification, the word "comprise" and variations of the word, such as "comprising" and "comprises", is not intended to exclude other additives, components, integers or steps.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A composite cushioning material comprising a combination of at least one sheet of slit, expanded paper sheet material and a layer of substantially unexpanded sheet material, juxtaposed so that adjacent layers of expanded sheet material are separated by a separator sheet of said substantially unexpanded sheet material.

2. A cushioning material as claimed in claim 1, comprising the combination of two layers of expanded paper sheet material separated by said separator sheet.

3. A cushioning material as claimed in claim 1, wherein the width of said separator sheet is substantially less than the width of said expanded paper sheet material when said expanded paper material is fully expanded, whereby the layer of said expanded paper sheet material extends beyond said separator sheet.

4. A cushioning material as claimed in claim 2, wherein the width of said separator sheet being substantially less than the width of said two layers of expanded paper sheet material when fully expanded, whereby the regions of said expanded paper sheet material which extend beyond said separator sheet are in contact with adjacent layers of expanded sheet material in a nesting engagement and said separator sheet prevents nesting of said two layers of expanded paper sheet material in the region separated by said separator sheet.

5. A cushioning material according to any one of claims 1 to 4, wherein said cushioning material is a cushioning pad having outer layers of unexpanded sheet material and at least one seal at each edge of said combination, to form an integrated structure having unslit outer layers and, between the outer layers, at least two layers of expanded sheet material separated by an unslit sheet, said unslit sheet being of a lighter weight paper than said expanded sheet material.

6. A method of making a roll of a composite cushioning material as claimed in claim 1, comprising the steps of:



applying expansion pressure to at least one sheet of slit, expandable sheet paper material to form a sheet of expanded material, which is expanded in length and thickness and reduced in width,

drawing a separator sheet of flexible material along with said expandable sheet,

5 wrapping said composite of said at least one sheet of expanded material and separator sheet around itself to form a roll in which all adjacent layers of expanded material have a separator sheet between them.

7. A method of making a roll of a composite cushioning material as claimed in
10 claim 6 in which said separator sheet is of less width than the expanded sheet, and the separator sheet lies between adjacent layers of expanded material and only edges of adjacent layers of expanded material form a nesting and interlocking engagement.

8. An apparatus for producing a composite cushioning material as claimed in claim
15 1, comprising:

at least one roll of flexible separator sheet material;

first and second rolls of expandable paper slit material in unexpanded form;

a first pair of guide rollers;

gripping means on said guide rollers for engaging said expandable material;

20 a first pair of expansion rollers;

said expandable material extending from said first roll of expandable paper slit material to said first pair of guide rollers, and from said first pair of guide rollers to said first pair of expansion rollers;

25 at least one of said expansion rollers in the first pair of expansion rollers having slit material gripping means on its surface, said slit material gripping means having an effective peripheral rotational speed greater than the effective peripheral rotational speed of said first pair of guide rollers, whereby rotation of said first pair of guide rollers draws slit material from said first roll of slit material and rotation of said first pair of expansion rollers at a rotational speed greater than the rotational speed of said
30 first pair of guide rollers expands said slit material in length and loft;

a second pair of guide rollers;

gripping means on said guide rollers for engaging said expandable material;

a second pair of expansion rollers;



said expandable material extending from said second roll of expandable paper slit material to said second pair of guide rollers, and from said second pair of guide rollers to said second pair of expansion rollers;

at least one of said expansion rollers in the second pair of expansion rollers
 5 having slit material gripping means on its surface, said slit material gripping means having an effective peripheral rotational speed greater than the effective peripheral rotational speed of said second pair of guide rollers, whereby rotation of said second pair of guide rollers draws slit material from said second roll of slit material and rotation of said second pair of expansion rollers at a rotational speed greater than the rotational
 10 speed of said second pair of guide rollers expands said slit material in length and loft; and,

packaging material delivery means for delivering said first expanded material in juxtaposition with at least the first surface of the unexpanded separator material and the second expanded material in juxtaposition with the second surface of said unexpanded
 15 separator material.

9. An apparatus as claimed in claim 8, further comprising means for delivering at least a second unexpanded sheet material to face of at least one of the first and second expanded sheet material remote from the separator sheet to form a composite having at
 20 least two layers of expanded sheet material separated by a separator sheet and at least one outer layer of unexpanded sheet material.

10. An apparatus as claimed in claim 9, further comprising means for delivering two outer layers of unslit sheet material and binding means to bind together said outer layers
 25 of unslit sheet material longitudinally at their sides thereby forming a bound composite packaging material having at least two layers of expanded sheet material separated by a separator sheet .

11. A composite cushioning material substantially as herein described with
 30 reference to the accompanying drawings.

12. A method of making a roll of a composite cushioning material substantially as herein described with reference to the accompanying drawings.



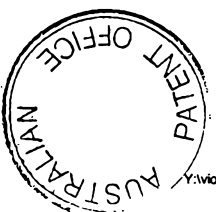
13. An apparatus for producing a composite cushioning material substantially as herein described with reference to the accompanying drawings.

DATED: 15 January, 2001

5 PHILLIPS ORMONDE & FITZPATRICK

Attorneys for:

DAVID P. GOODRICH



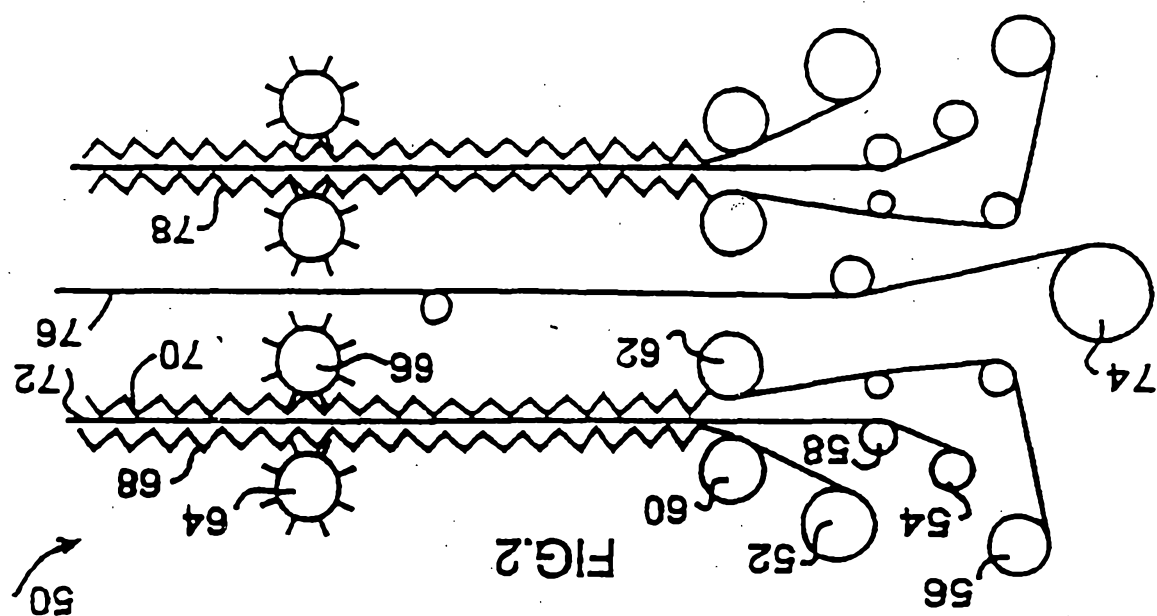


FIG. 2

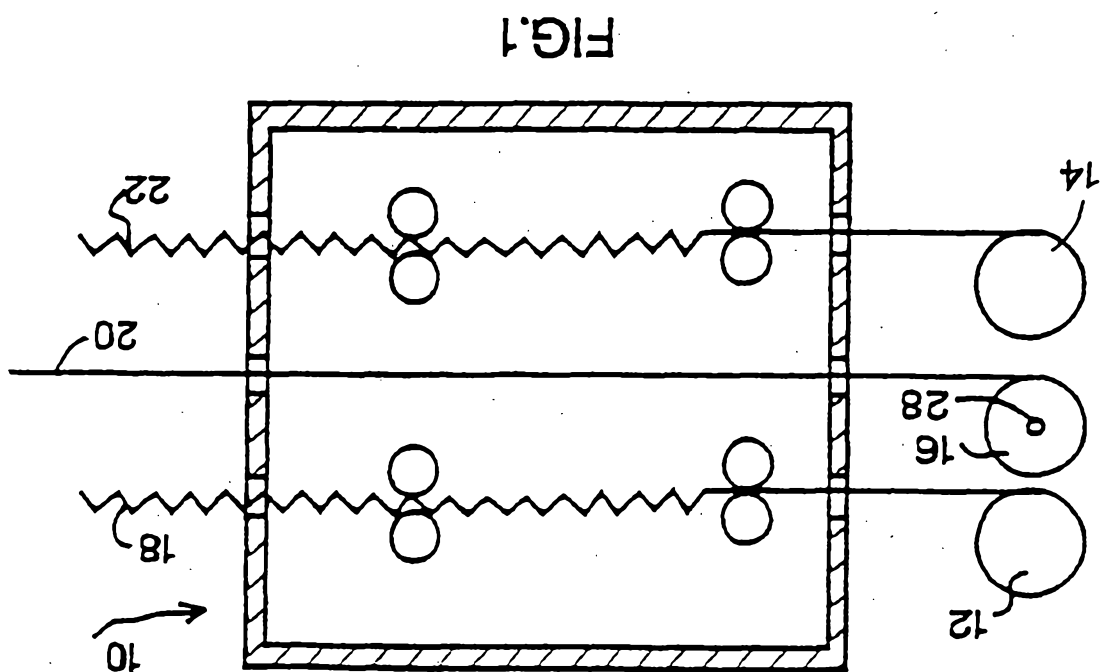


FIG. 1



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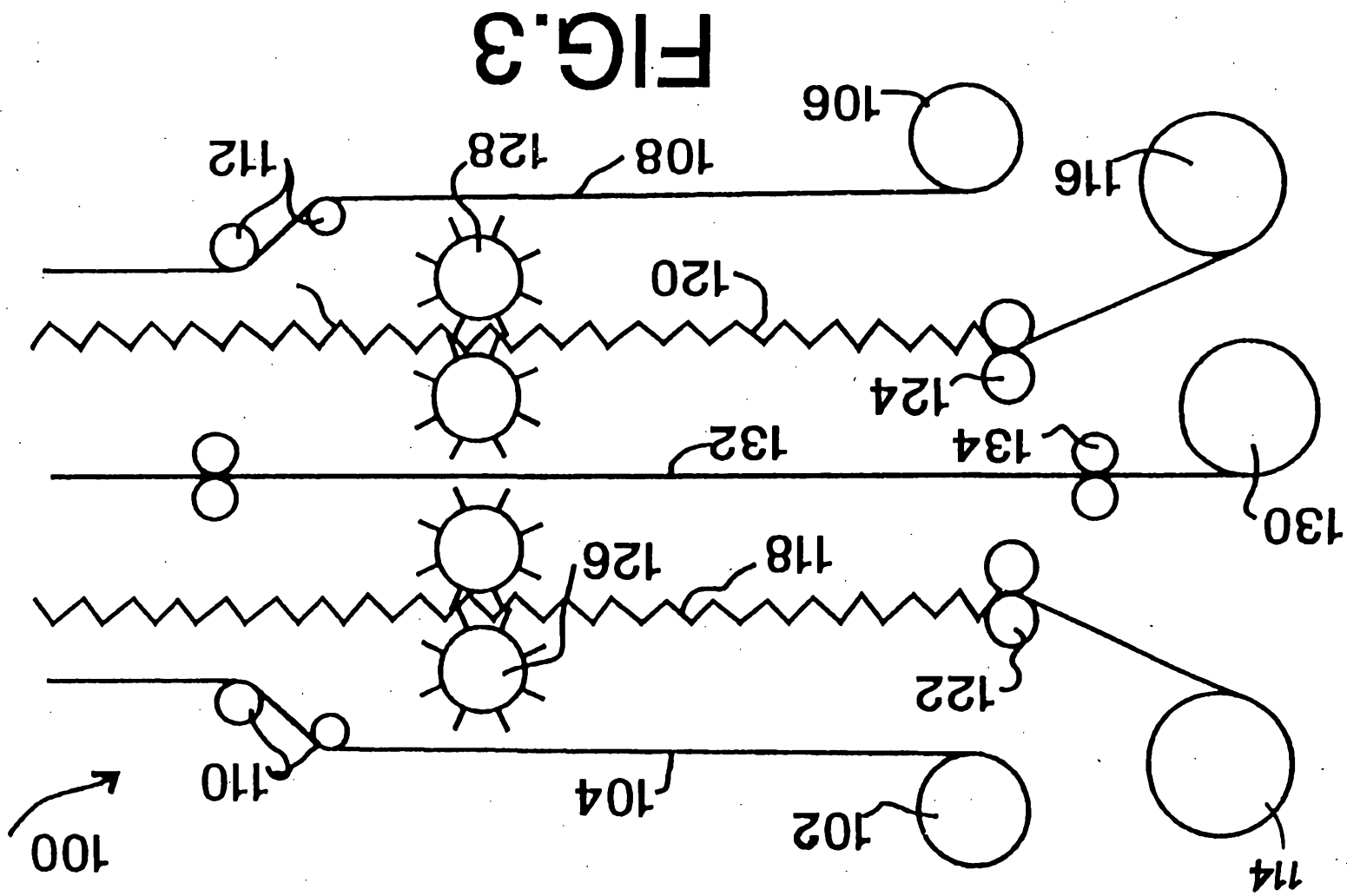


FIG. 3

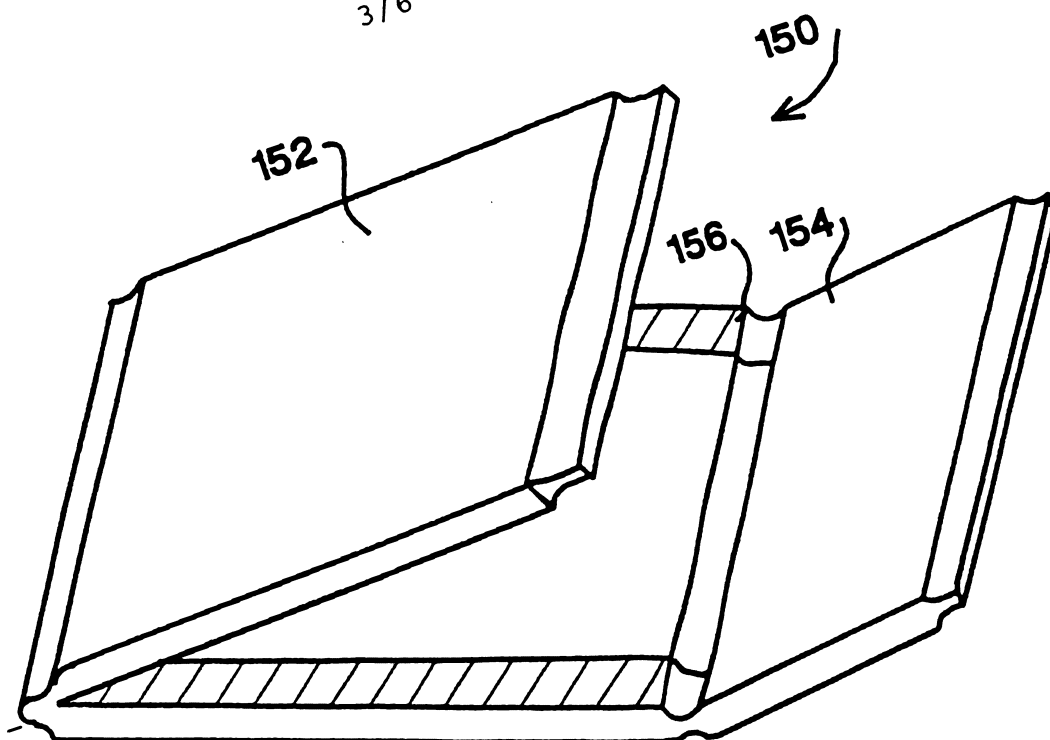


FIG. 4

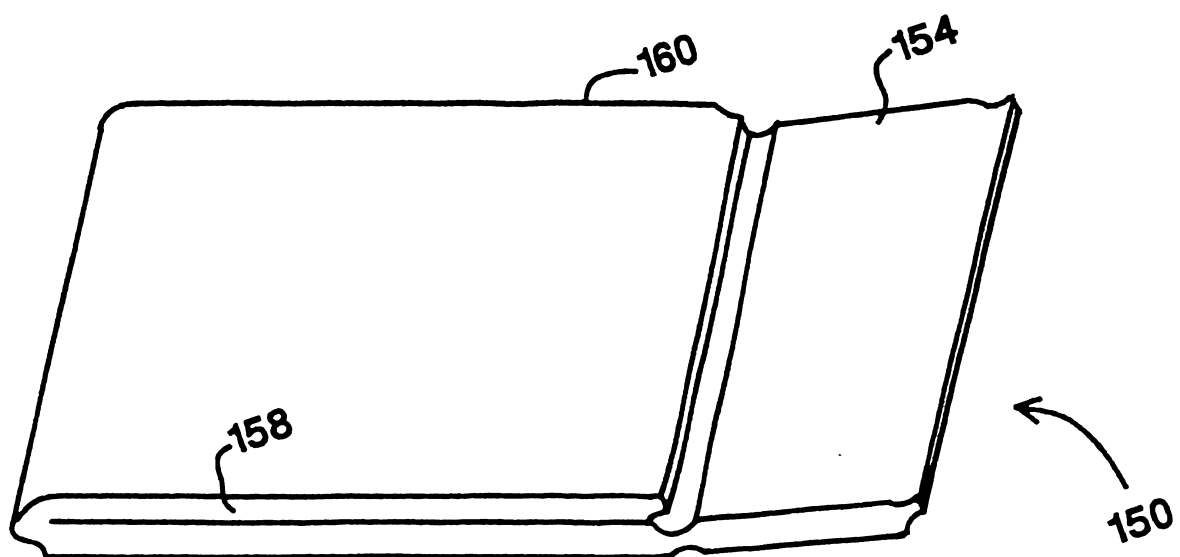


FIG. 5

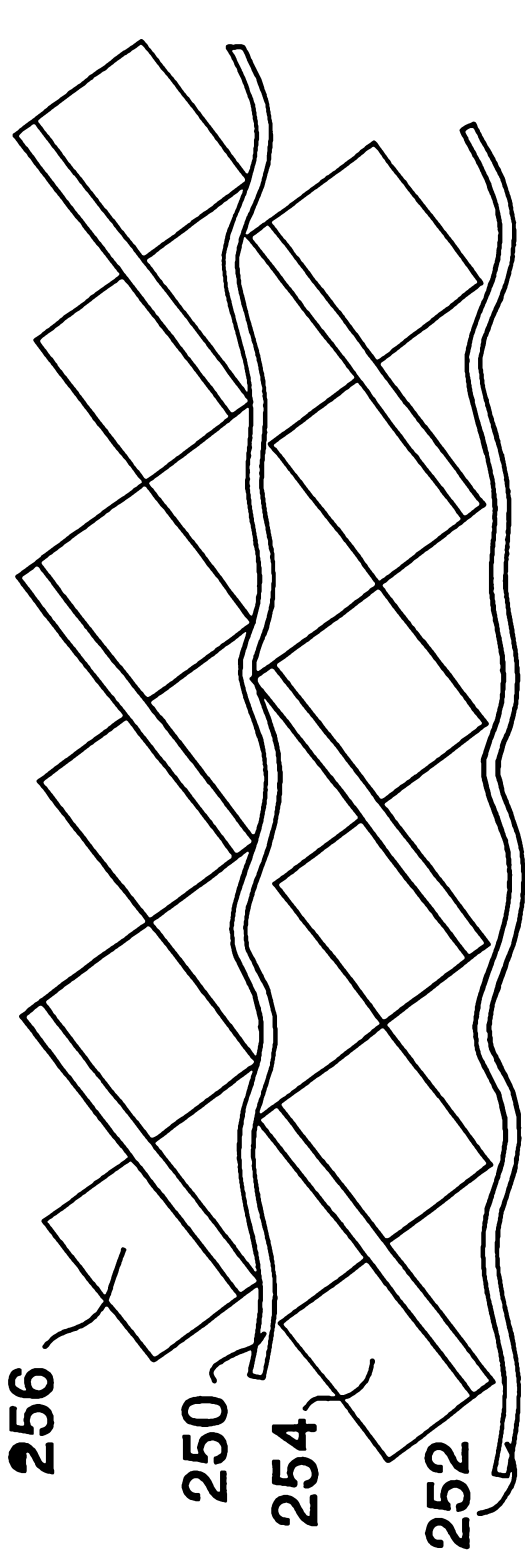


FIG. 6

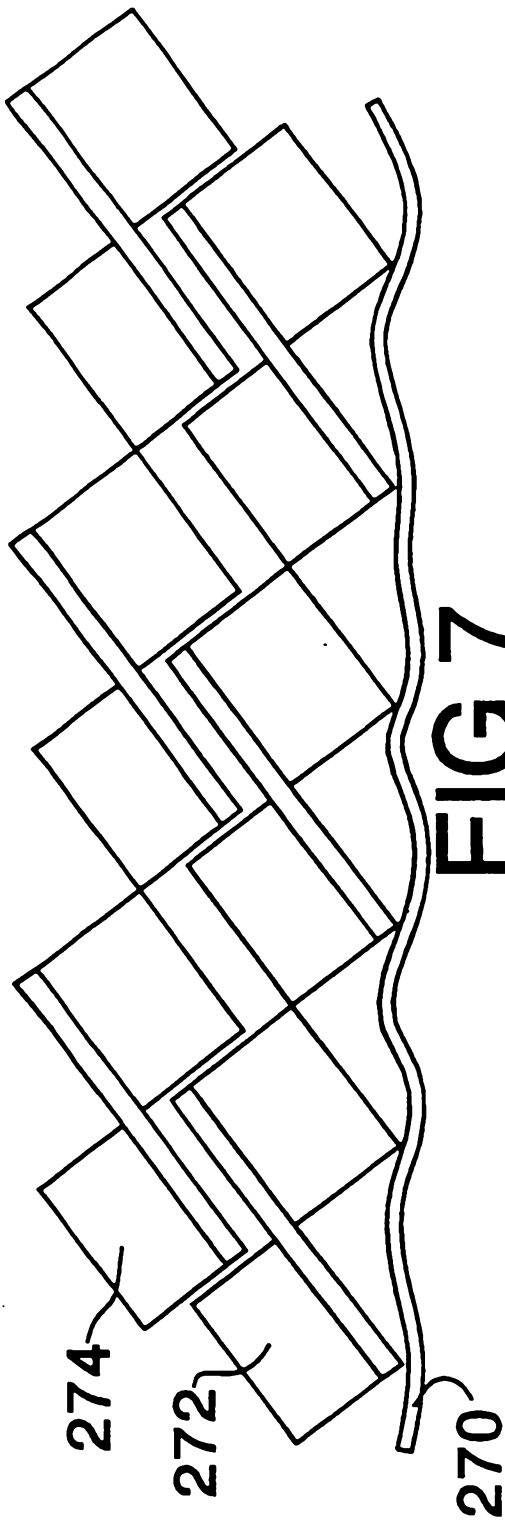
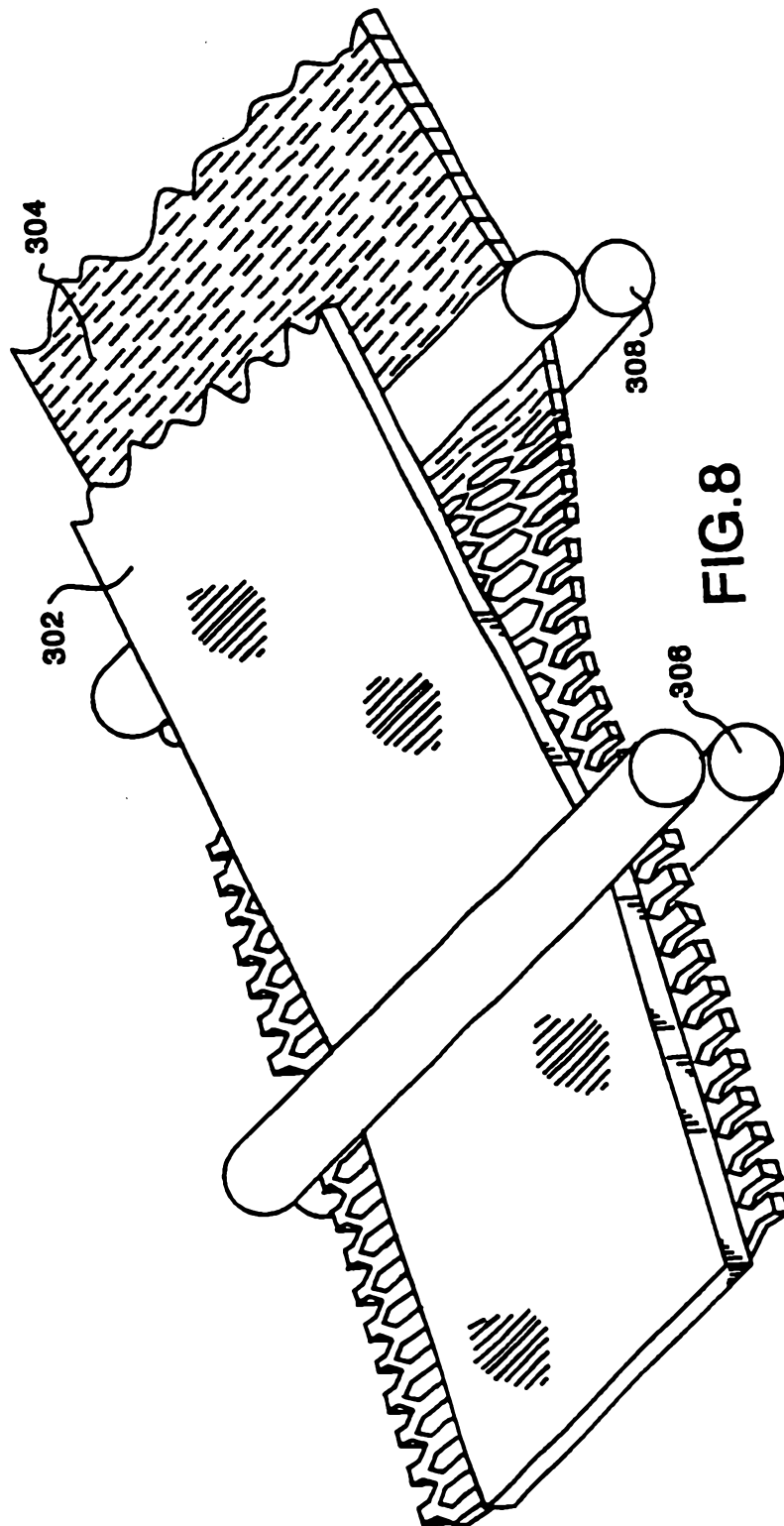
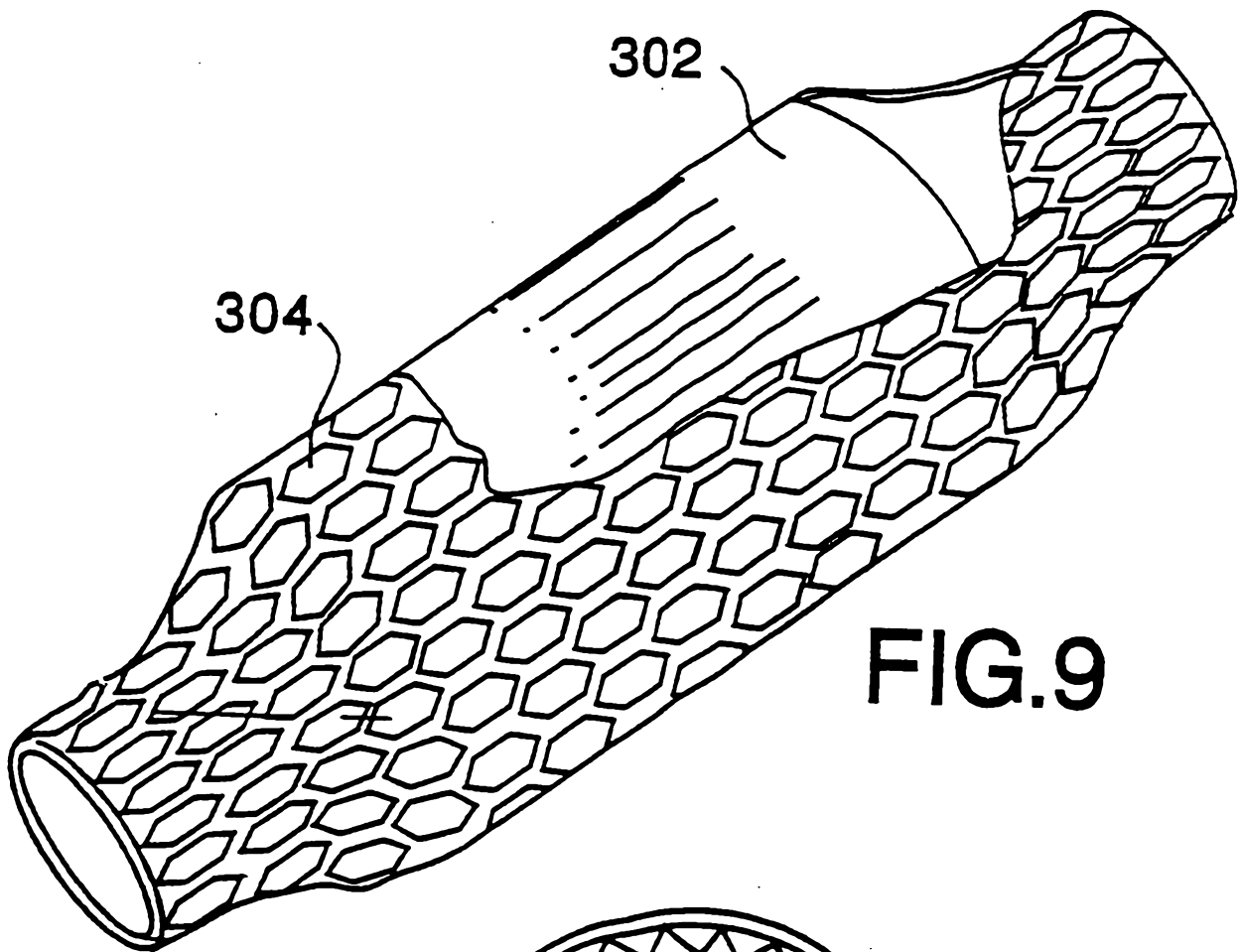
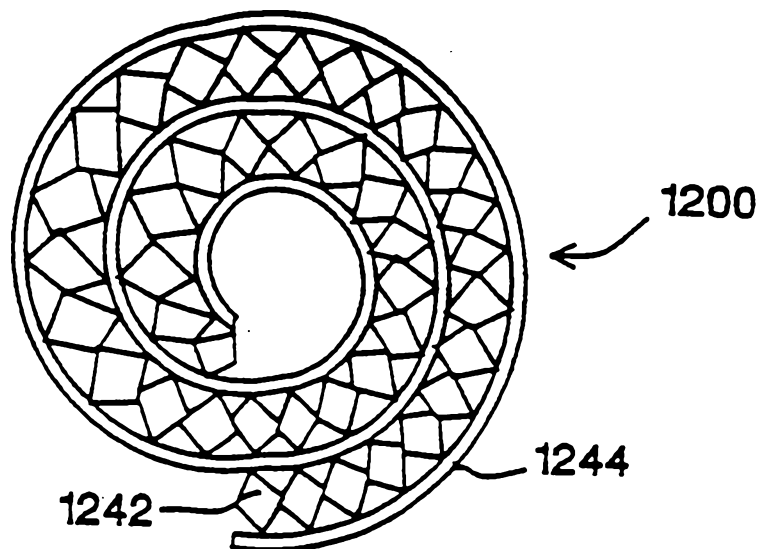


FIG. 7



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**FIG. 9****FIG. 10**

SUBSTITUTE SHEET (RULE 26)