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(54) Cushioned packaging materials

(57) A method of manufacturing cushioned packaging material (5,13,14) from paper, wherein an array of discrete portions (5a,5b) is formed over the majority of the surface area of the paper. Each of the discrete portions independently extends either above or below the

plane of the paper and thereby, in combination with the other discrete portions, provides a cushioning effect. A cushioned packaging material and paper packaging made from such material, including envelopes (15) and mailer bags, are also provided.

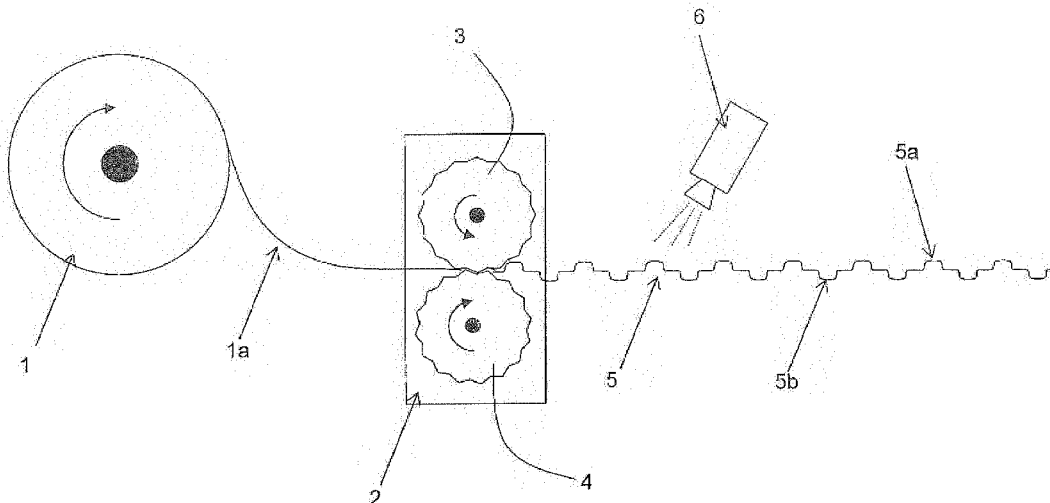


Fig. 1

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Description

Field of the Invention

[0001] The present invention relates in general to cushioned paper packing materials and methods of manufacturing such. In particular the present invention relates to envelopes and mailer bags formed using cushioned paper packaging materials.

Background of the Invention

[0002] During the transportation of objects via mail or courier services an object can be subject to mechanical stresses that can put the more fragile objects at risk. In order to help reduce the risk of an object being damaged in transit, objects may be wrapped in cushioned packaging materials or alternatively envelopes/bags comprising such materials.

[0003] One of the most popular forms of cushioned packaging material air cushioned mailers, which are provided with bubble wrap on their interior surface. The bubble wrap provides a cushioning layer which protects the contents of the mailer from mechanical stresses.

[0004] Bubble wrap is made primarily from plastic, and this tends to increase the manufacture costs of such packaging compared to packaging made solely from paper, for example.

[0005] In addition, recent moves towards more environmentally friendly and recyclable packaging have highlighted some disadvantages with these bubble wrap mailers in this regard. In particular there can be difficulties involved in removing the bubble wrap from the paper component of these air cushioned mailers. As a result recycling can be difficult and economically unattractive.

[0006] More environmentally friendly alternatives of air cushioned packaging are available. One such alternative takes the form of an envelope/mailer bag which has a twin-wall cavity between which recycled paper fibers can be retained. However, whilst more easily recycled at the end of their lifespan, these mailers tend to be heavier, which can mean that negate the benefits of their recyclability are negated by the increased fuel requirements for transporting such mailers.

[0007] Another alternative form of cushioned packaging material makes use of corrugated card or paper to provide the required cushioning feature to various types of packaging, including envelopes. Although the use of corrugated card/paper allows for the elimination of plastics from the packaging material, there are disadvantages to its use.

[0008] One such disadvantage is the amount of card/paper material required to make a standard sized envelope, which is greater than is required for a standard sized, non-corrugated envelope because of the way in which corrugation is formed. This increased material requirement of each envelope/mailer leads to an increase in the weight of the packaging, which again results in

increased fuel requirements when transporting the envelopes/mailers.

[0009] The present invention seeks to provide an alternative to the above-mentioned cushioned packaging containers which have lower manufacture costs, are lightweight and can be more easily recycled.

Summary of the Invention

[0010] The present invention provides a method of manufacturing a cushioned packaging material from paper, said method comprises forming an array of discrete portions across the majority of the surface area of the paper, wherein each of the discrete portions in the array independently extends either above or below the plane of the paper.

[0011] The array of discrete portions that covers a majority of the paper sheet provides a cushioning effect which, when wrapped around an object, provides a level of protection to such object. It is appreciated that in order for the material to provide an adequate level of protection at least 50% of the surface area of the paper needs to be provided with discrete portions. Although, of course, it is appreciated that greater surface area coverage could further improve the cushioning effect.

[0012] Preferably the array may be formed by embossing the paper with discrete portions.

[0013] Preferably the paper may be selected from the group consisting of: plain paper; chemically treated paper; laminated paper; and metalized paper. It is appreciated that the type of paper used to produce the packaging material of the present invention can be varied to suit the required characteristics of the end product.

[0014] It is appreciated that the paper used to make the packaging material may comprise either a single piece of paper or multiple layers of paper. Thus, depending on the quality of the paper being used, it is appreciated that it may be preferable for multiple sheets of paper, each having an array of discrete portions thereon, to be combined to form the cushioned paper packaging material. In this regard, it is appreciated that multiple sheets of lower grade (i.e. lower density or gsm) paper could be used instead a single sheet of high grade (i.e. higher density or gsm) paper.

[0015] Regardless of whether the packaging material is made from a single piece or multiple layers of paper in one embodiment of the present invention it is considered preferable that the paper is provided with an array of discrete portions that all extend from the plane of the paper in the same direction. In another embodiment the paper may be provided with an array of discrete portions that alternately extend above and below the plane of the paper. Further preferably, when the discrete portions extend in both directions, the discrete portions may be arranged in an alternating pattern.

[0016] Preferably the shape of each discrete portion may be uniform. Preferably the shape of the discrete portions may be selected from the group consisting of: sub-

stantially hemi-spherical; pyramidal, square, triangular, circular, rectangular, and diamond. Other shapes are considered possible within the general concept of the present invention, provided they can be arranged in an array.

[0017] Preferably the method of the present invention further includes the step of treating the paper with a hardening solution, such as starch, either after or before the array of discrete portions has been formed on the paper. In this way the array of discrete portions can be given structural strength that helps them retain their shape over time.

[0018] Preferably the method may further involve strengthening the cushioned packaging material by affixing an additional layer to the paper. Further preferably the additional layer may be selected from the group consisting of: paper; plastic; rubber; metal; and fabric. By affixing the additional layer to the paper it is possible to strengthen the cushioned packaging material and also in some cases help retain the shape of the discrete portions over time. Again, depending upon the material used for the additional 'structural' layer, the additional layer can provide the packaging material with additional technical features for more specialized packaging requirements (e.g. water resistance).

[0019] The present invention also provides a cushioned packaging material comprising paper having an array of discrete portions provided over the majority of the surface area of the paper, and wherein each of the discrete portions independently extends either above or below the plane of the paper.

[0020] It will be appreciated that the preferable features identified above in connection with the method of manufacturing the cushioned packaging material are also applicable to the packaging material product.

[0021] Preferably the distance that the discrete portions extend from the plane of the paper may be such that the paper has an effective thickness of at least 2mm. By providing an array of discrete portions on the paper it is possible to increase the effective thickness, or, in other words, the amount of cushioning the paper can provide. It is appreciated that in order for the packaging of the present invention to have a meaningful cushioning effect the minimum effective thickness needs to be at least 2mm.

[0022] It is appreciated that the cushioning effect of the packaging material of the present invention may be increased by using either a single piece of high quality paper (e.g. 90-200gsm), which can sustain more pronounced discrete portions, or a combination of multiple sheets of lower quality paper (e.g. 30-60gsm), which are less capable of retaining discrete portions. As the aggregate effective thickness of multiple pieces of lower quality paper can equate to the effective thickness of a single piece of higher quality paper, the use of single or multiple layers of paper can be used provide the same overall cushioning effect.

[0023] Depending on the quality of the paper used it

is appreciated that effective thicknesses of up to 6 to 8 mm are achievable from single paper pieces. In addition, it is envisaged that the use of treated or laminated paper can enable even higher effective thicknesses to be achieved because of the increased distance that the discrete portions can be extended from the plane of the paper before the paper breaks.

[0024] In a preferred embodiment of the present invention a cushioned paper packaging is formed from the packaging material of the present invention. Typical examples of paper packaging include envelopes and mailer bags.

[0025] Another preferred embodiment of the present invention provides a cushioned paper bag or envelope formed from a cushioning layer and a structural layer fixed in a layered relationship with one another, wherein:

the cushioning layer, which provides the inner surface of the bag or envelope, comprises one or more layers of paper having an array of discrete portions provided over the majority of the surface area thereof, wherein each of the discrete portions independently extends either above or below the plane of the or each layer of paper; and
the structural layer provides the outer surface of the bag or envelope.

[0026] Preferably the structural layer may be made of paper. It is envisaged that the cushioned paper bag or envelope of the present invention may have additional features. Suitable additional features will become apparent from the detailed description of the present invention.

Brief Description of the Drawings

[0027] The preferred embodiments of the various aspects of the present invention will now be described with reference to the drawings, wherein;

Figure 1 shows a manufacturing process by which a first variant of the cushioned paper packaging material is produced;

Figure 2 shows a manufacturing process by which a second variant of the cushioned paper packaging material is produced;

Figure 3 shows a manufacturing process by which a third variant of the cushioned paper packaging material is produced;

Figure 4a and 4b show the first variant of the cushioned packaging material that can be produced by the process represented in Figure 1;

Figure 5a and 5b show an intermediate variant of the cushioned packaging material;

Figure 6a and 6b show the second variant of the cushioned packaging material that can be produced by the process represented in Figure 2;

Figure 7a and 7b show the third variant of the cushioned packaging material that can be produced by

the process represented in Figure 3; and Figure 8 shows an envelope (or mailer bag) made from the cushioned paper packaging material of the present invention.

Detailed Description of the Present Invention

[0028] Primarily the present invention relates to a paper-based cushioned packaging material and methods of manufacturing such. The cushioning effect of the packaging material is essentially provided by paper - rather than plastic (c.f. bubble wrap) for example - which has been appropriately shaped with an array of individual raised, or indeed lowered, portions that extend from the plane of the paper. The raised (or lowered) portions are arranged across the plane of the paper in an array so as to provide the desired cushioning effect. Whilst the packaging material of the present invention is essentially paper based, it is appreciated that additional materials, such as plastic, could be used to supplement the properties of the paper in some situations.

[0029] It is anticipated that, whilst there will be a range of variants of the cushioned packaging material of the present invention (see figs 4a-7b), they all share the essential feature that the cushioning effect of the packaging material is provided primarily by a paper structure.

[0030] Figures 1 to 3 show various arrangements of manufacturing process, each of which can be used to produce one or more of the product variants shown in Figs 4a-7b.

[0031] Referring now to Figure 1, the various stages of the manufacture process can be appreciated. Firstly, a roll of paper 1 provides the stock material from which the cushioned packaging material of the present invention is produced. At its most basic the paper 1 a provided on the roll 1 can be virgin or recycled plain paper, (i.e. standard untreated paper made from wood pulp).

[0032] It is appreciated, however, that alternative types of paper, including paper made from animal dung, crape paper or Japanese knotweed, could be used effectively within the scope of the present invention for their own individual characteristics as required.

[0033] Although not essential to the invention in its broadest sense, the paper source material may also be pre-treated in some way depending upon what characteristics are required for the finished packaging product. Specific examples of ways in which pre-treatment of the source paper can be used to enhance the finished packaging product include:

a) applying a hardening treatment, in the form of a starch additive for example, to the paper material so that when the paper is shaped with an array of discrete portions such shaping is more resiliently maintained by the paper. It is appreciated that such a hardening treatment might alternatively be applied after the paper is shaped with an array of discrete portions.

b) laminating the paper with a layer of plastics material will increase the paper's tolerance to deformation, thus increasing the height that each discrete portion can extend from the plane of the paper without breaking. The amount of plastic material required to produce the cushioning effect provided by the packaging material of the present invention is lower than is required for Bubble Wrap, for example, because the paper provides the majority of the structure. This therefore reduces the material costs incurred during manufacture of a cushioned packaging material.

c) metalized paper may also be used to produce the packaging.

[0034] The use of metalized paper packaging may of particular use when transporting electrical components, for example.

[0035] In order for the cushioned packaging material of the present invention to provide a useful cushioning effect it is appreciated that the packaging material would preferably have an effective thickness of at least 2mm, which is achieved by the discrete portions extending from the plane of the paper. An effective thickness of between 6-8mm is considered more preferable because of the increased cushioning effect it affords.

[0036] It is appreciated that the lower the density (g/m^2 or gsm) of the source paper material the less capacity the source paper has to retain an array of discrete portions, which in turn effects the extent to which the discrete portions can extend from the plane of the paper.

[0037] The minimum effective thickness of the packaging material can be achieved by using a single sheet (or ply) of source paper that has a density of around 90-200gsm. Alternatively the effective thickness can be achieved by using a source paper that comprises multiple sheets (or plies) of lower density paper (e.g. 30-60gsm). Also, as mentioned above, the extent to which discrete portions can extend from the plane of the paper can be increased by pretreating the paper, for example by lamination with plastic or spraying with starch.

[0038] Returning now to the process shown in Figure 1, the source paper 1 a is supplied by the paper roll 1. The paper 1 a is shaped with an array of discrete portions and in this embodiment the discrete portions are embossed onto the paper by an embosser 2. It is envisaged that alternative mechanisms for forming the array of discrete portions may be adopted. The embosser 2 shown in Figure 1 comprises two rollers 3 and 4 each of which has a pattern of raised portions and corresponding indentations.

[0039] The rollers 3 and 4 are positioned relative to one another so that, when the rollers come together the raised portions of one roller are received within the indentations on the adjacent roller. In this way, when the rollers come together they impart a pattern of discrete portions which either extend upwards or downwards from the plane of the paper. As the paper passes through the

embosser 2 an array of discrete portions is formed on the paper.

[0040] The embossed paper 5 that exits the embosser 2 therefore has raised discrete portions 5a and lowered discrete portions 5b. The embossed paper 5 is considered to a variant of the cushioned packaging material of the present invention.

[0041] In the process shown in Figure 1 the embossed paper 5 is sprayed with a starch additive from a dispenser 6 to help strengthen and maintain the discrete portions 5a, 5b. Suitable forms of starch additive include oxidized acetyl and cationic starch; although other suitable forms of hardening additive will be appreciated too. In addition it is envisaged that alternative mechanisms for applying the additive to the paper include baths and wet rollers.

[0042] The variant of the cushioned packaging material that is produced by the process of shown in Figure 1 is shown in more detail in Figures 4a and 4b. The alternating arrangement of the raised and lowered discrete portions can be appreciated from Figure 4a.

[0043] Figure 2 shows an alternative process for producing cushioned packaging materials of the present invention. Once again a source paper roll 1 supplies a steady supply of paper 1 a, this time to an embosser 7. As mentioned above, the exact form of the paper 1 a can vary depending upon what characteristics the finished product needs to have.

[0044] The embosser 7 shown in Figure 2 has a different arrangement of rollers 8 and 9 to the embosser 2 shown in Figure 1. In contrast, the embosser 7 shown in Figure 2 is arranged to form discrete portions that only extend away from the plane of the paper in one direction. To this end one of the rollers is provided with a pattern of raised portions and the other roller is provided with a pattern of corresponding indentations. The rollers are aligned to ensure that the raised portions are receivable within the indentations.

[0045] As the paper 1 a passes through the embosser 7 an array of discrete portions 10a, all of which extend away from the plane of the paper in the same direction, are formed on the embossed paper 10. This embossed paper 10 considered to be an intermediate variant of the packaging material of the present invention and is shown in more detail in Figure 5a and 5b.

[0046] It is envisaged that, although the intermediate variant may not be as effective as the other variants described herein, the embossed paper 10 can provide an effective cushioning effect when applied to high density and/or pre-treated source paper.

[0047] Once again a dispenser 6 applies a hardening treatment to the embossed paper 10 to help strengthen and maintain the discrete portions 10a. It is appreciated that this step may not be necessary for higher density paper, or indeed paper that has been pre-treated, for example with lamination.

[0048] After the formation of the array of discrete portions 10a, the paper 10 passes over roller 11 which applies an adhesive to one side of the paper. It is envisaged

that various types of adhesive can effectively be used, but suitable examples include cold starch glue, PVA glue and EVA glue.

[0049] Preferably, and as is shown in Figure 2, the adhesive is applied to the underside of the paper 10a. The underside of the paper is considered to be the opposite side of the paper from which the discrete portions extend and has accessible flat portions. It is intended that the adhesive is primarily applied to the flat portions of the paper 10a.

[0050] Once the adhesive is applied to the paper 10 it is brought together with a secondary source of paper 12a, which is supplied by roll 12. The adhesive enables the two paper streams to combine to produce the cushioned paper packaging material 13, which is the variant of the packaging material that is shown in Figures 6a and 6b. The secondary source paper 12a helps to reinforce the structural integrity of the finished product.

[0051] It is envisaged that a suitably shaped roller can be used to ensure that the two sheets 10a, 12a are forced into adhesive contact with one another without flattening the raised discrete portions on sheet 10a.

[0052] It is also envisaged that, whilst preferably the paper 10 is strengthened by applying the second layer of paper, the strengthening function may be alternatively provided by another suitable material. Suitable alternatives envisaged by the inventors are plastic, rubber, metal and fabric.

[0053] Figure 3 shows another alternative process for manufacturing cushioned packaging material of the present invention. The process shown in Figure 3 can be used to produce the variant of cushioned paper packaging material 14 that is shown in 7a and 7b.

[0054] The arrangement shown in Figure 3 is similar to that shown in Figure 2 in that the roll 1 supplies the source paper 1 a to an embosser 7 which produces embossed paper 10. However in the arrangement shown in Figure 3 a second roll 1' supplies a second source paper 1a' to a second embosser 7' which produces a second stream of embossed paper 10'.

[0055] The first and the second embossed paper streams are aligned so that, once a suitable adhesive has been applied by roller 11 to at least one of the embossed paper streams, the two streams of embossed paper come together to form a further variant of the cushioned paper packaging material 14 (see Figs. 7a and 7b). As before the adhesive is applied to the underside (i.e. the side with accessible flat portions) and the two sheets are forced into adhesive contact by suitably shaped rollers.

[0056] The alignment of the array of discrete portions formed on the first 10 and second 10' paper stream is such that when the streams come together each discrete portion on the first stream of embossed paper 10 lines up with a corresponding discrete portion on the second stream of embossed paper 10'. In this way a 'bubble' shape is formed at each point where the discrete portions align. Providing the seal formed between the two paper

streams is adequate the 'bubbles' can act in a similar way to Bubble Wrap.

[0057] It is envisaged that, although the variants of the cushioned paper packaging material shown in the Figures all have discrete portions that have a substantially hemi-spherical shape, the discrete portions may have alternative shapes. Examples of suitable alternative shapes for the discrete portions include: pyramidal, square, triangular, circular, rectangular and diamond shaped. It is appreciated that any shape that can be embossed on to or in to paper in an array formation would be considered suitable.

[0058] Although not shown in any of Figures 1-3, it is envisaged that the finished cushioned packaging material (i.e. 5, 13 or 14) could be rolled up on to a roll (not shown) for easy transport and storage. Alternatively the packaging material could be formed into specific shapes and sizes, preferably by a die cutting machine, so that the packaging material can be formed into envelopes or mailer bags by an envelope forming machine. It is also envisaged that, if formed with the correct dimensions, the cushioned packaging material 13, in particular, could be used in place of Bubble Wrap in existing Jiffy mailer manufacturing machinery with only minor adaptation of the existing equipment.

[0059] An example of an envelope 15 formed from a cushioned packaging material of the present invention is shown in Figure 8. Of the above described variants of cushioned paper packaging material that are provided by the present invention that shown in Figure 6a and 6b is considered particularly suitable for the formation of envelopes and/or mailer bags like that shown in Figure 8.

[0060] The envelope 15 is formed with the array of discrete portions located on the inner walls of the envelope. The discrete portions thereby combine to provide a cushioned region 16 which helps to protect objects placed within the envelope 15 against mechanical stresses during transit. The external walls of the envelope 17 are provided by the secondary layer of paper 12a (see Figs 6a and 6b), which gives the envelope it structural integrity. It is envisaged that paper used to provide the external walls of the envelope 17 may be pre-treated to give it improved strength or water resistance, for example.

[0061] The envelope 15 is preferably formed from two sheets of cushioned paper packaging material which are fixed together along three sides to form the envelope. The two sheets can be fixed together by a range of fixing means, which include: cold starch glue, PVA glue, EVA glue, hot melt, heat sealing and stitching. It is envisaged that further fixing means might also be employed without departing from the scope of the present invention.

[0062] Adjacent to the open side of the envelope (i.e. the side where the two sheets of cushioned paper packaging material are not fixed together) is provided a closure flap 19. The closure flap 19 is fixed to one of the sheets using a similar suitable fixing means to those used to fix the sheets of the envelope together (see above).

[0063] In addition, the closure flap 19 is provided with

at least one adhesive strip 20a, 20b with a peelable cover strip, which enables the closure flap to be secured across the opening of the envelope 15 thus retaining to contents within the envelope 15. Preferably the closure flap 15 is provided with more than one adhesive strip (Figure 8 shows an envelope with two adhesive strips), so that the envelope can be used more than once.

[0064] It is envisaged that the cushioned paper packaging material of the present invention can be used to produce a wide variety of envelopes and mailer bags. Some examples of types of envelopes/mailer bags which might suitably be produced include:

- (1) Gusseted with a bottom flap and extended top for sealing;
- (2) Flat with a bottom flap and extended top for sealing;
- (3) Block bottom with an attached flap for sealing;
- (4) Any size and length; and
- (5) Enclosed by either sealing the side walls or bottom flap.

[0065] Another preferable feature of the envelopes/mailer bags provided by the present invention would be the addition of an individual number and bar code to the bag to aid tracking of a parcel in transit. Also, for security purposes, tamper proof security seals similar to those described in UK patent application No. 1006999.5 could be provided instead of standard finger lift tape.

[0066] In situations where the cushioning paper packaging material of the present invention is to be used to form envelopes or mailer bags it is envisaged that, rather than completely forming envelopes/mailer bags of standard sizes, two streams of cushioned paper packaging material (e.g. variant 13) could be cut to an appropriate width and then fixed together along the edges thereof to form what is essentially a length of packaging material in a tube. Such tubing could then be stored on a roll and then cut from the roll in appropriate lengths as required.

[0067] These bespoke lengths of packaging material tubing would then be sealed at one end to form the bespoke envelope. The remaining open end of the envelope would then be provided with a suitable closure flap. It is expected that this approach to envelope formation would reduce the need for void fill where the object being transported is too small for the envelope.

Claims

1. A method of manufacturing a cushioned packaging material from paper, said method comprises providing the majority of the surface area of the paper with an array of discrete portions, wherein each of the discrete portions in the array independently extends either above or below the plane of the paper.
2. The method of claim 1, wherein the array of discrete

portions is embossed onto the paper.

- 3. The method of claim 1 or 2, wherein said paper, which comprises either a single piece of paper or multiple layers of paper, is provided with an array of discrete portions that either all extend from the plane of the paper in the same direction or alternately extend above and below the plane of the paper. 5
- 4. The method of any of the preceding claims, wherein the shape of each discrete portion is uniform; and wherein preferably the shape of the discrete portions is selected from the group consisting of: substantially hemi-spherical; pyramidal, square, triangle, circular, rectangle, and diamond. 10
- 5. The method of any of the preceding claims, wherein the paper is treated with a hardening solution after the array of discrete portions has been formed thereon. 15
- 6. The method of any of the preceding claims, further comprising strengthening the cushioned paper packaging material by affixing an additional layer to the paper; said additional layer preferably being selected from the group consisting of: paper; plastic; rubber; metal; and fabric. 20
- 7. A cushioned packaging material comprising paper having an array of discrete portions provided over the majority of the surface area of the paper, and wherein each of the discrete portions independently extends either above or below the plane of the paper. 25
- 8. The packaging material of claim 7, wherein the array of discrete portions is embossed onto the paper. 30
- 9. The packaging material of claim 7 or 8, wherein the paper is selected from the group consisting of: plain paper; chemically treated paper; laminated paper; and metalized paper. 35
- 10. The packaging material of claim 7, 8 or 9, wherein said paper, which comprises either a single piece of paper or multiple layers of paper, is provided with an array of discrete portions that either all extend from the plane of the paper in the same direction or alternately extend above and below the plane of the paper. 40
- 11. The packaging material of any of claims 7 to 10, wherein the shape of each discrete portion is uniform; and wherein preferably the shape of the discrete portions is selected from the group consisting of: substantially hemi-spherical; pyramidal, square, triangle, circular, rectangle, and diamond. 45
- 12. The packaging material of any of claims 7 to 11, 50

wherein distance that the discrete portions extend from the plane of the paper is such that the paper has an effective thickness of at least 2mm.

- 13. The packaging material of any of claims 7 to 12, further comprising a strengthening layer affixed to the paper, said strengthening layer being selected from the group consisting of: paper; plastic; rubber, metal and fabric. 55
- 14. A cushioned paper packaging formed from the packaging material of any of claims 7 to 13. 10
- 15. A cushioned paper bag or envelope formed from a cushioning layer and a structural layer fixed in a layered relationship with one another, wherein: 15

the cushioning layer, which provides the inner surface of the bag or envelope, comprises one or more layers of paper having an array of discrete portions provided over the majority of the surface area thereof, wherein each of the discrete portions independently extends either above or below the plane of the or each layer of paper; and the structural layer, which is preferably made of paper, provides the outer surface of the bag or envelope.

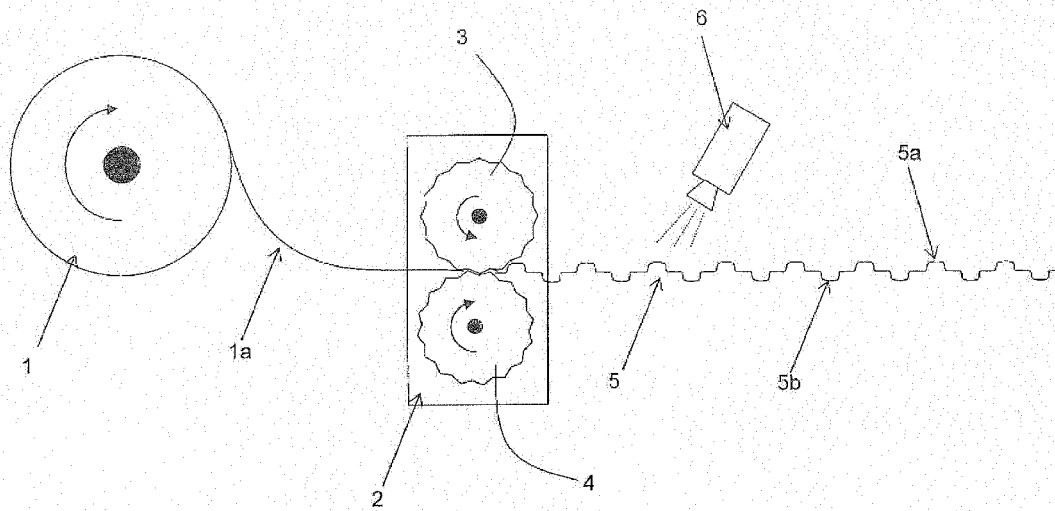


Fig. 1

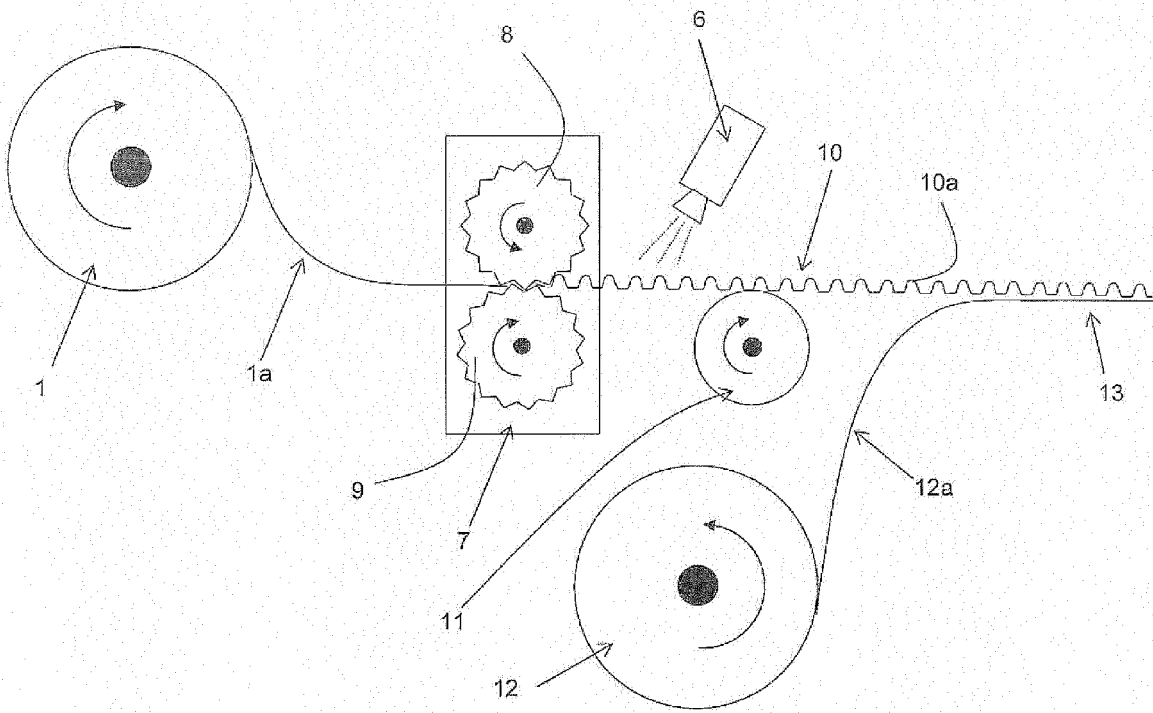


Fig. 2

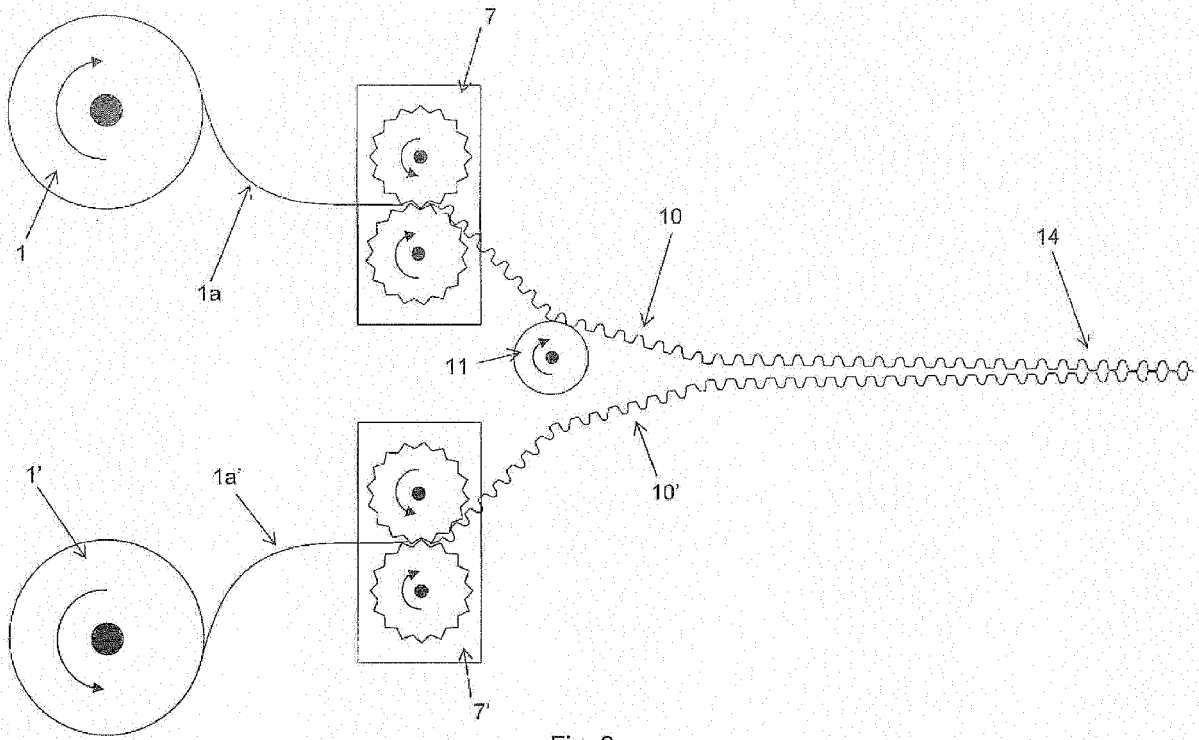


Fig. 3

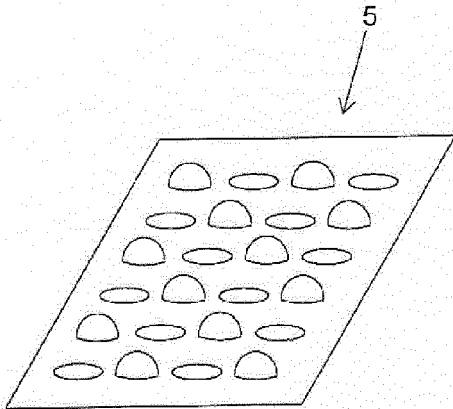


Fig. 4a

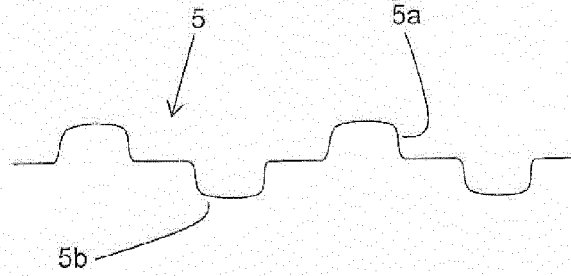


Fig. 4b

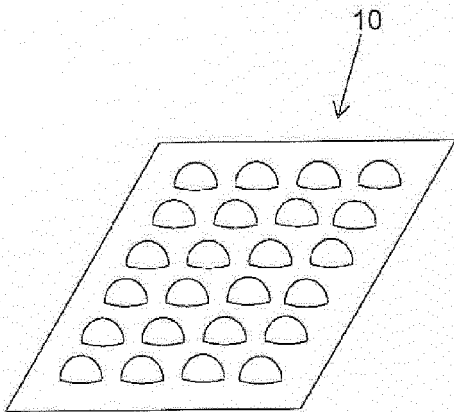


Fig. 5a

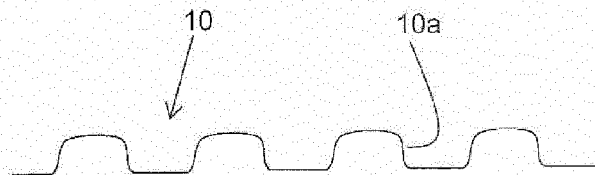


Fig. 5b

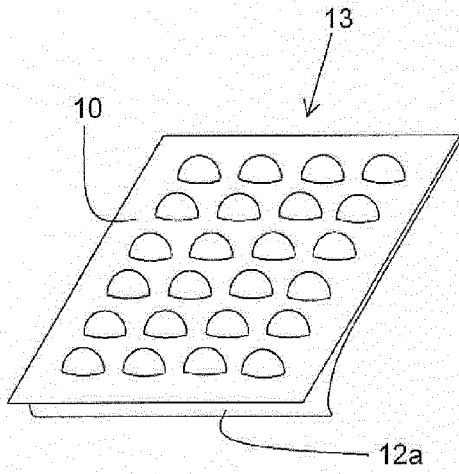


Fig. 6a

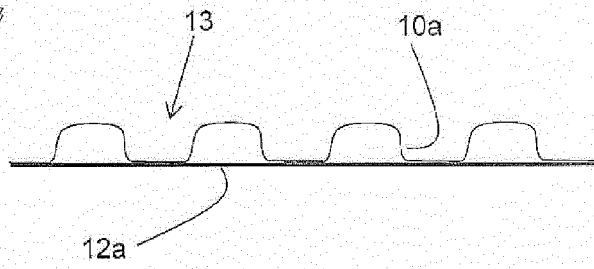


Fig. 6b

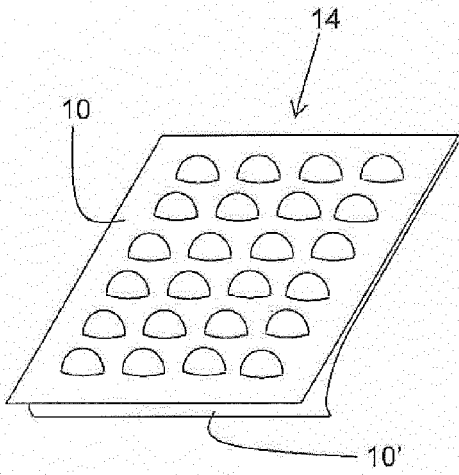


Fig. 7a

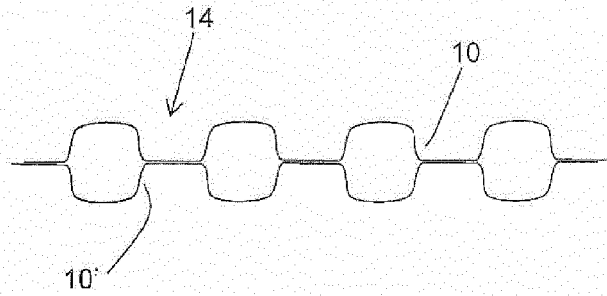


Fig. 7b

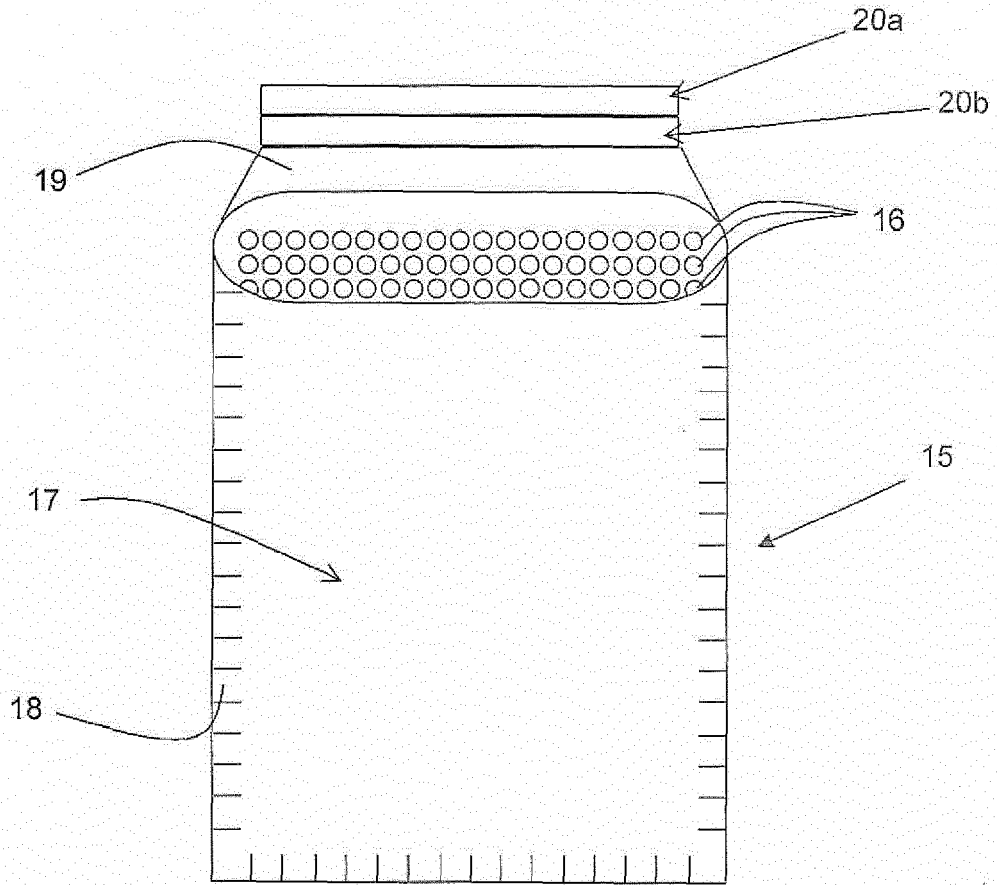


Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 1006999 A [0065]