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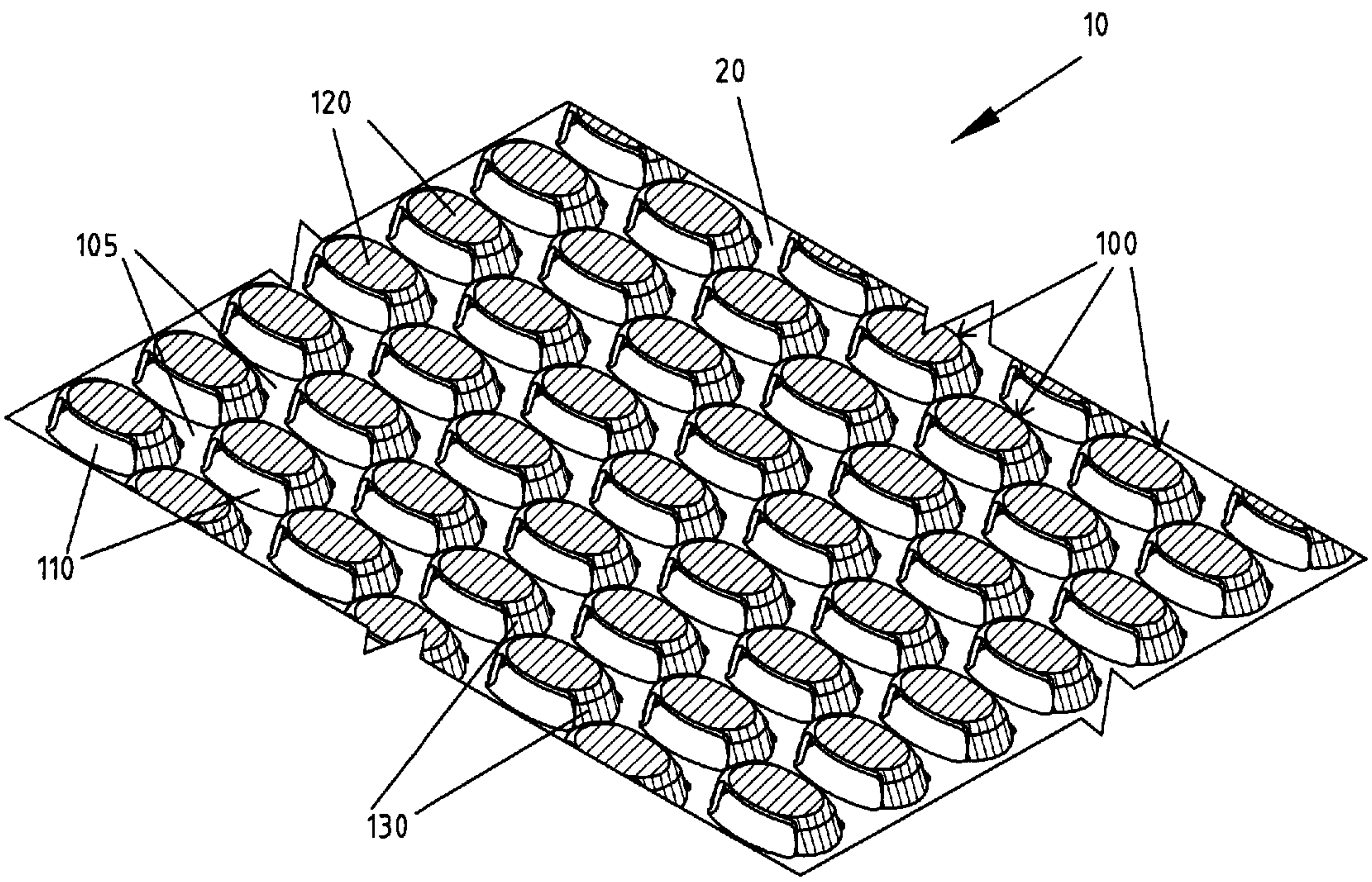


(57) Abrégé/Abstract:

A profiled film structure, textiles comprising at least two layers of the structure, and methods of making the structure and textiles. Each film layer is profiled with regularly arranged protrusions, separated by planar land areas. Portions of at least one side wall of the protrusions are slit to create apertures extending through the film and top members forming coplanar latching means extending over the apertures. When the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of each layer are received and retained within the apertures of the opposing layer, resulting in an efficiently assembled self-locking structure having selectable permeability for fluid flow through the structure.

ABSTRACT

A profiled film structure, textiles comprising at least two layers of the structure, and methods of making the structure and textiles. Each film layer is profiled with regularly arranged protrusions, separated by planar land areas. Portions of at least one side wall of the protrusions are slit to create apertures extending through the film and top members forming coplanar latching means extending over the apertures. When the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of each layer are received and retained within the apertures of the opposing layer, resulting in an efficiently assembled self-locking structure having selectable permeability for fluid flow through the structure.

FILM STRUCTURES FOR SELF LOCKING NONWOVEN INDUSTRIAL TEXTILE

FIELD OF THE INVENTION

The invention concerns film structures and textiles formed from at least two layers of selectively slit and profiled polymeric film. It is particularly concerned with such textiles in which the protrusions and slit openings are structured and arranged so that, when two similarly formed film layers are brought together in alignment such that the protrusions of one layer are positioned between those of the second, the resulting structure is self locking due to the interconnection of the top surfaces of the protrusions of one layer with openings in the sides of the protrusions in the opposing layer. The resulting two layer structure requires no additional bonding, is resistant to compressive loading and the aperture sizes can be selected to provide a desired permeability, and thus has application in a wide variety of industrial processes.

BACKGROUND OF THE INVENTION

Industrial textiles comprising at least one layer of slit and profiled film are known. For example, WO 2011/069259 to Manninen discloses industrial textiles made from at least one layer of selectively slit and profiled polymeric film which are embossed to impart surface contouring and other properties similar to those resulting from various weave designs for woven fabrics. The film is pressed by application of heat and pressure using a chosen mold pattern so as to selectively and permanently deform portions out of plane; a slitting process is used to create apertures at the deformations to allow the passage of fluids such as air and water through the fabric. The length of the individual slits is equal to the length of the aperture formed in the film. The document also discloses that a two layer fabric can be provided in which a first layer of a suitably slit and embossed film is mated with a second similarly imprinted sheet so that the outer surfaces of the deformations formed by the embossing processes face one another. The two layers must be secured together, for example by welding, such that the upper protrusion surfaces of a first film layer are joined to the land areas of a similarly slit and profiled second film layer to create the assembled film structure.

It is known from CA 2,779,969 to Manninen to provide industrial fabrics for conveying in an industrial process which are formed from two layers of profiled and aperture film, where at least some of the protrusions on the film surface are provided with a first end integral with a contiguous land area and an opposing second end having either a detached free end or a weakened end portion arranged to be detachable from a contiguous land area in response to strain. The film provides flexibility to allow controlled relative movement of the layers to minimize the effects of internal strain.

It is further known from CA 2,779,131 to Manninen to provide a nonwoven film fabric comprising two planar polymeric films which are thermoformed according to a desired embossing pattern. The embossments are shaped such that either: at least two end walls are provided with a shell-like configuration, or the side walls are materially reinforced due to the chosen slitting pattern. The size and location of the slits may be adjusted as required so as to impart a desired permeability. Nonwoven fabrics assembled from two like interengaged layers exhibit improved resistance to compressive loading in comparison to similar prior art fabrics, allowing them to maintain a void volume between the film layers and thus the chosen permeability.

From WO 2005/019531 to Fitzpatrick it is known to provide a grooved and vented industrial process belt including a porous membrane which has a porous polymer coating, a permeable polymer film or an assembly of short fibers or multifilaments. The porous polymer coating can be produced by laser drilling, removal of a soluble component, mechanical punching or by applying a resin as a reticulated or nonreticulated foam.

It is known from WO 2008/145420 to Bez et al. to provide a papermaking fabric comprising a plurality of films of polymer material which are laminated on one another, wherein the films each have a plurality of perforations which extend through their thickness to provide drainage channels. The perforations may be formed by removal of a filler from the polymer of which the films are comprised.

US 2010/0236740 to Mourad et al. discloses a nonwoven industrial belt comprised of at least one film layer which has been laser drilled to form shaped through openings to enhance topography of a sheet product conveyed thereon.

From WO 2008/112612 to Levine et al. it is known to provide a suction tape for use as a tobacco conveyer belt that is formed from a continuous polymeric film containing a polymer chosen to maximize the wear resistance and minimize toxicity of any polymer contaminating the tobacco. The tape is permeable and perforated according to a desired distribution by embossing mechanically, ultrasonically, or through a laser removal technique.

WO 2012/028601 to Eberhardt et al. discloses a perforated film fabric formed from a single layer or sheet of film. The lateral edges are not perforated, while the central area of the film fabric includes a plurality of pores which form passages between the two opposing surfaces of the belt.

WO 2012/123439 to Straub et al. discloses a papermaking fabric including a first and second layer each of which is formed by one or more film-shaped tapes which adjoin one another and are arranged next to one another in the CD. The tapes are arranged such that their lateral and longitudinal edges in a first layer are offset relative to those in a second layer. The tapes in one layer are bonded by one of various means to those in the other layer.

While industrial textiles made in accordance with the teachings of the above prior art may be satisfactory in certain applications, in each case, the component film layers are not self-locking or interlockable in a manner which allows them to be permanently or semi-permanently joined together, and must be joined together in a separate bonding process in order to form the completed structure, by aligning each film layer relative to the other and bonding, which process is time consuming and may introduce inaccuracies into the resulting structure.

It would thus be highly desirable to provide a patterned and apertured film structure formed from at least two film layers, each of which was interlockable or autojoinable with the other during a single assembly process. It would be further desirable if the interlocking means provided an interconnection which was sufficiently robust such that the resulting structure was self-retaining and did not require an additional bonding step such that the two film layers would be retained in their joined configuration, but allowing for minor movements to accommodate and minimize the effects of internal strain. It would also be desirable if the interlocking means substantially prevented or eliminated any opportunity for misalignment of the two film layers to be joined. It would further be desirable if, when the film structure is intended for use as an industrial textile, a seaming component could be incorporated into the assembly. The present invention addresses this need, by providing film structures which are self-locking and are assembled from two similarly profiled film layers each of which includes protrusions and apertures which interact to provide an integrated structure having features somewhat similar to those of a woven textile, such as an internal void volume, permeability and diagonal apertures through the assembled structure which allow for passage of fluids through the assembly.

SUMMARY OF THE INVENTION

The invention therefore seeks to provide a film structure having

(i) an upper surface and a lower surface; and

(ii) a plurality of protrusions separated by land areas and defining a profile of the upper surface, wherein

(a) each protrusion has a body comprising a top member having opposed first and second lateral edges and is supported by opposed first and second end walls;

(b) at least one of the lateral edges cooperates with the end walls to define an aperture extending through the film from the upper surface to the lower surface; and

(c) the top member comprises a coplanar latching means extending over the aperture, wherein when the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of the first layer are received and retained within the apertures of the second layer, and the latching means of the second layer are received and retained within the apertures of the first layer.

Preferably, the top member is substantially planar. Preferably also the first and second end walls are compression resistant.

For many intended end uses, preferably the film structure is constructed of a thermoplastic polymer material; but for some uses, it may be constructed of a thermoset polymer material, or a metal material, in particular a metal material selected from at least one of aluminum alloy, brass, cold rolled steel, copper, galvanized steel, high strength low alloy steel, hot rolled steel, steel alloy and zinc.

The invention also seeks to provide a two-layer film structure comprising a first layer and a second layer each constructed according to the invention, wherein the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer and the latching means of each layer are secured within the apertures of the opposing layer.

The invention also seeks to provide a nonwoven industrial fabric comprising at least one layer of a film structure according to the invention.

The invention also seeks to provide a method of constructing an industrial film, the method comprising the steps of

(a) providing a film having an upper surface and a lower surface;

(b) selectively applying pressure to selected portions of the film to form protruding embossed areas separated by land areas, creating a contoured profile in the upper surface, each protruding embossed area comprising a top member having opposed sidewalls connected to the top member at first and second lateral edges; and

(c) selectively cutting and removing material from at least one of the sidewalls to define protrusions each having a body supported by opposed compression resistant first and second end walls and to define at least one aperture extending from the upper surface to the lower surface, wherein the top member comprises a coplanar latching means extending over the aperture, such that when the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of the first layer are received and retained within the apertures of the second layer, and the latching means of the second layer are received and retained within the apertures of the first layer.

The invention also seeks to provide a method of constructing a nonwoven industrial fabric, the method comprising the steps of

(a) providing two layers of a film structure, each layer being constructed according to the invention;
(b) aligning selected protruded embossed areas of the first layer with land areas of the second layer, and aligning selected protruded embossed areas of the second layer with land areas of the first layer;
(c) applying pressure to at least one of the first layer and the second layer to engage the latching means of the protrusions of the first layer within the apertures of the second layer, and to engage the latching means of the protrusions of the second layer within the apertures of the first layer, to secure the first layer to the second layer.

For the methods of the invention, the preferred materials for the film or film structure will be as noted above in relation to the film structures of the invention.

As described herein, the film structure of the present invention is comprised of two film layers each of which is similarly profiled in an embossing process to provide a chosen pattern of protrusions, each of which is separated from another by generally planar land areas which, together, define a profile to the surfaces of the film layers. Each protrusion is initially provided as a generally frustoconical shape including a top surface which may be generally planar and which is coplanar with all of the other protrusions in the film layer, and is supported by the side walls and end walls of the protrusion. At least one and preferably both of the side walls are then cut away in a slitting process which passes through the film thickness to leave behind first and second end walls which may be configured so as to be compression resistant. The lateral edges of the top surface of a protrusion cooperate with the two end walls to define at least one aperture extending through the film from the upper surface to the lower surface.

The top surfaces of each protrusion provide a coplanar latching means extending over the or each of the apertures. When the upper surface of a first layer of the profiled and slit film is brought into contiguous relationship with the upper surface of a second and similarly profiled layer of film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of the first layer are now received by and retained within the apertures of the second layer, thereby joining the two film layers together. A small amount of pressure is applied so as to "snap" the latching means on the first layer past those of the second layer. Due to the deformable nature of the film, and because at least one of the sidewalls of each protrusion has been removed in a previous preparation step, the top surfaces of the protrusions can bend slightly under pressure, thereby allowing these surfaces to slide past each other. As they do so, a portion of the lateral edge of each top surface of each protrusion on a first film layer becomes partially located in an aperture of a corresponding adjacent protrusion on a second film layer, thus retaining the protrusions in an interlocked configuration. The protrusions on each film layer are located such that the amount of space between adjacent top surfaces of the protrusions of one layer is slightly less than the width of the top surfaces of the other layer. Once the respective top surfaces have passed one another, they then "snap" back into their previous conformation due to the open space provided to each lateral edge by the apertures. The top surfaces are locked in position such that one is above the other, and each is resting on the planar film surface located between each protrusion. The strength of the lock (and conversely of the snap) will be a function of numerous factors, as is explained in detail below. Depending on the end use application of the film structure, the join between the two film layers can be enhanced, for example, by one or more of various bonding methods, although for some applications this may or may not desirable as such bonding will minimize or eliminate any interlayer movement; bonding can be performed at all or only some of the connection points between the two layers.

Depending on end use requirements, the profiled and slit film layers used in the assembly of the film structures of the invention can be formed from a variety of materials, such as thermoplastics, thermosets, or metals as noted above. The films themselves may be formed in any width as would be practical having regard to existing manufacturing facilities and the intended end use, but widths of from about 0.1m to about 1.0m would be satisfactory for use in the assembly of industrial textiles such as would be used for filtration or conveyance in industrial processes. The openness, or permeability of the assembly can be easily adjusted according to need by reducing the overall density of the protrusions. The film surfaces can be micro-profiled to impart a surface roughness or texture, or they may remain smooth, depending on need. The film structures of the invention can be assembled in any desired manner, provided that the individual layers are mutually compatible. For example, when used in an industrial textile having a length much greater than its width, the individual profiled and slit films could be oriented in the intended machine or cross-machine direction, depending on end use requirements. One layer of film may be offset from the second film layer with which it is assembled in the manner described in WO 2011/069259 to Manninen, such that one layer partially overlaps the second layer to which it is adjacent. It is also possible to integrate a seaming component into the assembled film structure which is integral to the assembly and formed from the same materials. In lieu of bonding by chemical or energy means, the film layers may also be joined together by insertion of monofilament-like strands which pass across the joined film structure through the mated apertures of the protrusions, also as described by in WO 2011/069259 to Manninen.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a perspective view of a profiled and slit film in an embodiment of the invention;

Figure 2 is a perspective view of an intended seam region of a nonwoven industrial textile in an embodiment of the invention;

Figure 3 is a perspective view of the seam region of Figure 2 after folding of the textile;

Figure 4 is a sectional side view of the film of Figure 2, taken along the line 4-4;

Figure 5 is a sectional lengthwise view of the film of Figure 2, taken along the line 5-5;

Figure 6 is a side view of the industrial textile of Figure 2 after folding of the textile;

Figure 7 is a top view of the film of Figure 2;

Figure 8a is a top view of the industrial textile of Figure 2 after folding as shown in Figure 3;

Figure 8b is an enlarged view of a portion of Figure 8a;

Figure 9 is a side view of two protrusions in film in an embodiment of the invention showing the slitting process;

Figure 10 is a first perspective view of the protrusions shown in Figure 9;

Figure 11 is a second perspective view of the protrusions shown in Figure 9;

Figure 12 is a top view of the protrusions shown in Figure 9;

Figure 13 is a side view of two layers of film in an embodiment of the invention, showing the interlocking process;

Figure 14 is a perspective view of the two layers of film shown in Figure 13;

Figure 15 is a top view of the two layers of film shown in Figure 13;

Figure 16 is a perspective view of an assembled two layer film in a further embodiment of the invention;

Figure 17 is a sectional side view of the film of Figure 16, taken along the line 17-17; and

Figure 18 is a sectional side view of the film of Figure 16, taken along the line 18-18.

DETAILED DESCRIPTION OF THE FIGURES

Figure 1 is a perspective view of a portion of profiled and slit film precursor 10, according to an embodiment of the invention. Film precursor 10 is comprised of a generally planar thermoplastic film stock 20, which has been profiled in a thermoforming process to impart a plurality of regularly arranged protrusions 100 between which are located planar regions 105. In this embodiment, protrusions 100 each have a generally frustoconical shape including an elliptical base and planar top surface 120 as discussed in greater detail below, and are arranged in a regular array of columns and rows. Sidewalls 112 have been slit between end walls 130 so that each protrusion 100 comprises at least one aperture 110, which allows fluid flow through film precursor 10. As discussed further below, two compatible layers of film precursor 10 can be combined by aligning the protrusions of each layer between the protrusions of the other layer such that planar top surfaces 120 of one layer contact planar regions 105 of the other layer.

Figure 2 is a perspective view of a portion of profiled and slit film precursor 10 according to a version of the embodiment of Figure 1, in which the film has been provided with seam region 30. Protrusions 100a, 100b are constructed as in Figure 1, respectively having planar top surfaces 120a, 120b, and apertures 110a, 110b. Seam region 30 includes a plurality of land areas separated by seam apertures 32. When film precursor 10 is folded along the centre line of seam region 30, the land areas will form seam loops 31 (see Figure 3).

As shown, film precursor 10 has two body regions 10a and 10b, separated by seam region 30; both body regions 10a, 10b are essentially identical with regards to the height, width and separation of the protrusions 100a and 100b. The rest of the textile body away from seam region 30 would be profiled in the same manner as body regions 10a and 10b. Protrusions 100a and 100b are located so that when film precursor 10 is folded at seam region 30, protrusions 100a can be aligned between protrusions 100b to provide a two layer film, as further shown in Figures 3 to 6.

Figure 3 is a perspective view of a portion of the industrial textile shown in Figure 2 and illustrating the relative appearance of the planar tops 120 and apertures 110 in an assembled film structure after folding film precursor 10 shown in Figure 2 at seam region 30. This view clearly shows the means by which body regions 10a and 10b of precursor film 10 are joined to form a self locking industrial textile of the present invention. During folding and assembly in the manner shown in more detail in Figure 6, the planar tops 120a of the protrusions 100a in region 10a are located in alignment with and in between the corresponding protrusions in body region 10b. A small amount of pressure is applied so as to "snap" the planar top surfaces 120a of body region 10a into the corresponding but smaller available space between top surfaces 120b of body region 10b. Due to the deformable nature of film precursor 20, and because the sidewalls 112 of each protrusion have been removed in a previous preparation step, the top surfaces 120 of the protrusions 100 in each of body regions 10a and 10b can bend slightly to allow these surfaces to slip past one another. Once past, the top surfaces 120 "snap" back into their previous planar conformation due to the open space provided on each side by apertures 110 and are now secured in position such that one is above the other, and each is resting on planar regions 105 of the film such as spaces 140, 145 (see Figure 7), located between each protrusion. This securing action is illustrated in greater detail in relation to Figures 14 and 15 as discussed below. The strength of the securing action (and conversely of the snap) will be a function of various factors, including the film's resistance to deformation (e.g. Young's modulus), the amount of overlap that exists between the locking features (i.e. the planar top surfaces 120 as they fit into the apertures 110), their geometry, the pitch or spacing between adjacent protrusions 100, and film thickness; other factors may have relevance as well. At this point, the two body regions 10a and 10b, now comprising two layers of the intended textile, may be separated by pulling them apart in opposite directions. As the two-layer textiles of the invention will not generally be subjected to such forces in the direction which would result in separation, this will not present any problem. However, if further securing is considered advantageous for a specific end use, any unwanted relative movement between the layers can be prevented or minimized, by bonding the top surfaces 120 of the protrusions 100 of each layer to the planar surfaces of the film in the opposing layer, at all or selected ones of the connection points between the two layers.

Figure 4 is a side view of film precursor 10 of Figure 2 and taken along line 4 – 4, indicating seam region 30 and body regions 10a and 10b. When folded at seam region 30 the planar top surfaces 120a of protrusions 100a of body region 10a will nest into the widthwise spaces 145 (see Figure 7) between the protrusions 100b located on body region 10b as will be discussed in detail below. Figure 4 also shows apertures 110a and 110b in protrusions 100a and 100b respectively, as well as end walls 130 of each of protrusions 100a, 100b; the end walls 130 take the form of a shell and provide a measure of compression resistance to the assembled structure, thus ensuring that apertures 110a, 110b remain at least partially open when the assembled textile is in use to allow for passage of fluid or other materials.

Figure 5 is a lengthwise view of film precursor 10 shown in Figure 2 and taken along the line 5 – 5 in that Figure. In Figure 5, it can been seen that the top surfaces 120 of the protrusions 100 form a level plane rising out of film stock 20, the surfaces 120 being supported in this manner by the curved end walls 130 remaining for each protrusion following removal of a portion of the sidewalls 112 (see Figure 8) to form apertures 110.

Figure 6 is a side view of profiled and slit film precursor 10 of Figure 2 following a folding process along seam region 30 so as to bring opposing body regions 10a and 10b together. As can be seen, the generally planar tops 120 of each protrusion from each of body regions 10a and 10b rest in contact with planar land areas 105 on the opposing surface, and apertures 110 are in alignment to form open channels through the assembled structure; these channels provide a void volume to the assembled structure allowing for passage of fluid. These channels can be made larger or smaller according to need by selecting an appropriate height of end walls 130 of each protrusion 100. End walls 130a and 130b of each protrusion 100 are aligned across the width of the structure to provide support and resist compressive loading.

Figure 7 is a top view of a portion of a first surface of film precursor 10 shown in Figure 2, and showing top surfaces 120a and 120b of protrusions 100a and 100b on each of opposing body regions 10a, 10b, adjacent to seam region 30. Apertures 110a and 110b formed in each of protrusions 100a and 100b can also be seen on each side of protrusions

100a, 100b, and extending between end walls 130. In this embodiment, as noted in relation to the embodiment shown in Figure 1, each protrusion has an elliptical base which is shaped during the thermoforming process. As the protrusions are initially formed, each has a frustoconical geometry providing generally rounded sidewalls and end walls 130. During subsequent processing, a portion of at least one sidewall of each protrusion is removed such as by a precision laser slitting process forming apertures 110, and leaving behind planar top surfaces 120, and end walls 130 on each protrusion 100. Protrusions 100 are arranged on the surface of film precursor 10, such that lengthwise space 140 and widthwise spaces 145 and 146 between protrusions of one of body regions 10a, 10b will accommodate the corresponding top surfaces 120 of the protrusions 100 from the other of body regions 10a, 10b in a manner allowing top surfaces 120 of protrusions of each of body regions 10a, 10b snap into apertures 110 of the other of body regions 10a, 10b, such that top surfaces 120 can contact the planar film surface 105 in the area defined by lengthwise space 140 and widthwise space 145. The widthwise separation dimension of spaces 146 of two top surfaces 120 of two adjacent protrusions 100 in the same row is generally preferably about twice as large as the widthwise separation dimension of spaces 145 of their bases. This separation dimension of spaces 146 is sufficient to allow adjacent top surfaces 120b to pass between adjacent top surfaces 120a, and subsequently be retained in a secured configuration.

Figure 8a is a top view of a portion of assembled film precursor10 of Figures 2 to 7, showing body region 10a, and illustrating in greater detail the relative positioning of the planar top surfaces 120 of the protrusions 100 in relation to the corresponding apertures 110 in the two film layers which have been assembled in the manner described above in relation to Figure 3. The lower part of the figure shows one of the lateral edges of the assembled textile, and shows four exemplary partially assembled protrusions 100 of body region 10a, which are identified as 100w, 100x, 100y and 100z, and two fully assembled protrusions identified as 100u and 100v.

Protrusion 100w, for example, shows protrusion top surface 120a, as well as a portion of protrusion top surface 120b from one of protrusions 100b in body region 10b. This protrusion top surface 120b is at the same time locked into one aperture 110a of protrusion 100w and one aperture 110a of adjacent protrusion 100u.

This area is shown in greater detail in the enlargement in Figure 8b. Exemplary protrusion 100w includes two shell-shaped end walls 130, identified as 130c and 130d, which are vertically continuous and extend to planar top surface 120a. End walls 130c and 130d are preferably shell shaped in the manner described in CA 2,779,131 to Manninen to provide support for planar surface 120a, enabling it to resist compressive force applied to the completed textile.

It will be noted that the lower of the two apertures 110a of each of protrusions 100w, 100x, 100y, 100z, which occur at a lateral edge of the assembled film precursor, do not include a portion of a planar top surface 120b from a corresponding protrusion 100b of body region 10b. The cutting process can be selected so that apertures 110 are not formed in protrusions 100 adjacent to lateral edges of film precursor 10, or if apertures are formed, they can be sealed, if required, in an appropriate manner during a finishing step.

Figure 9 is a side view of two protrusions such as would be provided to a planar film 20 for use in the industrial textiles according to the invention. Protrusion 101 is shown as formed in the thermoplastic film 20 in a thermoforming process and before cutting the sidewalls 112 to form apertures 110 through the protrusion. Protrusion 100, originally having the same configuration as protrusion 101, is shown following the cutting away of portions of each of the sidewalls 112, while retaining end walls 130 and planar top surface 120.

Figure 10 is a first perspective view of the protrusions 100 and 101 as formed in a thermoforming process in film sheet 20, as shown in Figure 9 and as seen from above one surface as if looking into the interior of the protrusions. As can be seen, protrusion 101, before cutting, has a generally bowl-like shape including sidewalls 112 which are continuous with end walls 130 around the outer perimeter of the protrusion and extending to the top planar surface 120. Protrusion 100 shows the same protrusion as 101 after cutting away a portion of each sidewall 112 to provide apertures 110 on both sides of protrusion 100, and defining end walls 130c and 130d.

Figure 11 is a second perspective view of the protrusions 100 and 101 as presented in Figures 9 and 10, but seen from their top surfaces 120. It will be apparent that apertures 110c and 110d extend to the interior of protrusion 100 while end walls 130c and 130d serve to support planar top surface 120 in the manner previously discussed.

Figure 12 is a top view of the protrusions 100 and 101 shown in Figures 9 to 11, showing protrusion 101 before cutting away a portion of side walls 112, and adjacent protrusion 100 after cutting away side walls 112 leaving behind apertures 110c and 110d on each side. As discussed above in relation to Figure 7, the base of protrusion 100 is laterally spaced from protrusion 101 by a space 145, while the planar top surfaces 120 of the protrusions are separated by spaces 146 which are larger than spaces 145 but smaller than the corresponding widths of the planar top surfaces 120. The dimension of spaces 146, in addition to the open space provided by e.g. apertures 110c and 110d, is sufficient to allow the planar top surfaces 120 of an opposing profiled film to be located between cut protrusions 100 when two similarly profiled film layers 20 are snapped together. Figures 13 to 15 show this process in greater detail.

Figure 13 is a side view of two similarly slit and profiled film layers 20a and 20b as they are brought together into an interlocked configuration, which area is indicated as 200. During assembly, profiled film layer 20a is brought into alignment with similarly profiled film layer 20b; both film layers are passed around a curved surface such as a roll so as to open and maximize the lateral spaces 145b, 146a between adjacent protrusions 100. Each of protrusions 100 has a first aperture 110c and a second aperture 110d. As the two layers 20a and 20b are brought together in a nip, a first edge of first planar top surface such as 120a is hooked under a corresponding second edge of second planar surface 120b at second aperture 110d, because its width in the direction of movement D is sufficient to allow it to pass through space 146 in a tight fit; as the two film layers 20a and 20b proceed in the direction D into the nip, pressure applied by the rolls (not shown) pushes second edge of first planar surface 120a down such that it is latched under first edge of second planar surface 120b at first aperture 110c. The two film layers are then locked together as they enter region 200. This occurs across the entire width of the two film layers 20a and 20b so as to join the two film layers together into a single assembly. The layers 20a, 20b are retained in the desired locked configuration because the width of the planar top surfaces is greater than the width of the spaces 146 between the adjacent top surfaces.

Figure 14 is a perspective view of the interlocking process shown in side view in Figure 13. To simplify understanding, the figure shows a single set of protrusions 100 on each of two film layers 20a, 20b, as they proceed in direction D. However, it will be understood that each film layer will comprise a plurality of protrusions 100 in rows across its width, i.e. perpendicular to direction D, and the protrusions 100 of each row in layer 20a will interlock simultaneously with the protrusions 100 of the corresponding row in layer 20b. As can be seen, as the two film layers 20a and 20b proceed into interlocked region 200, the leading edge of planar top surface 120a becomes located under the trailing edge of corresponding surface 120b as it snaps into second apertures 110d. As the layers enter the nip in region 200, the trailing edge of surface 120a is snapped into first aperture 110c and beneath surface 120b, thus locking the two protrusions, and the remainder of the row of protrusions (not shown) of which it is a component, together.

Figure 15 is a top view of film layer 20a in the interlocking process illustrated in Figures 13 and 14, and showing the region I, indicating where the protrusions of each layer start to interlock with the protrusions of the other layer; and region II, where the protrusions are fully interlocked. In the manner described in relation to Figures 13 and 14, as the two layers 20a and 20b (not shown) proceed in direction D, trailing edge of surface 120b enters first aperture 110c of protrusion 100a, and thereafter leading edge of the next following surface 120b enters second aperture 110d of protrusion 100a. Trailing edge of that surface 120b will then enter first aperture 110c of the next following protrusion 100a.

As noted above, the curvature imparted to the film layers 20a, 20b as they pass around suitable rolls (not shown) to enter the nip area spreads apart the protrusions 100 from each other at their top surfaces 120, and effectively enlarges the distance 146 between adjacent protrusions sufficiently to allow the planar top surfaces such as 120a to pass by and become hooked beneath surfaces 120b where they are retained in position following assembly.

Figure 16 is a perspective view of a portion of an assembled profiled film precursor 11 showing an embodiment in which protrusions 500a on film layer 11a are greater in height than protrusions 500b located on film layer 11b, but are dimensioned so that film layers 11a and 11b are mutually compatible. In the same manner as in the embodiments shown in Figures 1 to 15, protrusions 500a of film layer 11a, having planar top surfaces 520a, end walls 530c, 530d (see Figure 18) and apertures 510a, are interlocked with protrusions 500b of film layer 11b, having planar top surfaces 520b, end walls 531c, 531d (see Figure 18) and apertures 510b.

Figure 17 is a sectional side view of the industrial textile shown in Figure 16, taken along the line 17-17 in that figure. It can be seen that protrusions 500a on film layer 11a are greater in height than protrusions 500b located on film layer 11b. The protrusions of the two film layers 11a, 11b are interlocked in the same manner as in the embodiments shown in Figures 1 to 15. The height difference between protrusions 500a and 500b is shown in this figure and in Figure 18 as being approximately a factor of two, but other differences can be selected according to the intended end use and required properties for the industrial textile.

Figure 18 is a sectional side view of a portion of the industrial textile shown in Figure 16 and taken along the line 18-18 in that Figure. The illustration shows the relative position of the protrusions 500a and 500b, the apertures 510a and 510b formed by the interlocking of the protrusions 500a and 500b, the relative location of the planar top surfaces 520a in the assembled structure, and their supporting end walls 530c, 530d and 531c, 531d.

The embodiment shown in Figures 16 to 18 would exhibit comparatively less interlayer movement of the two interlocked layers 11a and 11b when compared to the embodiments in which the height of all of the protrusions in both layers is the same. A further feature of this embodiment is that the structure places more of the mass of the film preferentially towards the side having the shorter protrusions such as are in film layer 11b. Nonwoven industrial textiles constructed in accordance with this second embodiment will also have lower air permeability but, due to the size of the relatively shorter protrusions 500b they will not be as resistant to compression as textiles which include two layers of protrusions all of which are of the same height.

The film structures and self locking nonwoven industrial textiles of the present invention can be formed from any suitable film or sheet forming materials such as are commonly used in the manufacture of industrial textiles; however, thermoplastics such as polyesters, polyamides, polyimides and the like are particularly suitable for these applications. Polyethylene terephthalate (PET) and its copolymers, with or without hydrolysis stabilization, depending on the intended end use, is generally preferred as this material is particularly amenable to the various process steps through which the film must proceed in order to form and assemble the textiles. The PET films may be coextruded with a laser weld enabled component as described by Manninen in CA 2,758,622, or they may be bi-axially oriented and hydrolysis stabilized in the manner as described by Manninen in CA 2,778,513.

The film structures and textiles of the invention can also be constructed o other materials, including thermoset polmers, or metals such as aluminum alloy, brass, cold rolled steel, copper, galvanized steel, high strength low alloy steel, hot rolled steel, steel alloy and zinc.

The protrusions formed in the film by means of a profiling process will be generally shaped as described by Manninen in CA 2,779,131, in particular as in Figure 14 of that application, but with one significant difference in the slitting configuration. As described in the '131 document, the apertures or slits are generally linearly extending, parallel, and extend from the forward to the rearward walls of each protrusion. The protrusions themselves are frustoconical with elliptical bases and top planar surfaces. In the present invention, the slitting has been modified so as to generally conform to the curvature of the side walls of each protrusion so as to more effectively facilitate the interlocking of the two similarly profiled film layers. Because the protrusions are regularly arranged, both they and their apertures may be sized so as to accept one or more polymeric monofilaments which can be inserted across the width of two layers of the joined and profiled slit film; in such a configuration, the monofilaments will serve to prevent collapse of the two layer structure under excessive compressive loading, and could also be used to augment the interconnection of the film layers.

In the embodiments of the invention in which the protrusions of each film layer are of the same height, for a film 20 having an original thickness of 0.25mm, each protrusion would have a height above the plane of the film of about 1.5mm, a length at the base of the protrusion of about 6mm, and a width at the base of 3.7mm. The major radius of the elliptical top planar surface would be 2.5mm and the minor radius 1.75mm; this provides a planar top planar surface 120 having a width of about 2.8mm, whereas the cross direction spacing between each protrusion, and between which the surface 120 must be pushed, is 2.5mm. The major radius of the ellipse at its base would be 3.0mm, and the minor radius at the same location 1.85mm. Dimensions other than those noted above may prove suitable depending on the end use application of the structure or textile. In the embodiments shown in Figures 1-15, the pitch spacing of the protrusions in the lengthwise (machine direction) dimension is 6.5mm and in the crosswise (CD) direction is 5.0mm. Pitch spacing may be varied according to the intended end use. Each of top surface and base of the protrusions 100 will preferably include a small radius at their edges to ease film release from the machine surface on which it is formed.

It is also possible to use two film layers each having differing but mutually compatible protrusions and apertures to form a joined film, such as in the manner described by Manninen in CA 2,779,131.

Further, one or both layers of the film may optionally be embossed to impart a surface pattern to them, such as striations, raised dots or ellipses, cross-hatching, or any desired regular or randomly arranged design. The elevation of such pattern would be much less than the height of the protrusions. Such patterns could be used, for example, on a conveying surface of a papermaking fabric, to emboss a paper sheet product, or to enhance the release of contaminants; or on either surface of a structure or textile to increase the frictional or other tactile characteristics of the film surfaces.

CLAIMS:

1. A film structure having

(i) an upper surface and a lower surface; and

(ii) a plurality of protrusions separated by land areas and defining a profile of the upper surface, wherein

(a) each protrusion has a body comprising a top member having opposed first and second lateral edges and is supported by opposed first and second end walls;

(b) at least one of the lateral edges cooperates with the end walls to define an aperture extending through the film from the upper surface to the lower surface; and

(c) the top member comprises a coplanar latching means extending over the aperture, wherein when the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of the first layer are received and retained within the apertures of the second layer, and the latching means of the second layer are received and retained within the apertures of the first layer.

2. A film structure according to Claim 1, wherein the top member is substantially planar.

3. A film structure according to Claim 1 or Claim 2, wherein the first and second end walls are compression resistant.

4. A film structure according to any one of Claims 1 to 3, constructed of a thermoplastic polymer material.

5. A film structure according to any one of Claims 1 to 3, constructed of a thermoset polymer material.

6. A film structure according to any one of Claims 1 to 3, constructed of a metal material.

7. A film structure according to Claim 6, wherein the metal material is selected from at least one of aluminum alloy, brass, cold rolled steel, copper, galvanized steel, high strength low alloy steel, hot rolled steel, steel alloy and zinc.

8. A two-layer film structure comprising a first layer and a second layer each constructed according to any one of Claims 1 to 7, wherein the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer and the latching means of each layer are secured within the apertures of the opposing layer.

9. A nonwoven industrial fabric comprising at least one layer of a film structure according to any one of Claims 1 to 7.

10. A method of constructing an industrial film, the method comprising the steps of

(a) providing a film having an upper surface and a lower surface;

(b) selectively applying pressure to selected portions of the film to form protruding embossed areas separated by land areas, creating a contoured profile in the upper surface, each protruding embossed area comprising a top member having opposed sidewalls connected to the top member at first and second lateral edges; and

(c) selectively cutting and removing material from at least one of the sidewalls to define protrusions each having a body supported by opposed compression resistant first and second end walls and to define at least one aperture extending from the upper surface to the lower surface, wherein the top member comprises a coplanar latching means extending over the aperture, such that when the upper surface of a first layer of the film is brought into contiguous relationship with the upper surface of a second layer of the film, and the protrusions of each of the respective layers are aligned between adjacent protrusions of the other layer, the latching means of the first layer are received and retained within the apertures of the second layer, and the latching means of the second layer are received and retained within the apertures of the first layer.

11. A method according to Claim 10, wherein step (a) comprises providing a film constructed of a thermoplastic polymer material.

12. A method according to Claim 10, wherein step (a) comprises providing a film constructed of a thermoset polymer material.

13. A method according to Claim 10, wherein step (a) comprises providing a film constructed of a metal material selected from at least one of aluminum alloy, brass, cold rolled steel, copper, galvanized steel, high strength low alloy steel, hot rolled steel, steel alloy and zinc.

14. A method of constructing a nonwoven industrial fabric, the method comprising the steps of

(a) providing two layers of a film structure, each layer being constructed according to any one of Claims 1 to 7;

(b) aligning selected protruded embossed areas of the first layer with land areas of the second layer, and aligning selected protruded embossed areas of the second layer with land areas of the first layer;

(c) applying pressure to at least one of the first layer and the second layer to engage the latching means of the protrusions of the first layer within the apertures of the second layer, and to engage the latching means of the protrusions of the second layer within the apertures of the first layer, to secure the first layer to the second layer.

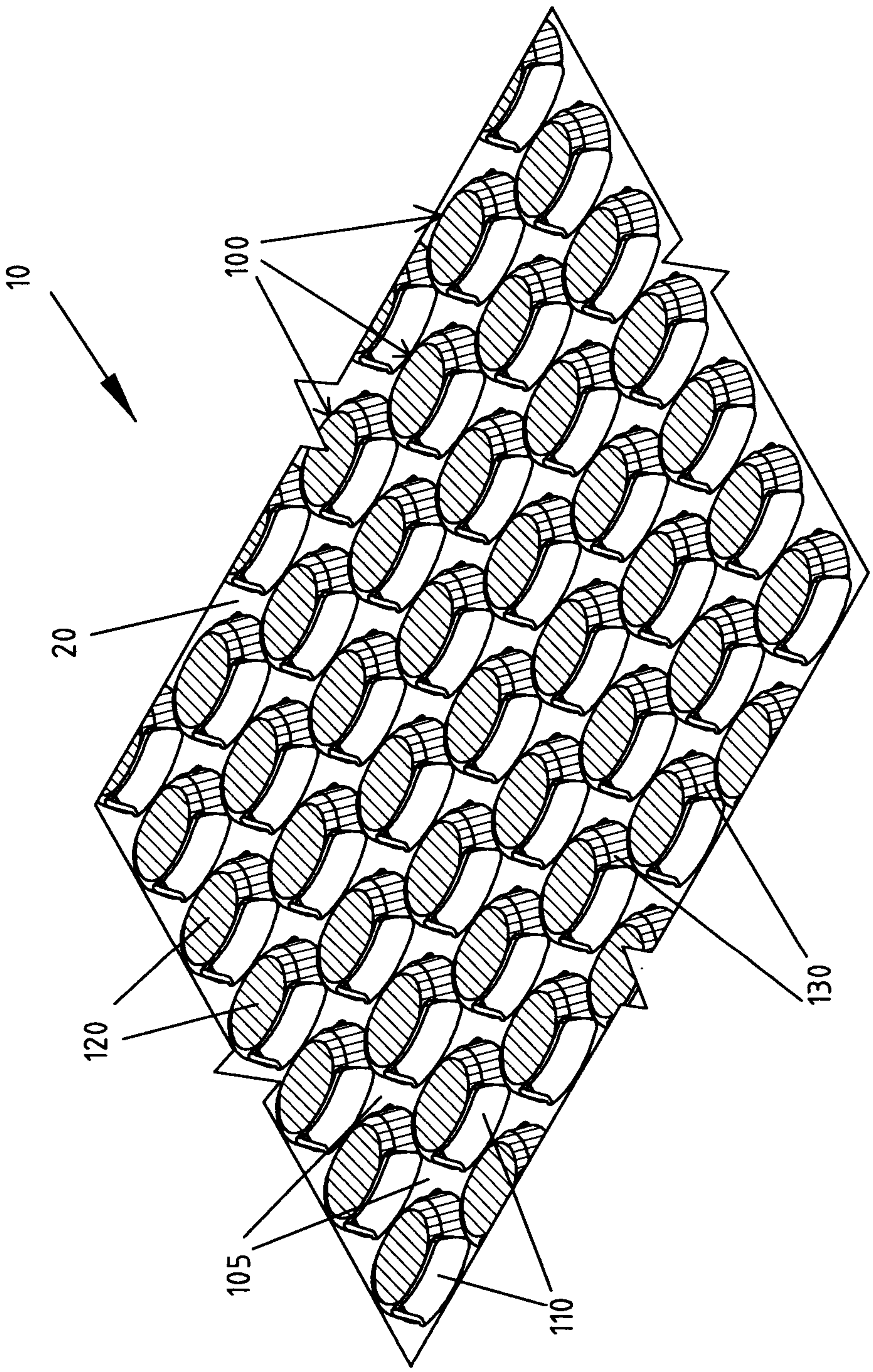


FIGURE 1

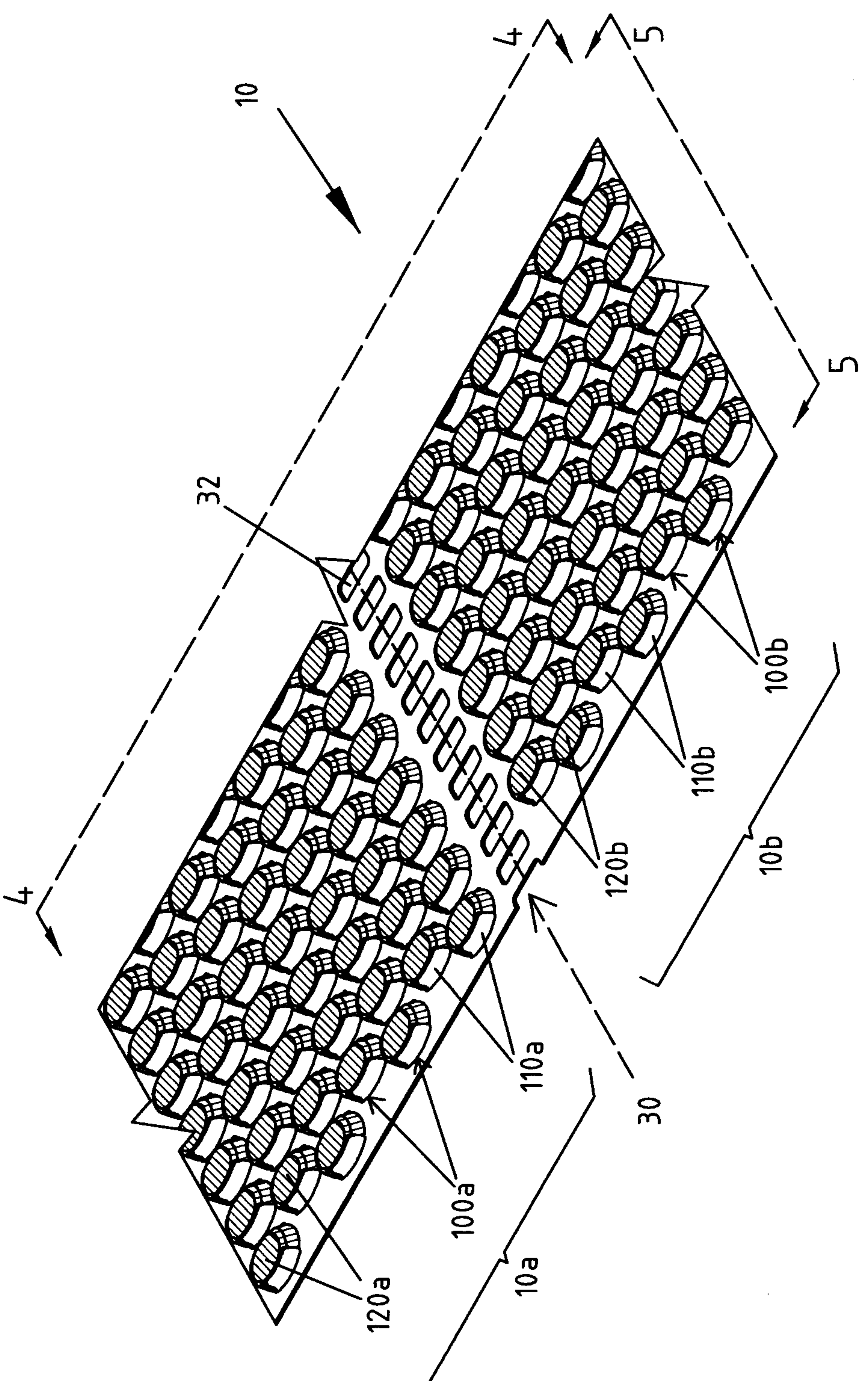


FIGURE 2

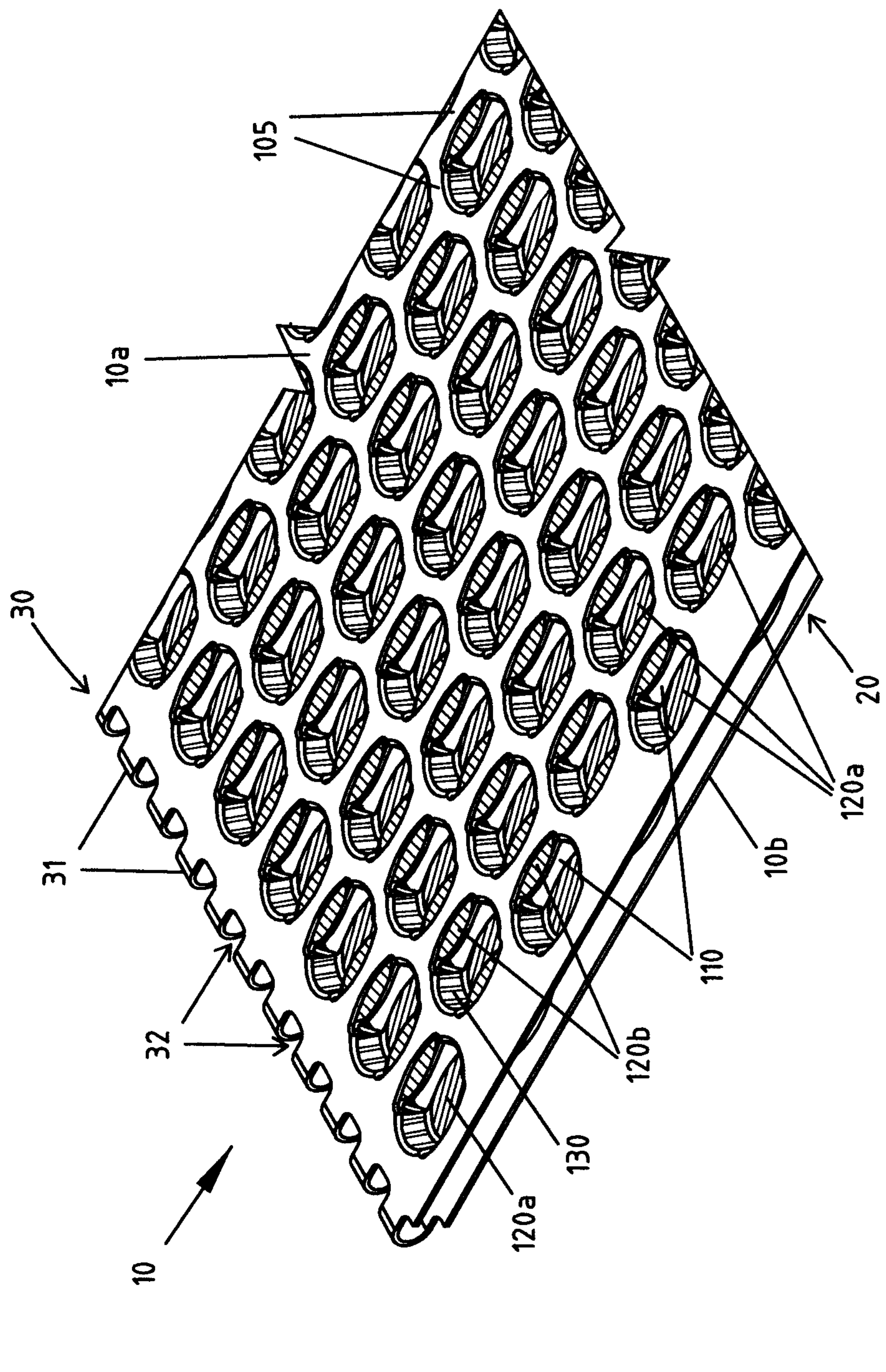


FIGURE 3

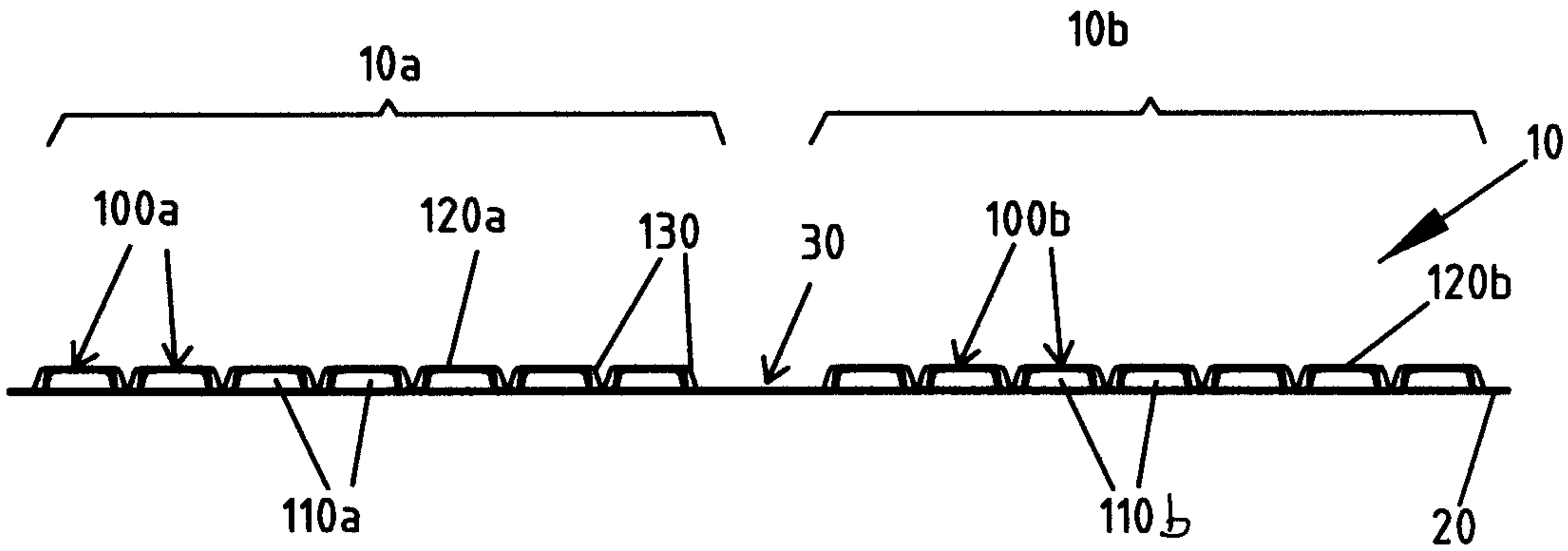


FIGURE 4

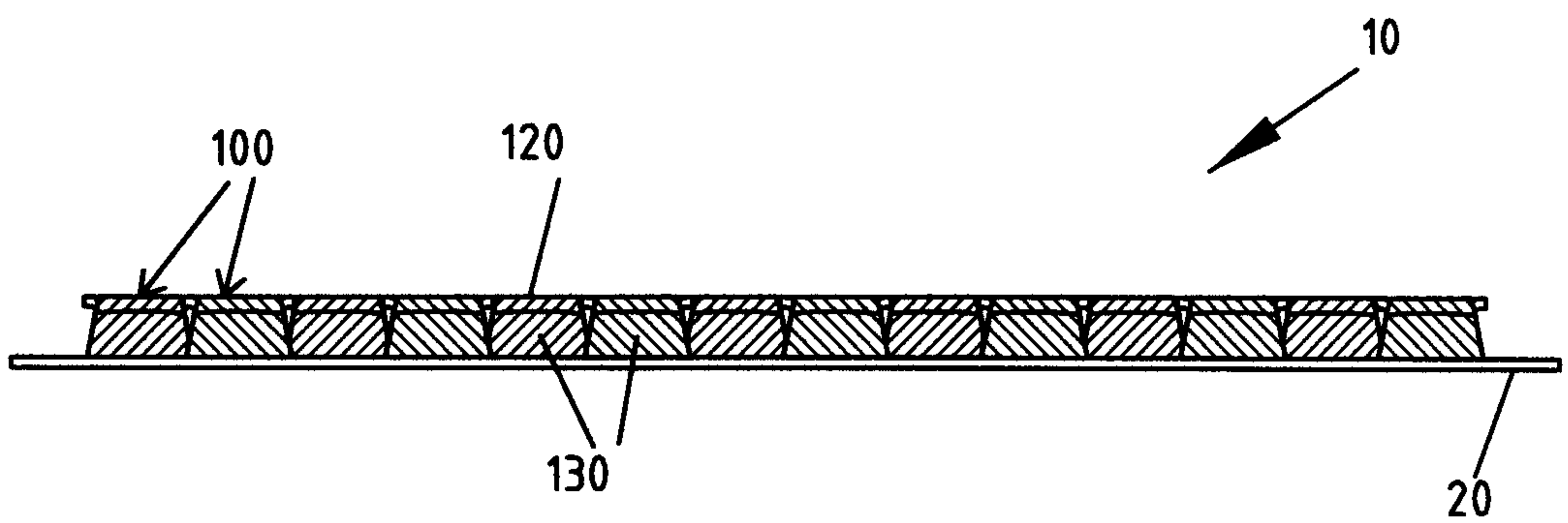


FIGURE 5

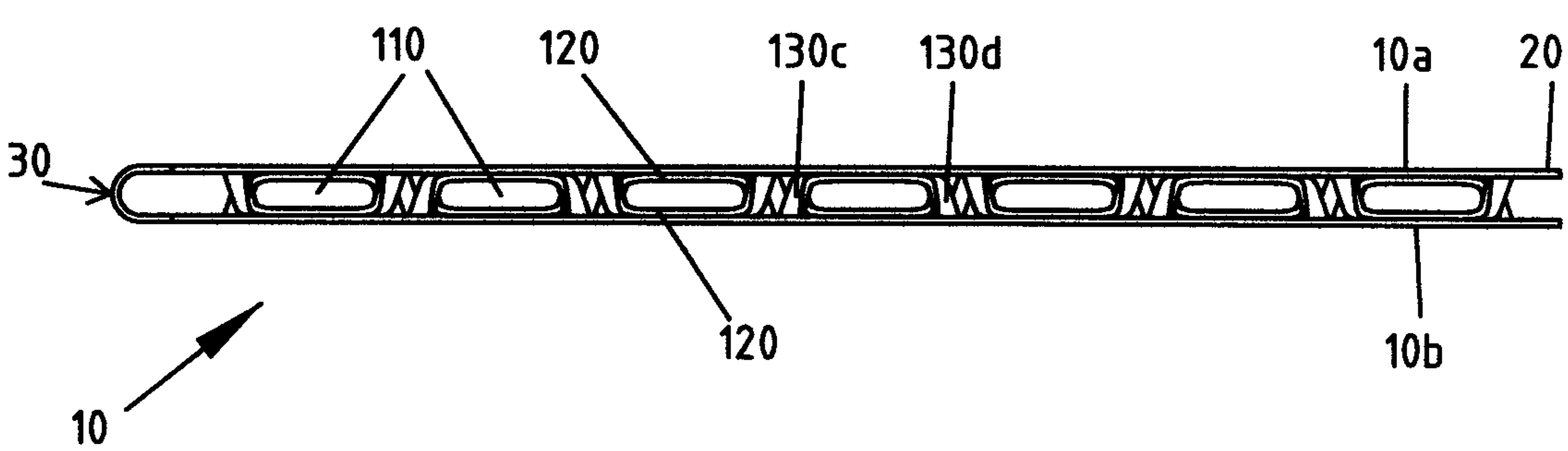


FIGURE 6

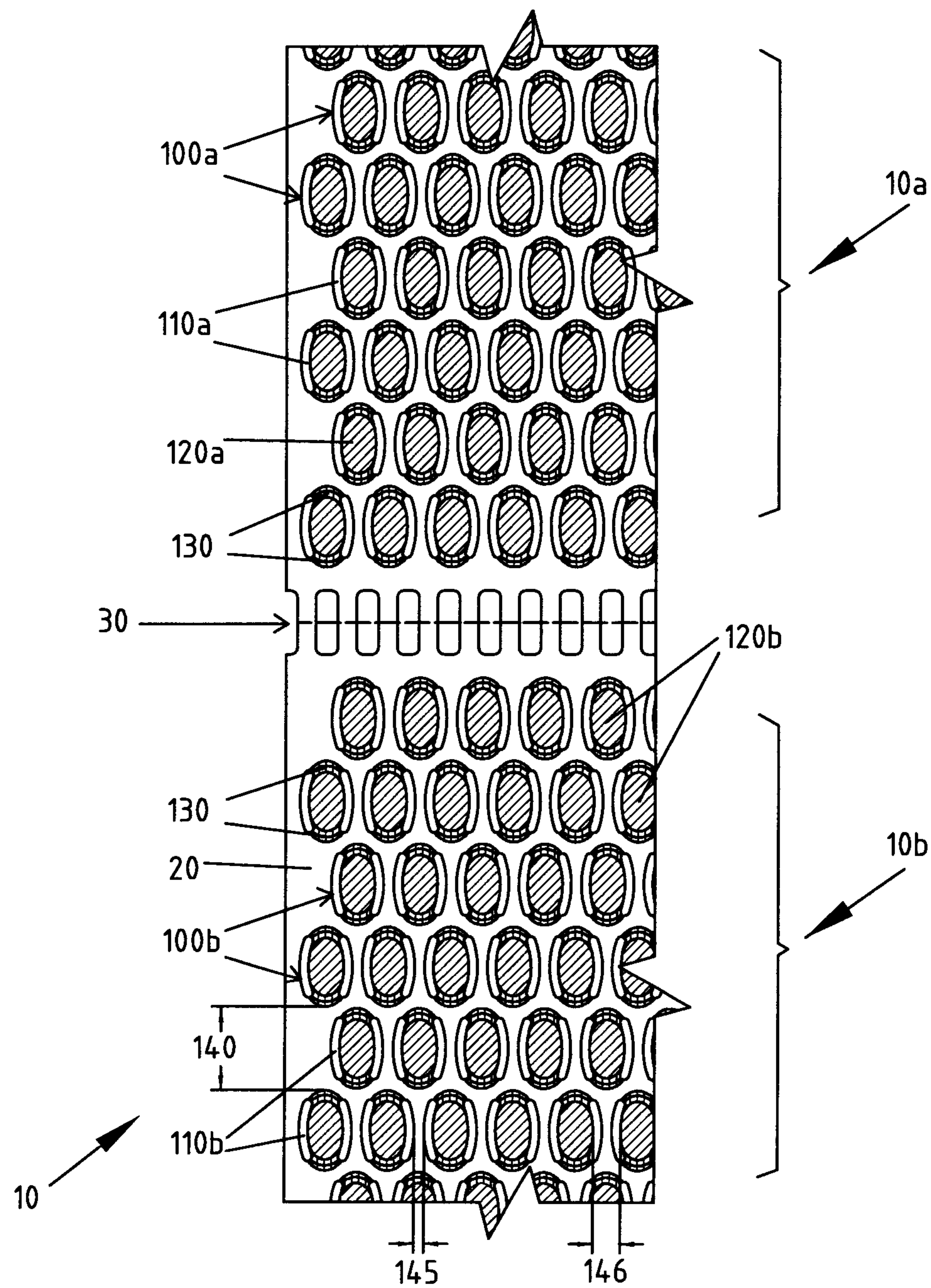

100a
10a
110a
120a
130
30
120b
130
20
10b
100b
140
110b
10
145
146

FIGURE 7

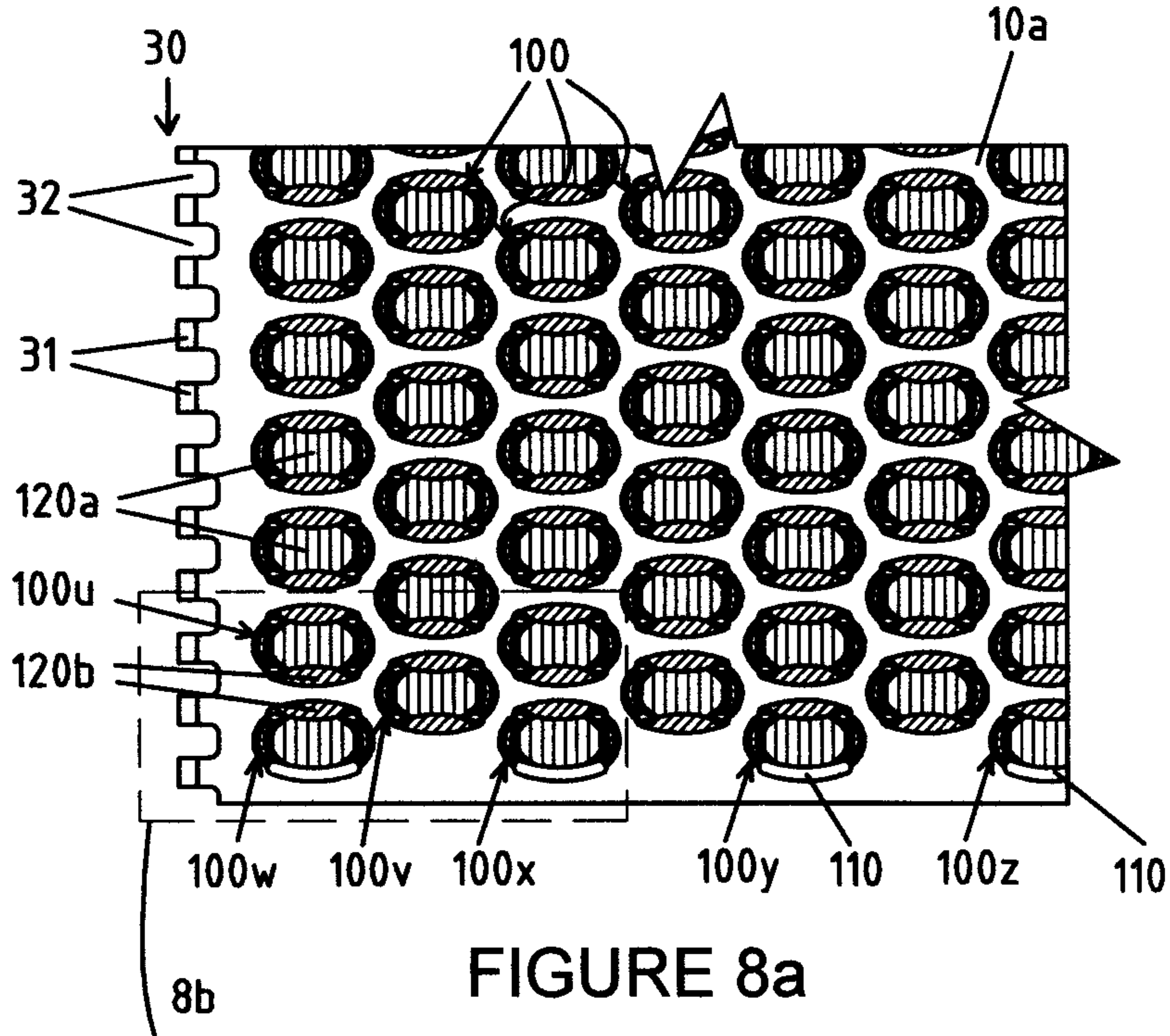


FIGURE 8a

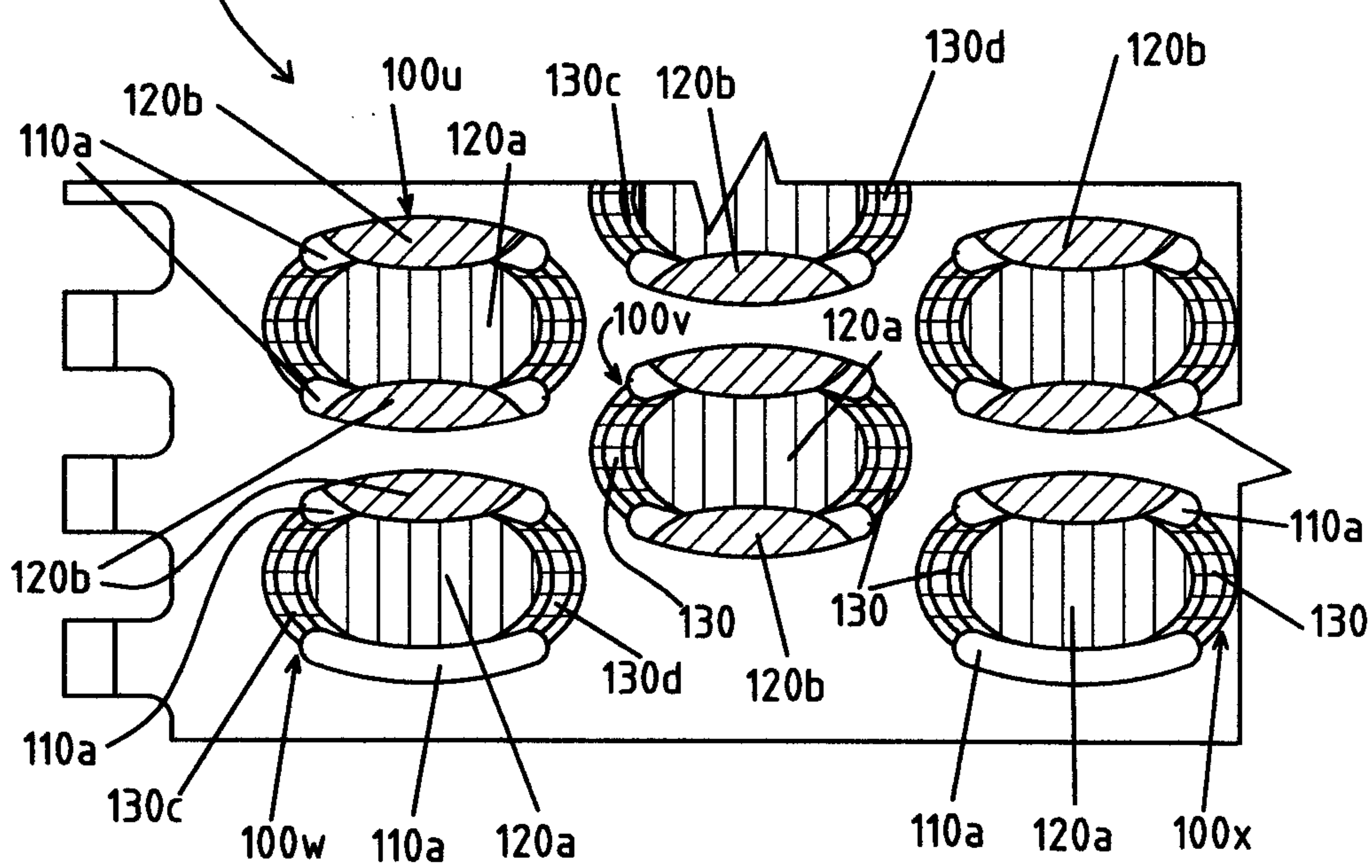


FIGURE 8b

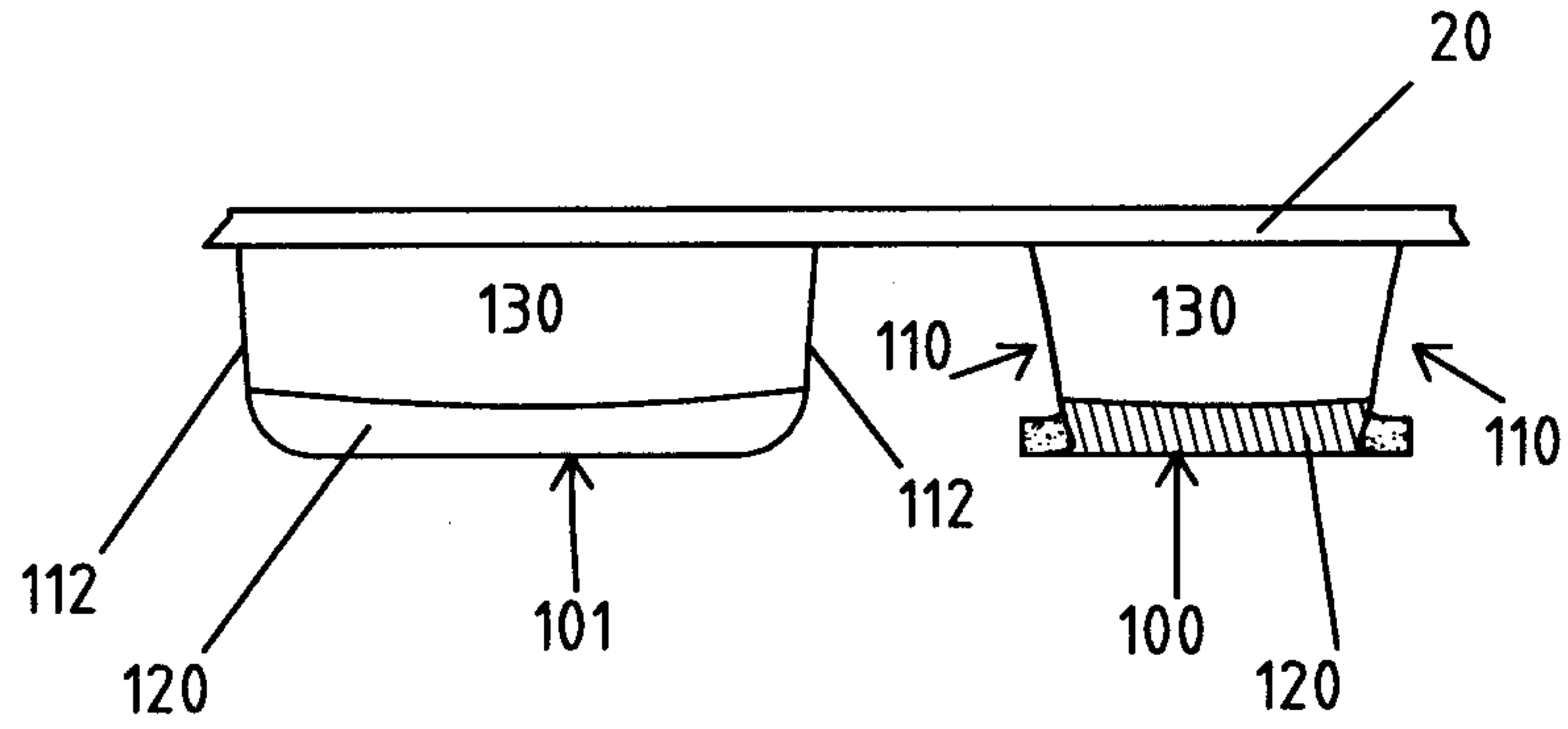


FIGURE 9

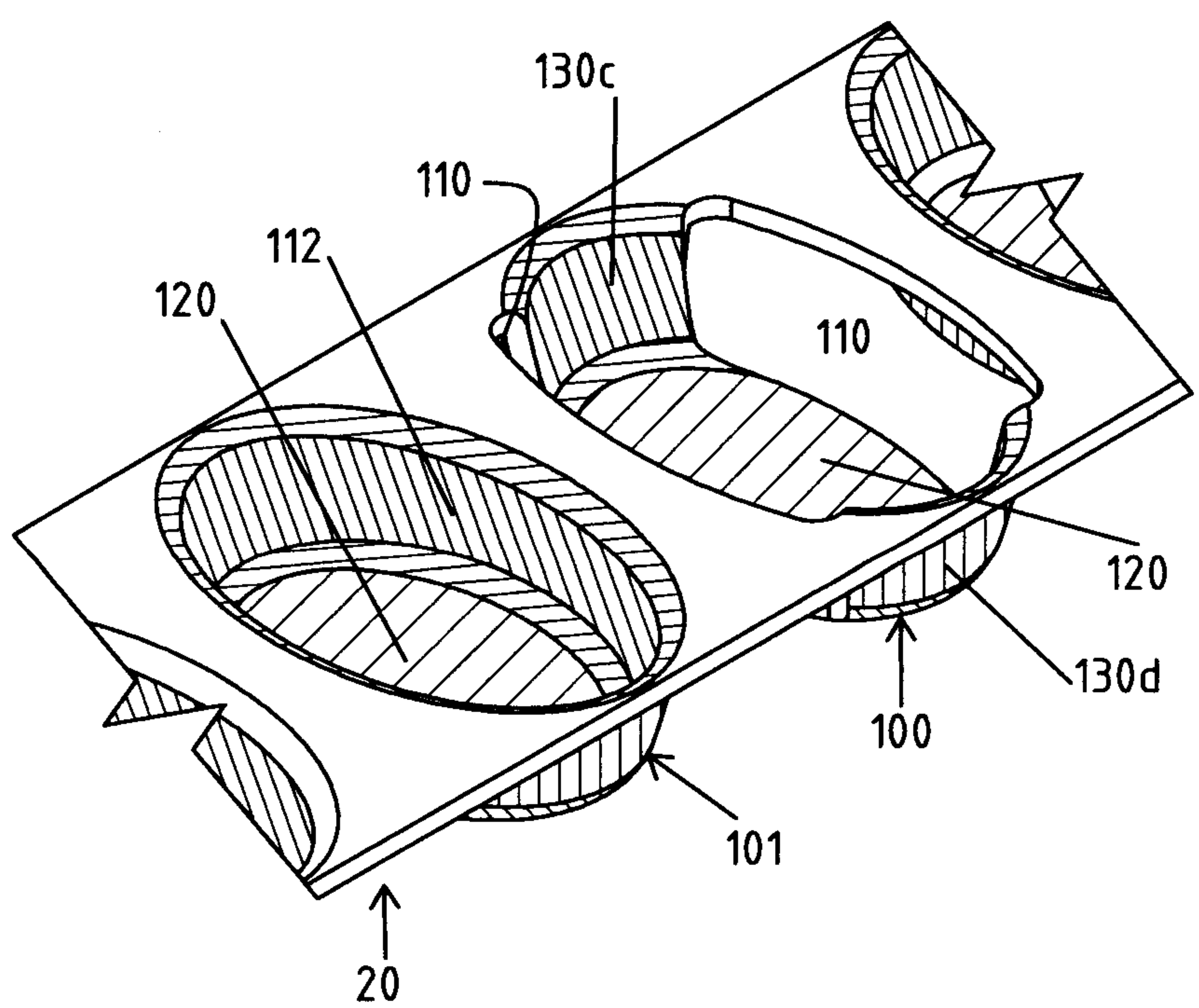


FIGURE 10

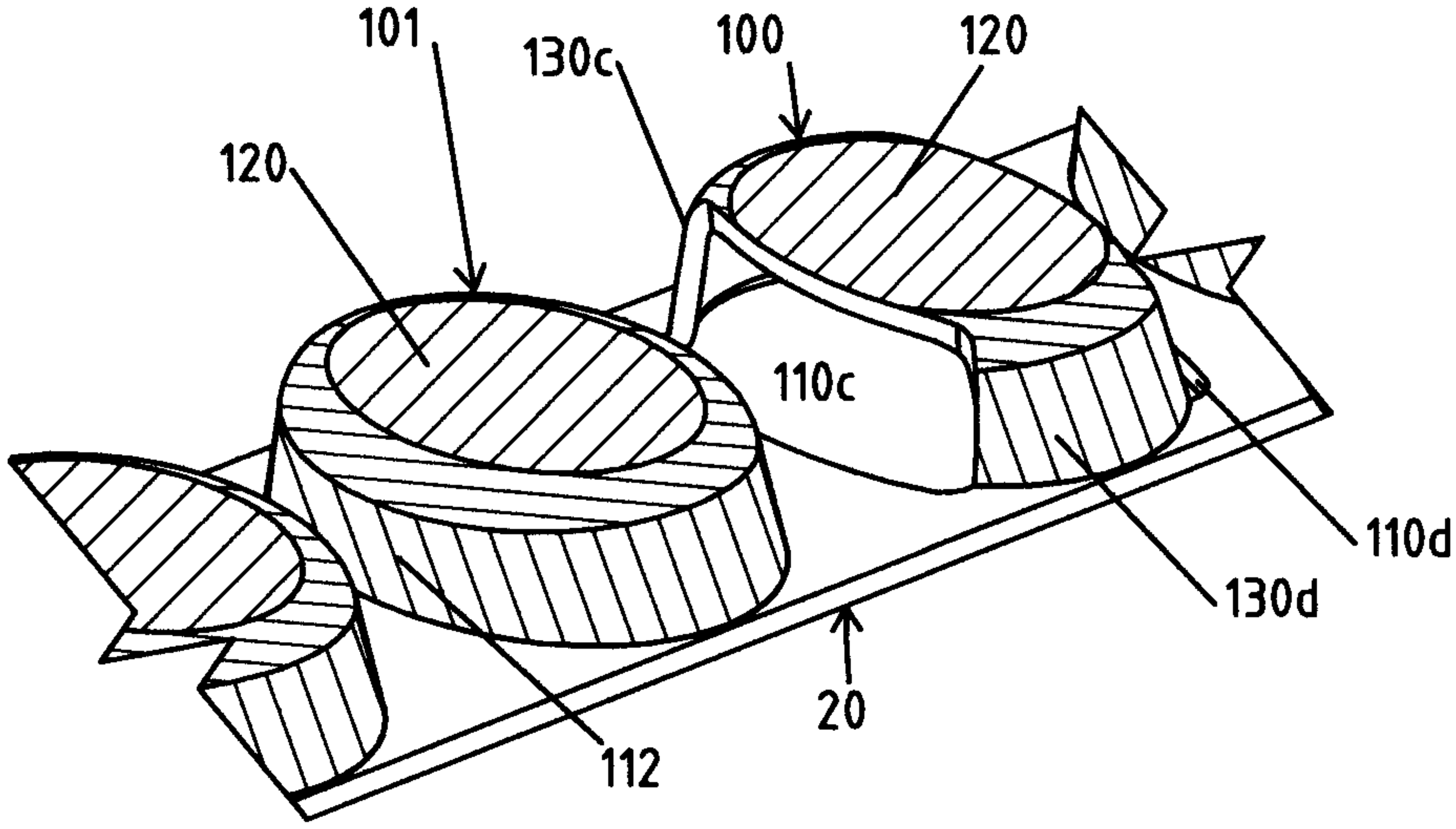


FIGURE 11

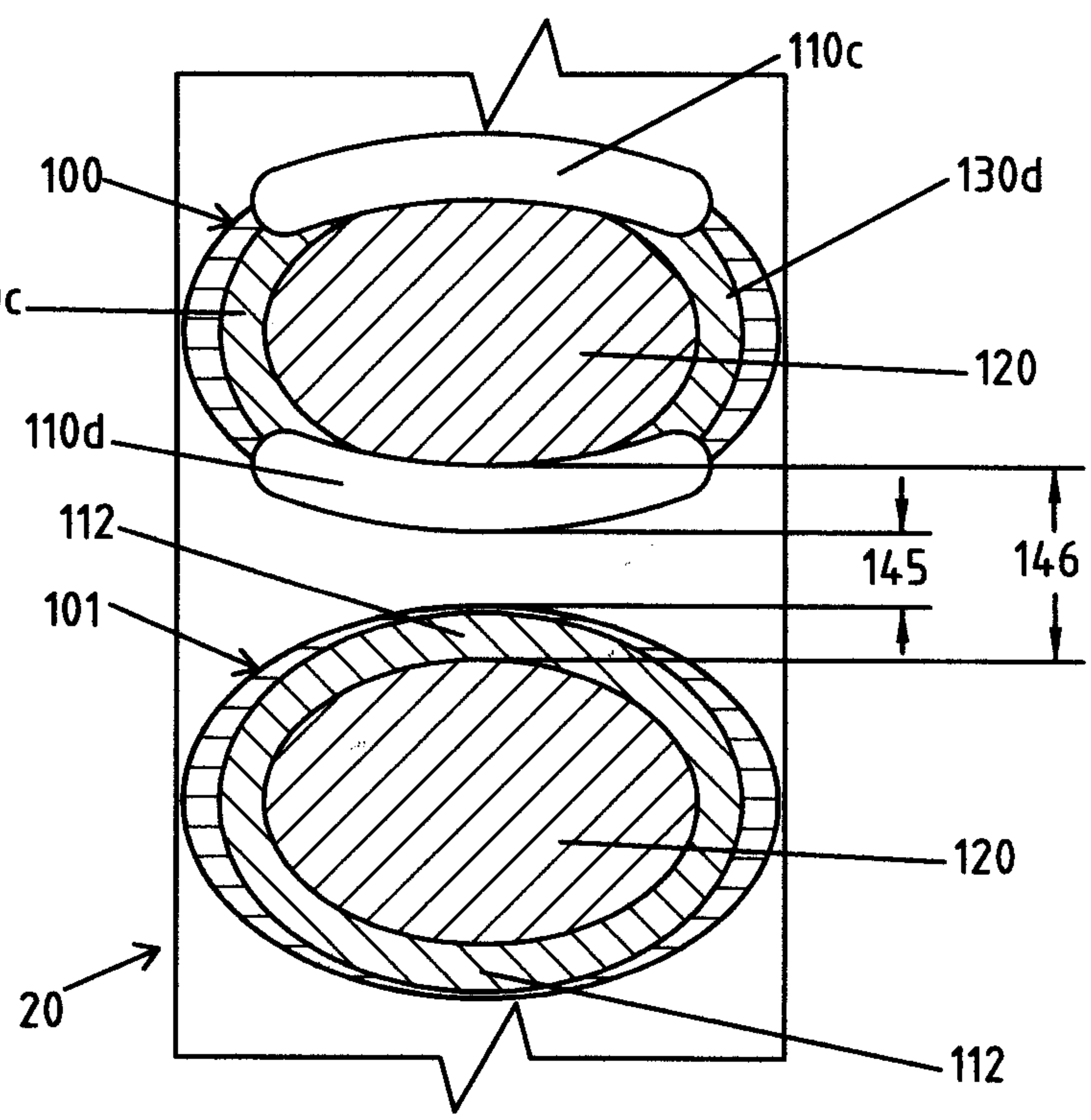


FIGURE 12

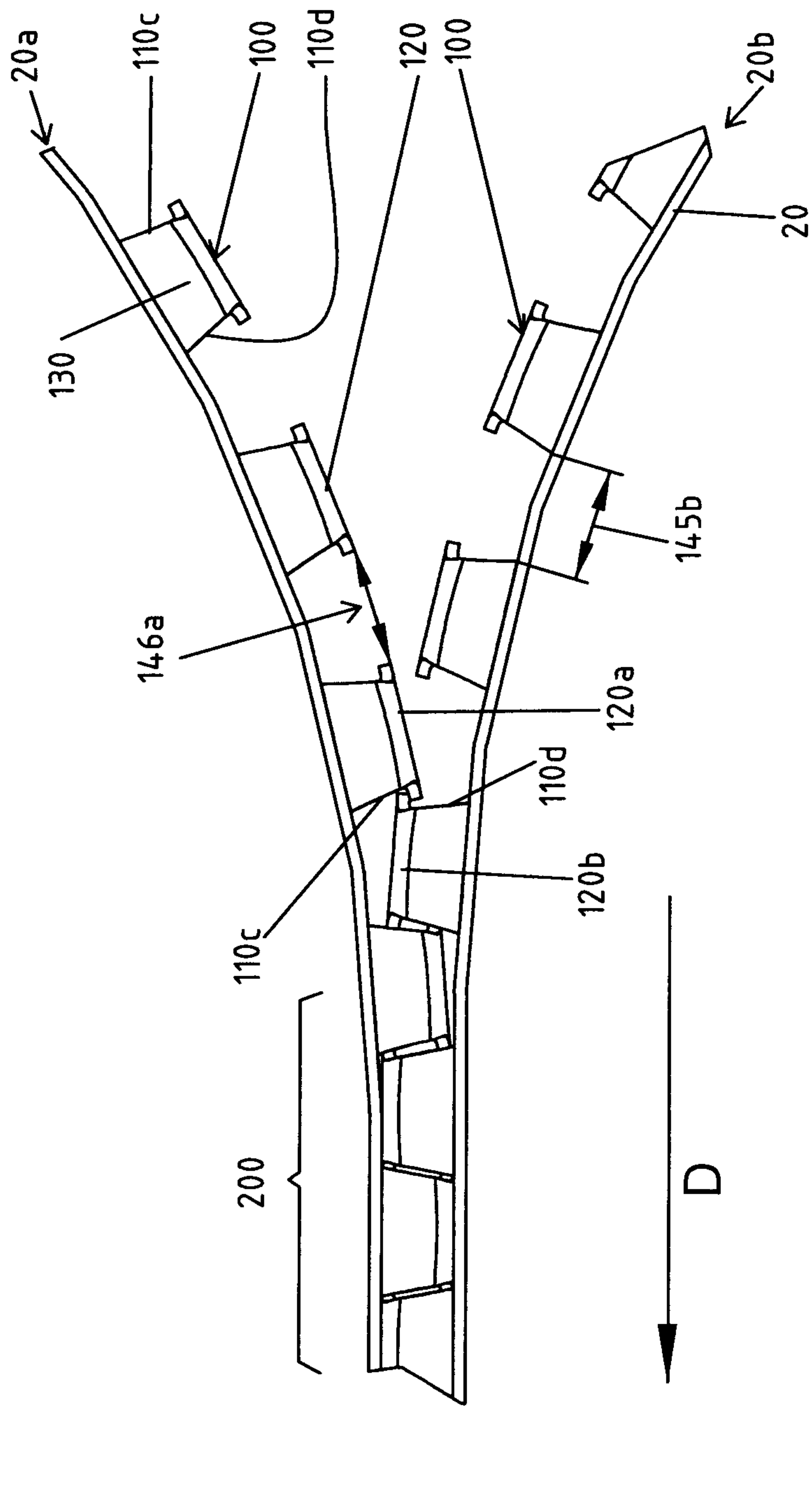

20a
110c
100
110d
120
100
20b
20
130
145b
146a
120a
110d
120b
110c
200
D

FIGURE 13

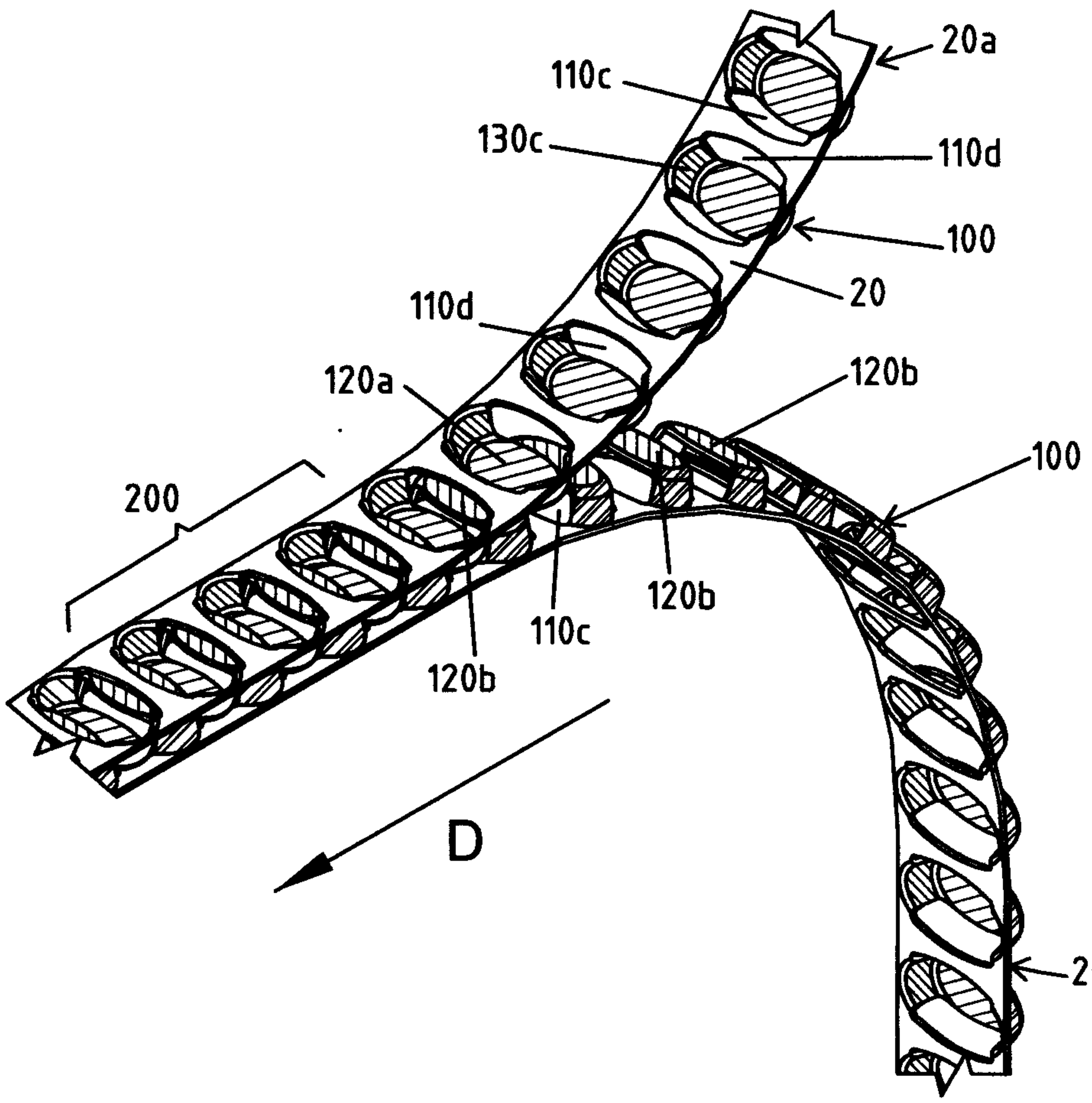

20a
110c
130c
110d
100
20
110d
120a
120b
100
200
120b
110c
120b
D
20b

FIGURE 14

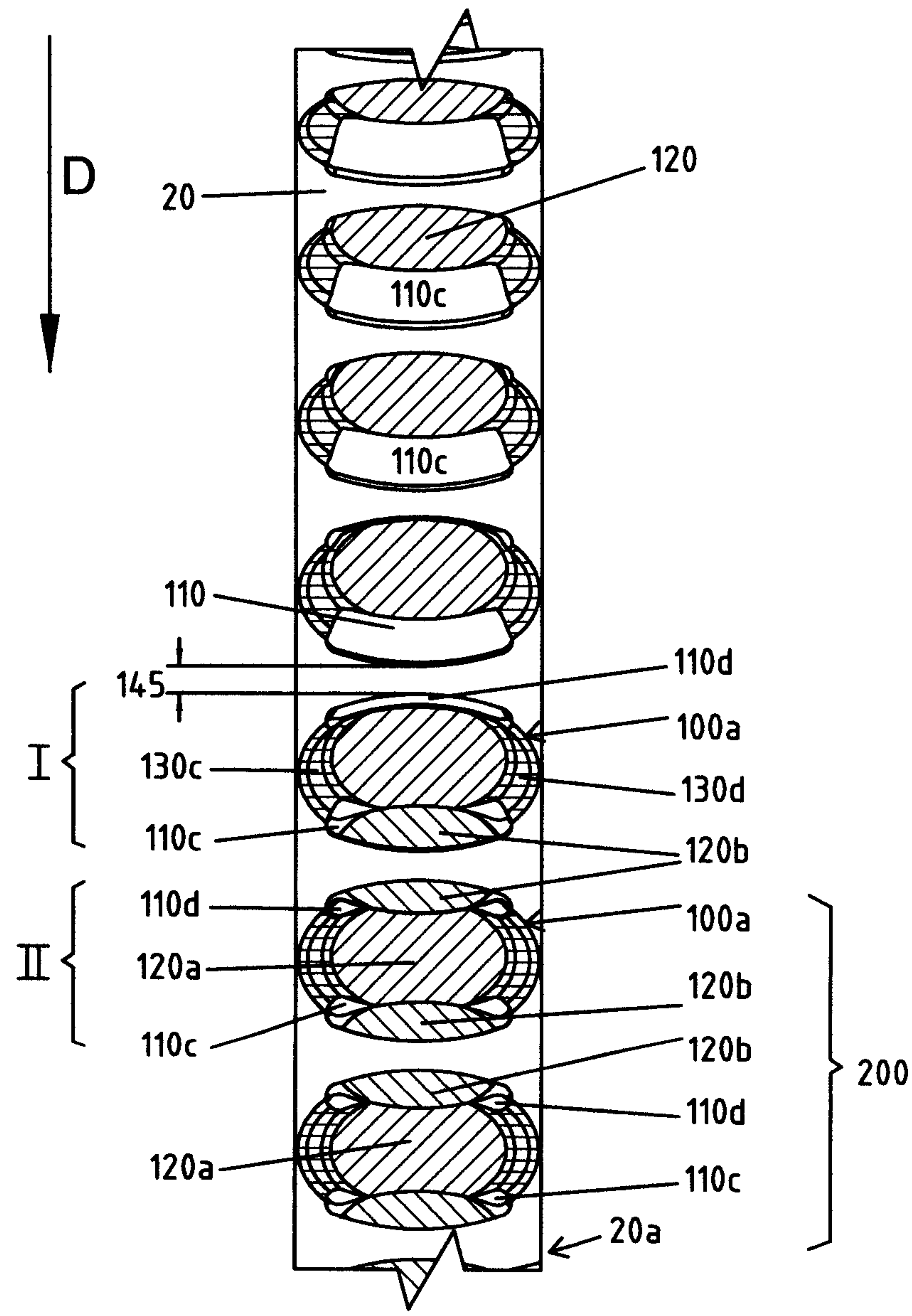

D
20
120
110c
110c
110
145
110d
100a
I
130c
130d
110c
120b
II
110d
100a
120a
120b
110c
120b
200
110d
120a
110c
20a

FIGURE 15

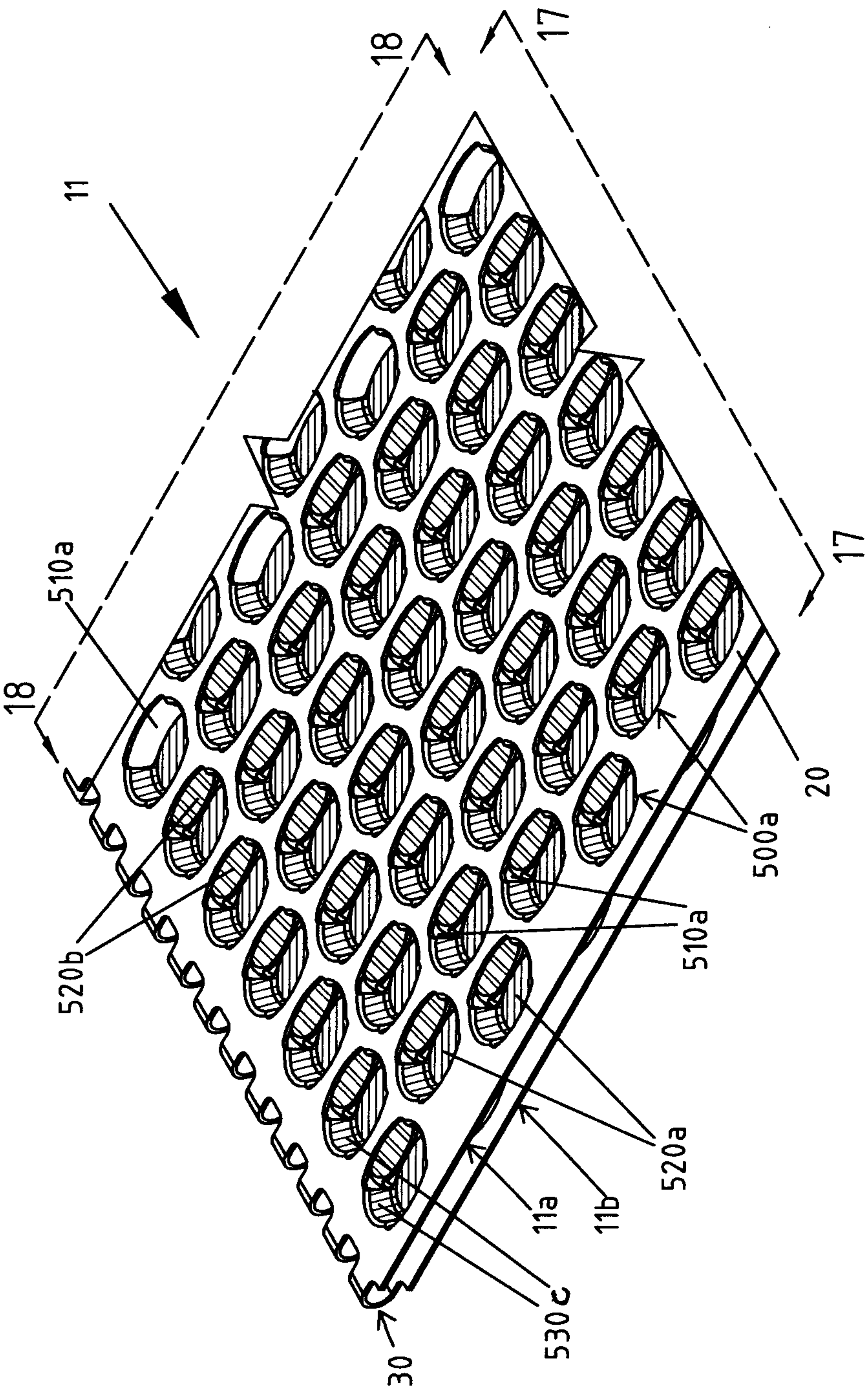


FIGURE 16

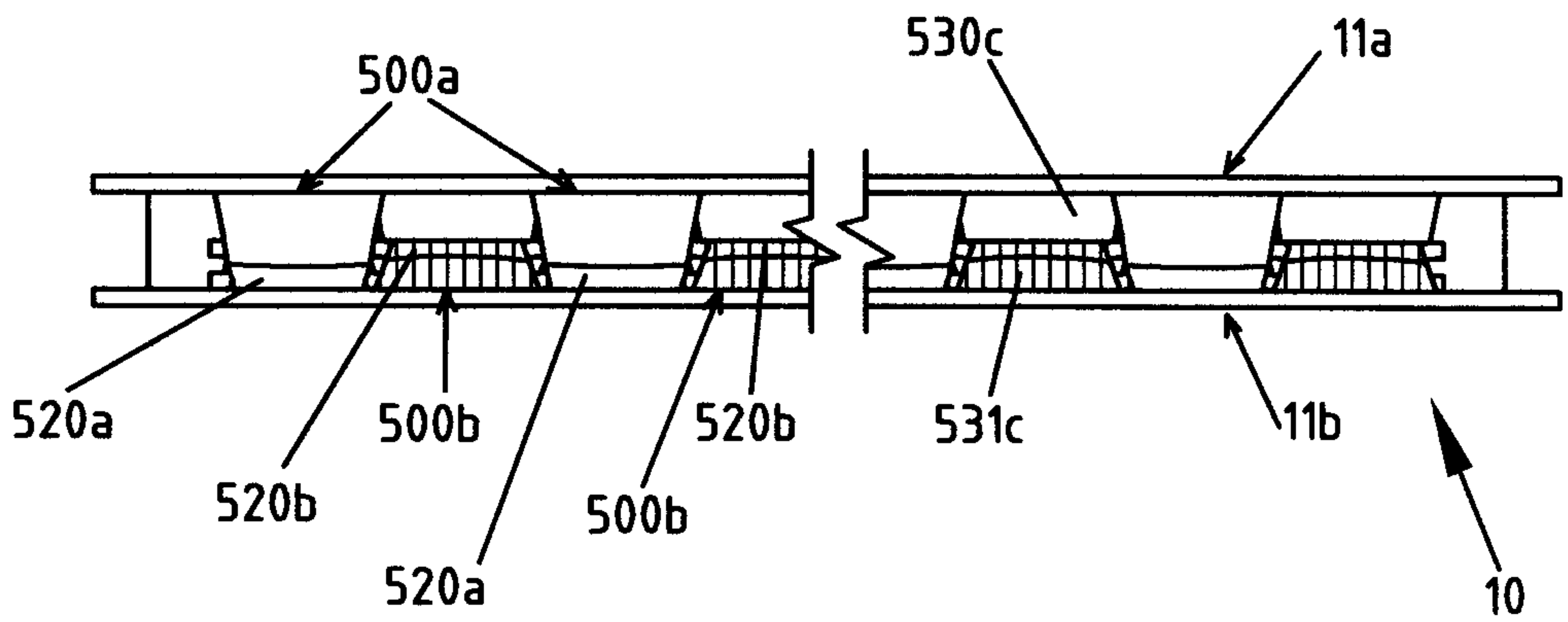


FIGURE 17

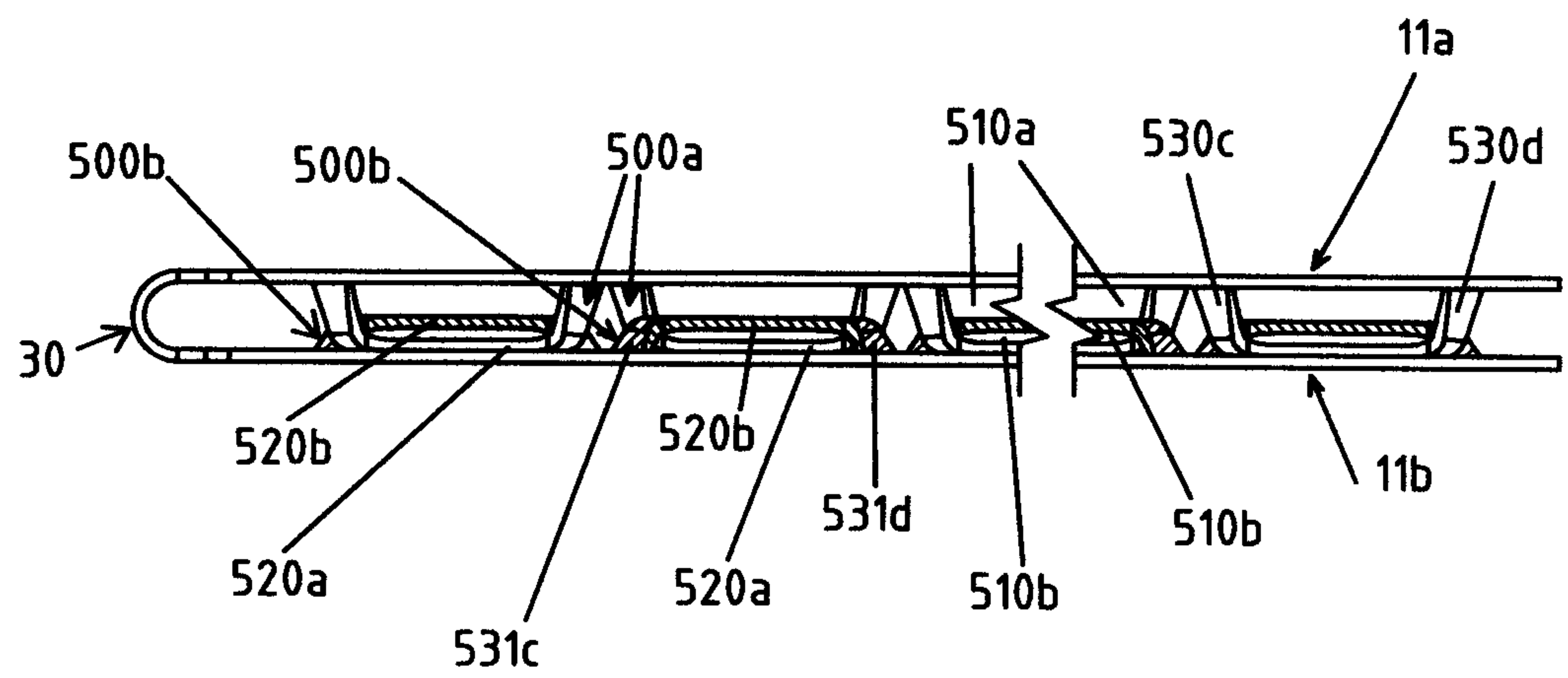
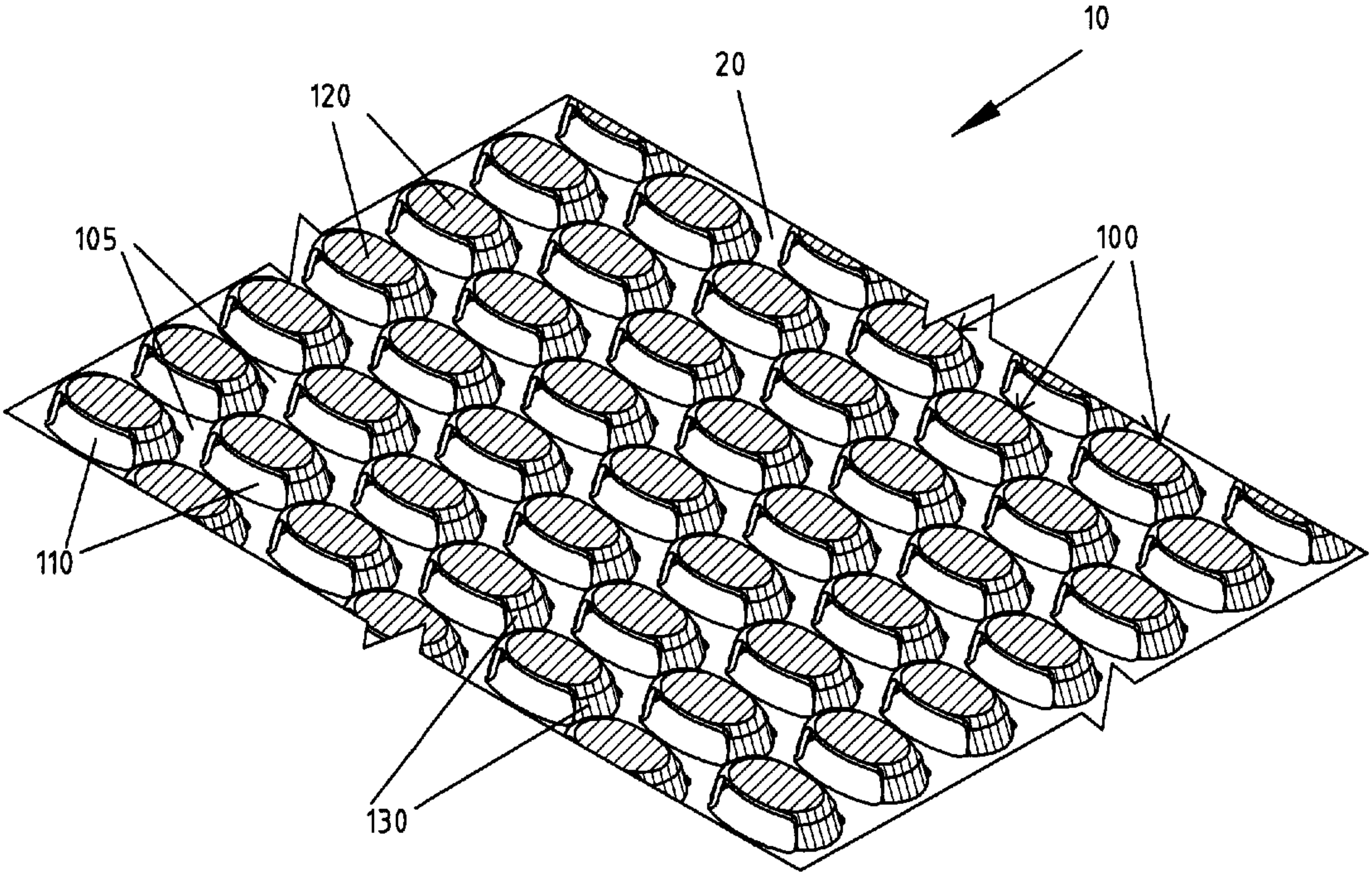


FIGURE 18


10
20
120
105
100
110
130