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(54) **Title:** DAM CLADDED WITH RINGS

(57) **Abstract:** The invention comprises a dam with a cladding which comprises a set of rings which are arranged on an inclined flank of the dam, to slow down wave tongues flowing up and down along the dam, and a method of making the dam.

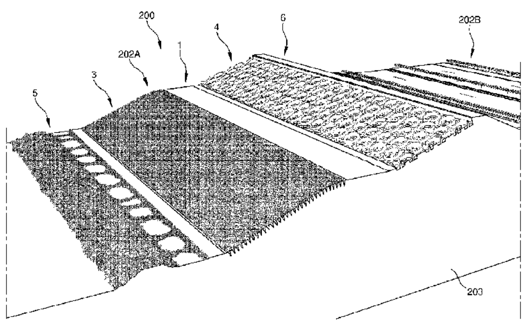

Fig. 1A

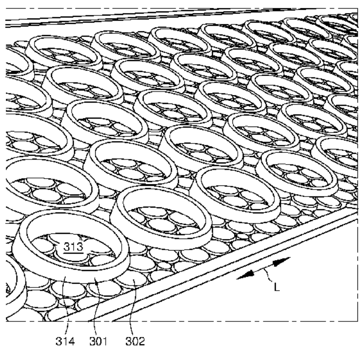

Fig. 22

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Title: Dam cladded with rings

This patent application claims the right of priority from NL2019840 and NL2019985, incorporated herein by reference.

This invention relates to a dam having a cladding from a large number of cladding elements. The dam is, for example, a sea dike. The cladding, hereinafter also referred to as dike cladding, is especially intended for protecting the dike body against erosion which is caused by water waves beating on the dike and/or by water flow. The invention is especially directed to the higher-located part of the dike, above the part of the dike that is struck by the waves. This higher located part of the dike is chiefly exposed to water streams up and down along the dike caused by the wave tongue as a result of the waves having struck the dike. The invention furthermore relates to a dike cladding provided with such cladding elements and a method for the formation of a dike cladding.

Dikes usually comprise a dike body, having a top surface and two flanks, at least one of which faces a body of water. At least this one flank facing the body of water is usually at least partly clad with a dike cladding which can consist of one or more cladding elements or at least can comprise such cladding elements. The or each flank then extends substantially between a toe and a crest of the dike, that is, between a lower end, near the water bed, and an upper end or top of the dike. The side or flank of the dike facing the body of water is exposed to wash and flow load from the body of water and should therefore be protected, for example against erosion. At least for this purpose, the dike cladding is applied.

US3990247A discloses a dike cladding from rings placed in rows and columns, placed against each other by the outer side thereof. The rings lie flat on the dike body, have an internal diameter between 15 and 180 centimeters and a wall thickness of at most 18 centimeters.

US5176466A discloses a dike cladding from massive cylindrical blocks with gaps between them. US3096621A discloses a dike cladding of hollow rectangular blocks placed against each other. US4142821A discloses a dike cladding of car tyres lying flat, placed against each other.

Object of the invention is many-sided and concerns a dike cladding to which one or more of the following points apply: with which a wave running up against the dike is prevented from overtopping the dike; optimum protection against water waves; low cost manufacture; long life; to be placed at the location of use simply and accurately one by one and/or in a unit of a large number of loose, identical cladding elements in a, for example two- or more-dimensional, pattern; provides an attractive appearance to the upper surface of the dike body; saving on material use; a dike cladding of low weight; optimum use of the green strength during production; use of the interlocking action of the cladding elements to provide resistance to upwardly directed forces acting in the height direction of the cladding element; suitable for making a dike cladding from set cladding elements, preferably in a repetitive regular, for example two- or more-dimensional pattern; suitable for making a dike cladding which in extreme situations, such as hurricane, possibly in combination with spring tide, is directly loaded by the wave tongue flowing up and down along the dike cladding; optimum capacity of settling, for example through minimization of friction with the substrate, for example slope; suitable for making a damage-tolerant dike cladding.

To this end, it is proposed that the dike cladding comprises substantially identical, round or polygonal, annular elements, hereinafter referred to as rings, which form a closed or open radial circumference, in a two- or more-dimensional pattern, preferably a regular pattern, for example in rows and columns, which are placed lying and project up from the dike body or a surface hardening thereof, such as a cladding stone setting and/or keep an interspace with directly neighbouring rings. Herein, 'ring' is understood to cover 'cylinder'. The shape in height direction is preferably cylindrical, prismatic or tapered, for example, a truncated cone, widening upwards or downwards. The shape in top plan view is preferably a circle or an ellipse or an oval. If polygonal, the ring is, for example, at least pentagonal or hexagonal or heptagonal or octagonal. The ring is preferably hollow inside, in other words, thin-walled. Each ring is preferably a separate, prefabricated element, preferably one-piece or composite from two or more segments or parts. Buildup in the work from prefabricated parts, for example set stones, is also a possibility.

An example of a regular pattern is that the distance between a ring and its directly adjacent surrounding rings is identical for a large number of, or all or substantially all, rings of the dike cladding, for example all or substantially all rings belonging to a row, more preferably for all or substantially all rings belonging to at least two or three rows.

Without wishing to be bound to it, the invention could be based on the following theory: This dike cladding ensures that the wave tongue flowing over it has to twist and turn, both upwards and sidewards, to flow up and down along the slope. The wave tongue is thereby forced to flow meanderingly following a three-dimensional pattern, seeking a path between the rings and over the edges of the rings, so that the energy of the uprushing wave tongue is absorbed. The uprushing wave tongue is moreover additionally hindered by the preceding wave tongue flowing back, which is also forced to flow meanderingly.

The dike cladding, such as surface hardening, hereinafter also referred to as stone setting, is preferably formed by a setting of separate elements which are inside and/or outside the rings and preferably form a substantially closed surface. Preferably, these elements are at least 12 and/or at most 50 centimeters high, as approximately 30 centimeters; and/or have a diameter of at least 15 and/or at most 40 centimeters, as approximately 25 centimeters. The dike cladding preferably provides a substantially projectionless surface, apart from the rings, and/or the upper surface thereof inside and outside the rings is substantially at the same level. Preferably, the stone setting has a regular two- or more-dimensional pattern.

Preferably, with respect to the stone setting, one or more of the following applies to the rings: embedded and/or set in the stone setting, internally and/or externally; closely surrounded by the stone setting, internally and/or externally; extend at least 10 or 20 centimeters deep into the stone setting; project at least 10 or 20 or 30 and/or at most 100 or 125 centimeters, for example about 50 or 75 centimeters, above the stone setting; extend upwardly from the level of the underside of the stone setting; have their underside flush with the underside of the stone setting; are kept spaced apart by the stone setting; the stone setting presses sideways against the rings.

The rings and/or elements of the stone setting are dimensionally stable and are preferably made of at first, in other words: initially, form-free, preferably stony, material, such as concrete, preferably without reinforcement. Reinforcement provides strength, but reduces the durability because of corrosion in the salty environment. The stony material preferably contains one or more of: binder, such as mineral binder (for example, cement) or polymer binder; aggregate, such as mineral aggregate, such as sand and/or gravel; a hardener; a plasticizer. The ring or the element is preferably made by bringing hardenable, initially form-free material into the desired shape, preferably by pressing, for example, by pressing moist mortar in a mould. An alternative is to pour or dump the form-free material into a mould and, after hardening, to remove it from the mould. Pressing is preferred since the moulded article can be removed from the mould directly or virtually directly to harden further outside the mould, so that optimum use is made of the green strength.

The dike body can consist, for example, of loosely dumped earthy or stony material. The free upper surface of the dike body, or at least of the or each waterbody-facing flank directly exposed to the influence of the water, is preferably at least substantially formed by the upper surface of the dike cladding, in particular the upper sides of the cladding elements which protect the dike body against erosion by the waves. The cladding elements preferably clad the dike flank facing the body of water, preferably the portion of the dike flank that extends in the area which the rolling waves beat against during a heavy storm or hurricane and/or high tide or spring tide. The relevant portion of the dike flank preferably has an inclination of at least 10 (1:6) or 12.5 (1:5) or 15 (1:4) or 20 (1:3) degrees and/or at most 30 (1:2) or 35 (1:1.5) or 45 (1:1) degrees, for example about 20 (1:3) or 25 (1:2.5) or 30 (1:2) degrees with respect to the horizontal or an inclination of at least 1:1.5 or 1:2 and/or at most 1:3 or 1:3.5 or 1:4 or 1:5 or 1:6, for example about 1:2 or 1:2.5 or 1:3 (x:y means: x units up, y units horizontally, so e.g. 1:2 means: 1 meter up per 2 meters horizontally).

The dike cladding which comprises the rings and/or stone setting can rest on a suitable support layer, such as a filter layer which contains, for example, a filter cloth and/or a hard core. Under the support layer which preferably runs parallel to the dike cladding is the dike body. The dike cladding preferably rests loosely on the substrate, preferably with smooth underside for easy sliding over the substrate.

The stone setting preferably ensures that the rings are held in place in the dike cladding.

For the rings, preferably one or more of the following points apply: are at least 5 or 10 or 20 and/or at most 50 or 60 or 100 or 125 centimeters high, are, for example, about 10 or 20 or 30 or 40 or 80 centimeters high; have a wall thickness of at least 5 or 10 or 15 and/or at most 30 or 50 or 75 centimeters, for example about 17.5 centimeters; an internal diameter of at least 100 or 125 and/or at most 200 or 250 centimeters, for example about 150 centimeters; with a directly adjacent ring an interspace of at least 10 or 20 or 35 and/or at most 60 or 80 or 100 centimeters, for example about 45 or 47.5 or 50 centimeters; rest by the underside on the substrate or the filter layer; keep a distance to a number of, preferably at least one half or two-thirds of, or all, directly adjacent rings; keeps a distance from or seamlessly adjoins or is placed against a directly adjacent ring, preferably this applies to two rings located preferably approximately diametrically on either side of the ring (see Fig. 6); has at least or exactly four or six directly adjacent rings, in other words, is surrounded by these directly adjacent rings (see Fig. 16); stand in mutually parallel, straight rows next to each other (preferably with the rows running parallel to the length direction of the dike body), preferably with the adjacent row, in the direction of the row, shifted over at least 25% and/or at most 75%, for example about 50%, of the radius or diameter, so that the rings form a staggered pattern; a top and/or bottom being straight or non-straight, as bevelled, preferably bevelled at least 5 or 10 and/or at most 30 or 45 degrees, having, in the case of a non-straight top or bottom, the high side preferably facing the crest of the dike and/or preferably a bevel angle of the top and/or bottom equal to or smaller or greater, preferably at least 5%, than the slope angle; viewed from the toe to the crest of the dike, at least three or four or five rings one after the other; the rings in a row are in register with the at least second or third or fourth directly adjacent row, hence between two rows with the rings in register there are at least one or two or three rows, respectively, that are not in register with these two rows and preferably this applies to all rows. The alternatives mentioned in this paragraph should not be construed as limiting in any way.

In an embodiment, the rings, viewed in top plan view, are in parallel rows which extend parallel to the length direction of the dike body and/or which extend parallel to the direction from the toe to the crest (in other words, the height direction of the slope), or include an acute angle with this height direction, preferably of less than 60 or 45 degrees. In an implementation, the rings within a row, preferably a row running parallel to the length direction of the dike body, keep a mutual distance, while each ring of a row adjoins an at least one or exactly one or two rings of a directly adjacent row, so that with such an adjoining ring an interspace is lacking or is so small as to entail a negligible influence on the flow of the wave tongue.

In an embodiment, the interspace between two directly adjacent rings is bridged by a single set stone and/or the internal diameter of the ring is bridged by exactly two set stones (Fig. 30).

As a result of settling, the pattern may deviate somewhat from the straight line.

Height direction concerns the direction perpendicular to the plane in which lies the upper surface of the slope, that is, the flank on which the cladding elements are arranged. The height direction may therefore include an angle with a horizontal plane.

Embodiments not limiting the patent protection are represented in the accompanying drawing, in which:

Figs. 1 and 1A show in part a dam in a cross-sectional side view and in perspective view;

Fig. 1B shows a perspective view of a test setup of a portion of a dam, in particular a dike;

Fig. 2 shows an elevation in perspective of a first exemplary embodiment of the cladding element;

Fig. 3 shows the representation of Fig. 2 halved;

Fig. 4 shows a second exemplary embodiment;

Fig. 5 shows a top plan view of the first exemplary embodiment;

Fig. 6 shows a detail of Fig. 2;

Figs. 7-9 show a stretch of dike cladding in perspective, in each case represented from a different viewing angle;

Fig. 10 shows in top plan view the central plane of Fig. 7;

Fig. 11 shows an alternative to Fig. 10;

Figs. 12-14 show a detail of Fig. 7;

Figs. 15-17 show, in the representation of Figs. 12-14, the detail for an alternative cladding element;

Fig. 18 shows a stretch of dike cladding in perspective, made from an alternative cladding element;

Fig. 19 shows in perspective the upper part of the dam of Figs. 1 and 1A;

Fig. 20 shows a detail of Fig. 19;

Fig. 21 is a photographic representation of a detail of the dike cladding based on Fig. 19;

Fig. 22 shows a view in perspective of an alternative dike cladding according to the invention;

Fig. 23 shows an individual ring in perspective;

Fig. 24 shows an alternative ring in perspective;

Fig. 25 shows various ring types in side view;

Fig. 26 shows two ring types as placed on the slope, in side view;

Fig. 27 shows in top plan view three rings in the dike cladding;

Fig. 28 shows a top plan view of an element for the stone setting;

Fig. 29 shows a top plan view of an alternative to the element shown in Fig. 28;

Fig. 30 shows a top plan view of a part of the dike cladding;

Fig. 31 shows a top plan view of alternative shapes of the ring; and

Fig. 32 shows a portion of dike cladding in top plan view.

In this description, the same or corresponding parts have the same or corresponding reference numerals. The embodiments shown and described are for illustration only and should not be construed as limiting the invention in any way. Many variants on them are possible.

In this description, wording such as 'substantially' and the like is to be understood to mean that small deviations are also covered thereby, such as, for example, though not limited to, at least deviations up to 20%, more particularly up to 15%, more particularly up to 10% of a given size or measure, also falling within the definition.

Figs. 1 and 1A show schematically a dam 200 in the form of a dike, further also called dike 200. In particular, Figs. 1 and 1A show a flank 202A facing a body of water 201. The dam comprises a dike body or dam body 203, made in a known manner from, for example, at least sand, clay and the like, and has on either side a flank 202A, 202B, of which one flank 202A faces the body of water 201.

The flank 201A facing the water includes in the example shown a horizontal berm portion 1, for example approximately halfway the height H of the part of the dike 200 situated above the average waterline 2 of the body of water 201. The flank below this berm portion 1 is struck in particular during storm by breaking waves and is covered by a cladding layer 3 of columnar or pillar-shaped cladding elements 100, herein also referred to as pillar 100. The flank 202A above the berm portion 1 is especially intended to prevent water overtopping the dike 200, so that no pillars are needed here and possibly a different type of cladding layer 4 can be applied, for example, with rings 301 to be further described hereinafter. Also shown are the toe 5 and the crest 6 of the dike 200. For example, the berm portion 1 is five meters and the crest 6 nine meters above the toe construction 5 which is at or below the level of the average waterline 2.

Fig. 1B shows a photographic representation of a test setup on scale of a portion of a dam 200 according to the invention, in particular a flank 202A with berm 1, toe 5 and crest 6 and cladding layers 3 and 4.

In Figs. 19-32 a cladding 4 according to the invention for an upper part of a flank 202A of a dike body 200 is shown, which can be used in cooperation with the dike cladding 3, for example formed by cladding elements 100 as are described hereinafter in particular with reference to Figures 2-18 for a lower part of the flank 202A, located proximal to the toe 5. The upper part of the flank 202A extends, for example, between the berm 1 and the crest 6 of the dike 200. This portion of the dike 200 is especially intended to prevent water overtopping the dike 200, and here a type of cladding layer 4 according to the invention is used. Also shown is the crest 6.

Fig. 19 shows in particular the upper part of the dam or dike 200, along which wave tongues wash and which is equipped with an upper dike cladding 4 according to the invention. The arrow L indicates the length direction of the dam 200, being the direction in which the dam 200 extends along the water 201. In Fig. 1 this is the direction perpendicular to the plane of the paper.

As Figs. 20 and 21 show, the upper dike cladding 4 comprises rings 301 which project above a stone setting 302 in which and/or on which the rings 301 are set. The rings 301 in this implementation keep a distance to all directly adjacent rings 301. In the embodiment shown in Figs. 20 and 21, the rings 301 are in mutually parallel, straight rows next to each other. The rows extend in the length direction L of the dam 200. The directly adjacent row in each case is shifted relative to an adjacent row in the direction of the row by one half of the diameter D_{301} of the rings 301. The row which, viewed from a row, is the second directly adjacent row, has the rings 301 in register again. As a result of settling, the pattern may deviate somewhat from the straight line.

In this description, ring 301 should be taken at least in the usual sense as a body formed by an edge 31 extending wholly or partly around an opening 313, which edge 31 encloses the opening 313 preferably at least through an angle of at least 200 degrees, more particularly at least 270 degrees and preferably between 270 and 360 degrees or wholly. A ring 301, as shown in the figures, can have a substantially circular shape, but may also be, for example, oval or elliptical, or may be, for example, polygonal, as shown, for example, in Fig. 31. A ring 301 according to the invention preferably has no bottom, though a bottom may be provided in embodiments.

In the dike cladding 4 shown in Figs. 20 and 21, each ring 301, except at the boundaries of the dike cladding 4, is surrounded all around by six directly adjacent rings 301. This is also shown in Fig. 32, which shows three parallel rows of rings of the dike cladding, and the rings 301 designated with A are each surrounded all around by six directly adjacent rings 301.

Clearly, other arrangements are possible, such as shown, for example, in Fig. 22 or differently still, for example, in staggered regular or irregular patterns.

Fig. 22 shows an alternative where the rings 301, viewed in top plan view, form rows extending in length direction L of the dike body 200, within which the rings 301 keep a distance to each other, while each ring 301 of a row adjoins a single ring 301 of a directly adjacent row, so that with such an adjoining ring 301 an interspace is lacking or is so small as to entail a negligible influence on the flow of the wave tongue.

While Fig. 23 shows a ring 301 with a straight top 310, that is, having an upper surface 310 which is substantially at right angles to a central axis Y of the ring 301, Fig. 24 shows a ring 301 with bevelled top, that is, an upper surface 310 which is substantially at an angle β to the central axis Y of the ring, for example an angle between 90 and 30 degrees, more particularly between 87 and 45 degrees. The central axis Y is preferably approximately at right angles to the plane of the flank 202A on which the respective ring 301 is arranged. Fig. 25 shows different types of rings 301 which can be applied in the invention, with different angles of inclination of the upper surface 310 with respect to the axis Y. As is visible in Fig. 25, the ring 301 may be provided at the underside 311 with legs 312 by which the ring can be set in or on the flank 202A. However, the underside may also be implemented without such legs.

If the rings 301 are used with an inclined upper surface 310, preferably a high side of the ring 301 is placed farthest from the body of water 201, as in Fig. 26 the upper one of the two rings 301. Rings having differently-inclined upper surfaces 310 and/or inclined or non-inclined upper surfaces 310 may be combined in a dike cladding 4, as shown, for example, in Figs. 25 and 26.

Fig. 26 shows the rings 301 which are placed loosely on the substrate or flank 202A. The same preferably also applies to the stone setting 302 in which the rings 301 are embedded. The bottom surface formed by the bottoms of the rings 301 and stone setting 302 may be projectionless, as the projectionless, inclined upper surface of the dike body, which forms the dike flank 202A on which the dike cladding 4 has been placed.

In this description, stone setting should be understood to mean a covering of at least a relevant part of a surface of a flank 202A and/or B with stones 303, as for instance shown for illustration in Figs. 19, 20, 22 and 27-30, on which and/or in which the rings 301 have been placed. The stones 303 of such a stone setting may for instance have been laid loosely on the surface mentioned and lie against each other. The stone setting may for instance have been arranged on a filter layer on the flank, as schematically shown in Fig. 26.

The measurements given in Figs. 27-29 are in millimeters. These are shown for illustration only and should not be construed as limiting in any way. Fig. 27 shows circular rings 301, having, for example, an inside diameter (the diameter of the opening 313) of 1500 mm, and an outside diameter (the diameter of the outer circumference of the edge 314) of 1850 mm, which have been set down at a pitch (centre-to-centre) of 2325 mm. The rings 301 can have a height of, for example, between 50 and 600 mm, for example between 100 and 400 mm. These dimensions and measurements are mentioned for illustration only and should not be taken as limiting in any way.

Figs. 28 and 29 show, by way of illustration, examples of possible stones that can be used in a stone setting 302. The stone 303 of Fig. 28 is intended for inside the rings 301, in the opening 313, the stone 303A of Fig. 29 for in-between the rings 301. The stone 303 is, for example, to some extent pizza wedge-shaped and so large that, for example, six of such stones fill up a lower part of the opening 313, as shown in Fig. 30. Clearly, other dimensions may also be chosen, so that more or fewer stones can be placed in the opening 313. The stone 303A of Fig. 29 is substantially pentagonal in top plan view, having three substantially straight sides and two curved sides, so that between three rings 301 as shown in Fig. 27, three such stones 303A can be laid down in a closed relative arrangement. Clearly, in a similar manner, stones 303A can be shaped to fit between rings which have been laid down in a different relative arrangement. The stones can be formed from any suitable material, in any suitable manner, such as, for example, though not exclusively, by pressing from concrete.

Fig. 30 shows in a top plan view three rings 301 as in Fig. 27, with stones 303 in an opening 313 and a ring of stones 303A around one of the rings 301 and a part of such a ring of stones 303A around the other rings 301, from which it can be seen that, for example, two stones 303A are part of a second one of such rings of stones 303A. In this embodiment, the stones 303A are formed slightly differently, such that each flank thereof is provided with at least one notch, so that between flanks of the stones laid against each other an opening or channel is created.

Fig. 30 shows three rings 301 and a part of the stone setting 302 formed from stones 303, 303A. Fig. 31 very schematically shows an oval ring 301 which is not closed in circumferential direction, a quadrangular ring 301 and a hexagonal ring 301, as alternatives to the substantially circular ring of, for example, Figs. 19-29. Many shapes can be used for a ring 301 according to the invention, also including, for example, rings in rings.

The rings 301 according to the invention are preferably made of a relatively hard, erosion- and water-resistant material, such as, for example, concrete, and can be manufactured in any suitable manner, as, for example, by casting in a mould, by pressing or by a material-removing technique or combinations thereof.

In advantageous embodiments, the rings 301 and the stone setting 302 have been loosely formed and placed on the flank 202, that is, without use of adhesion means and the like. Due to their being placed on an inclined flank, the rings 301 and stones 303, 303A will be pressed against each other under the influence of gravity and, as a result, be firmly retained. As is apparent from the figures, a part of the stone setting, such as, for example, between and in the rings, may become grown.

Without wishing to be bound to any theory, it seems the rings 301 on the dike body, in particular on the flank 202A, offer the advantage that waves, in particular wave tongues that pass the lower part of the flank and the berm 1, are ruptured by their flowing into and out of, and between the relatively coarse, rough surface, formed by the rings 301, of the dike cladding 4. This takes the speed out of the water flowing in upward direction along the dike cladding 4 and simply and effectively hinders the water overtopping the dike, even at high water and storm. The water will flow over the edges 314 into and out of the openings 313 so that it is slowed down, and will also flow over the stone setting 302 between the rings 301. In this way, moreover, the effect that seems to occur is that backwash water is slowed down in the backwash direction and influences, in particular slows down, a new wave tongue.

In a dike according to the invention, a lower part of the flank 202A will preferably be clad with a dike cladding 3 that is well-resistant to fierce beating of the waves and wave load and erosion. In an advantageous further embodiment such a dike cladding 3 can comprise a setup of cladding elements or pillars 100, as will be described hereinafter, which can be set up in a relatively close packing, on a flank 202 or, for example, on a stone setting 302, which may for instance be implemented as described hereinbefore or in a different manner.

A cladding element or pillar 100 according to the invention preferably has a head part 101, a foot part 102 and an intermediate body part 103. A body axis X-X extends through the head part 101, foot part 102 and body part 103, and preferably intersects the head part 101 and foot part 102 in approximately the centre thereof. In Figs. 2-4, for example, the head part 101 and the foot part 102 have an axial height H_{101} and H_{102}, respectively, and the body part has an axial height H_{103}. In embodiments, the heights H_{101}

and/or H_{102} can be 0 cm or more. If the heights H_{101} and/or H_{102} is/are 0 (zero) cm, the respective head part and/or foot part is formed by the respective upper and/or lower end face 120, 121. The height H_{103} of the body part 103 is preferably considerably greater than the heights H_{101} and H_{102}, for example, at least five times the sum of those heights and/or, for example, at least ten times the greater of those two heights H_{101} and H_{102}.

Generally, a cladding element or pillar 100 according to the invention is preferably characterized in that at least one of the head part 101 and the foot part 102, and preferably both, has a non-circular cross section, viewed in a plane at right angles to the body axis X-X. The or each unround cross section has at least one greatest inscribed dimension or long axis A_1, and at least one smallest inscribed dimension or short axis A_2, as schematically drawn in Fig. 5 for elliptical or oval cross sections of a head part 101 and a foot part 102. In a cladding element 100 according to the invention the longest axis $A_{1(101)}$ of the cross section of the head part 101 and the long axis $A_{1(102)}$ of the foot part 102 mutually include an angle α, such that they are not parallel. The angle α is preferably in a range between 30 and 150 degrees, more particularly between 45 and 135 degrees and more particularly it is about 90 degrees, as shown in Fig. 5. The body part 103 has an outside surface 105 which smoothly connects the head part 101 with the foot part, and is preferably slightly waisted in side view. In embodiments, the body part 103, viewed axially between the head part 101 and the foot part 102, in particular approximately axially midway between the head part 101 and the foot part 102, can have an approximately circular cross section 106, transversely to the body axis X-X with a diameter or longest axis D which is shorter than the long axis A_1 of at least one of the head part 101 and foot part 102, preferably shorter than each of those long axes $A_{1(101)}$ and $A_{1(102)}$. Preferably, the diameter D is moreover longer than at least one of the short axes A_2 and preferably each of the short axes $A_{2(101)}$) and $A_{2(102)}$ of head part 101 and foot part 102. A part 103A of the pillar 100 above said cross section

106 can be called an upper height part 103A, the part located below it the lower height part 103B.

As will be further elucidated hereinafter, the cladding elements or pillars 100 are preferably shaped such that they, as shown for example in Fig. 7, at least by the head parts 101 and/or the foot parts 102 thereof, can be placed closely against each other, preferably against each other, while two juxtaposed pillars 100 have the outside surfaces 105 of their body parts 103 extending at a small distance from each other or abutting against each other along at least a curved line. As is visible, for example, in Fig. 5 and Figs. 7-9 and 12-18, this means that in placed condition a foot part 102 of a pillar 100 is situated, viewed in a direction parallel to the body axis X-X, under at least one head part 101 of an adjacent pillar 100, and preferably under at least two head parts.

As shown, for example, in Fig. 13, it holds that if a pillar 100 is pushed and/or pulled up in axial direction, in the direction as designated by the arrow P in Fig. 13, the foot part 102 of the pillar 100 will be clamped between at least the outside surfaces 105 bending towards each other of two pairs of pillars 100 placed against the respective pillar, thereby hindering the respective pillar 100 from being able to move further up.

During use, the pillars are preferably placed on a flank 202A of the dike body with their respective body axis X-X approximately at right angles to the respective flank, so that the body axis X-X is inclined with respect to a horizontal plane V. As a result, the pillars 100 are pressed against each other by gravity. The pillars can be placed loosely on a flank 101. Clearly, the pillars or cladding elements 100 can also be applied to substantially horizontal surfaces or bent surfaces, for example for cladding driving surfaces, such as roads or a berm 1 or crest 6.

The pillars 100 can for instance be placed in a layer of hard core or the like or directly on a substrate.

Fig. 2 shows such a pillar 100 and Fig. 3 shows the pillar 100 of Fig. 2 in cross section along a sectional plane running in height direction, that is, in the direction parallel to the body axis X-X, that is, in axial direction, which sectional plane comprises the body axis X-X and which, for example, also comprises the longest axis $A_{1(101)}$ of the head part 101, so that a pillar halved along its height is visible. Viewed in height direction, the axial outside surface 107 of the foot part 102 passes into the head part 101 via bent lines running in height direction; this holds for every turned position of the sectional plane running in height direction, around the height axis X-X of the pillar 100. Consequently, the axial outside surface of the body part 103 of the pillar 100 is substantially formed by surfaces curved in two directions (both in height direction and in lateral direction). In other words, in every vertical cross section of the pillar 100 through the body axis X-X, the sectional plane (surface) V is bounded on two opposite sides by a bent line 105A, resulting in a double-curved outside surface 105.

Fig. 4 shows an alternative pillar of which the foot part 102 has a smaller dimension in comparison with that of the head part 103. The obverse is also possible. The cross section of the head part 101 of Fig. 4 has dimensions $A_{1(101)}$ and $A_{2(101)}$ which are, for example, equal to those of Fig. 1, while the foot part 102 has smaller dimensions $A_{1(102)}$ and/or $A_{2(102)}$, for example, the length is 5% shorter ($A_{1(102)}$) while, for example, the width ($A_{2(102)}$) is identical to that in Fig. 2.

Figs. 2-4 are on scale and the figures concern units of length, for example, centimeters. Thus, in Fig. 2, for example, the long axis A_1 can be about 122 cm and the short axis A_2 can be about 72 cm, while the height H_{100} of the pillar between the end faces 120, 121 can be, for example, about 120 cm. These dimensions merely serve for illustration and should not be construed as limiting in any way.

Fig. 5 schematically shows the top plan view of the pillar of Fig. 2. The inscribed circle 106 is the shape of the cross section 106 of the pillar 100 at a height between the head part 101 and the foot part 102, for example in particular at about the half-height, while the ellipses 130, 131 respectively represent the cross section of the head part 101 and the foot part 102. The diameter D of the circle 106 is greater than the short axis A_2 and smaller than the long axis A_1 of the ellipse 107, 108 of the head and foot part 101, 102. The surface of the circle is, for example, approximately as great as the surface of the ellipses 130 and/or 131. Fig. 5 shows the full ellipse. In embodiments, the long ends, that is, the apex of the ellipse at the ends of the long axes $A_{1(101)}$ and/or $A_{1(102)}$, are truncated as shown, for example, in Fig. 2. In the case where the ellipse is truncated, the surface of the ellipse can be smaller than that of the circle at the half-height, by an amount being the sum of the surfaces of the deletions through the truncation.

As Figs. 2-4 show, in the embodiment shown therein, adjoining the top and bottom surface 110, 111, respectively, are a head and foot part 101, 102 of a constant shape, so prismatic in shape, adjoining which, viewed in the direction of the half-height, that is, the axial middle 106 of the pillar 100, is a body part 103 with a double-curved surface 105 so that from the ellipse a smooth transition to the circular cross section 106 halfway the height is provided. The upper height portion 103A of the pillar 100 above the level halfway the height is preferably practically identical in shape and dimension to the lower height portion 103B below said level, though turned through 90 degrees around the ascending body axis X-X of the pillar. Clearly, the included angle α can also be smaller or greater than 90 degrees.

The pillar 100 is preferably substantially symmetrical according to two planes of symmetry extending mutually perpendicularly and parallel with the ascending body axis X-X, however, the lower half is turned 90 degrees relative to the upper half.

Fig. 6 shows the ascending curved line 105A which describes the outside surface 105 of the pillar 100 along the shortest path from halfway along the long outer side of the ellipse, that is, an end of the short axis $A_{2(101)}$

of the head part 101 to the outer side of the foot part 102 straight under it, seen in side view.

Fig. 7 gives an impression of the relative positioning of the pillars. The associated circles 106 which describe the pillar shape at half height are also inscribed. Note that in this embodiment the pillars are mutually in contact throughout their height along an ascending contact line 105B. At the head and foot parts 101, 102 the pillars 100 bound between themselves star-shaped interspaces 111 with three points 112 and inwardly bent sides 113, and at the half height 106 they are star-shaped interspaces 114 with four points 115 and inwardly bent sides 116. These interspaces 111, 114 form upwardly extending flow channels 117 for water, which are sideways sealed from each other by the pillars 100, apart from relatively minor leakage gaps because of the pillars 100 not adjoining each other perfectly. Note how two three-pointed star-shape interspaces 111, proceeding towards the level at half-height 106, meet in the single four-pointed star-shaped interspace 114.

The pillars in the shown embodiment in for instance Fig. 7 stand in parallel, straight rows next to each other, along the long axis A_1 of the head part 101. Each row in this embodiment has been shifted relative to an adjacent row, in the row direction, over one half of the long axis A_1 of the head part 101. As a result of settling, the pattern may deviate somewhat from the straight line.

While Fig. 7 shows a representation with a viewing direction oblique to the row direction, for Fig. 8 a viewing direction along the row direction has been used. For Fig. 9 yet another viewing direction has been applied.

Fig. 10 shows the pattern of the circular profile 106 halfway the height of the cladding elements 100 of the dike cladding of Figs. 7-9. At the top, left, in the drawing, a square has been inscribed whose angular points coincide with the centres of four circles grouped around a star-shaped interspace 114 with four points, which centres preferably coincide with the body axis X-X of each pillar 100. This applies to the whole pattern. Fig. 11 shows an alternative pattern according an equilateral triangle instead of a square. The relative positioning of head and foot parts 101, 102 changes accordingly.

Fig. 12 shows the cladding element 100 of Fig. 2 in the position turned through 90 degrees around the ascending body axis X-X. Fig. 13 shows the cladding element 100 of Fig. 12 surrounded by identical cladding elements 100 (only partly shown) as in the dike cladding of Figs. 7-9. Fig. 14 is the same representation as Fig. 13, but the cladding elements 100 have been omitted and the interspaces 111, 114 between the cladding elements 100 are now represented as bodies. From Figs. 13 and 14 together, the shape and the course of the interspaces 111, 114 is apparent. In height direction, a three-pointed star-shaped interspace 111 changes into a four-pointed star-shaped interspace 114, at a height between the head part 101 and the foot part 102, for example at the half-height 106 (only half of this four-pointed star is shown) which proceeds to divide into two mutually substantially parallel three-pointed star-shaped interspaces 111 (only one half of these two three-pointed stars is shown).

From Figs. 13 and 14 it is also apparent how the flow channel 117 formed by the interspaces and running in height direction has been turned at the head part 101 with respect to the foot part, as the head part 101 has been turned relative to the foot part 102.

Figs. 15-17 show an alternative cladding element 100 with a recess 118 in the upper end face 110, for example in the shape of an oval or ellipse. At least, a ring 119 has been provided on or at the end face 110. Figs. 16 and 17 show representations comparable to Figs. 13 and 14, and the interspaces have a shape and course comparable to Figs. 13 and 14.

The representation of Fig. 18 relates to pillars whose circular cross section 106 at the half-height has a smaller diameter D in comparison with the pillar of Figs. 2-9, there is no line contact between the pillars 100 throughout the height now.

A pillar 100 according to the invention can be manufactured in any suitable manner, such as, for example, by casting, pressing or the like, and can be manufactured from any suitable material, such as, for example, concrete, concrete mixtures and the like, or from stone, or other water- and erosion-resistant materials.

In a dam 200 according to the invention, on a flank 202A, preferably near a lower end thereof, that is, near the water surface 2, a first cladding 3 has been applied, substantially formed with cladding elements 100 which are placed relatively closely against each other, and, located higher on the flank, for example between the first cladding 3 and the crest 6, at least a second cladding 4 has been provided, built up using the rings 301 and preferably a stone setting 302.

The measures disclosed herein can be individually taken together in any other conceivable combination and permutation to provide an alternative to the invention. Also encompassed are technical equivalents and genera or generalizations of the disclosed measures. A measure of an example is also generally applicable within the framework of the invention. A measure disclosed herein, for instance from an example, may be straightforwardly generalized for inclusion in a general definition of the invention, for example to be found in a patent claim. For example, a shape may be angular instead of smooth or sloping.

CLAIMS

1. A dam with a cladding which comprises a set of rings (301) which are arranged on an inclined flank (202) of the dam (200), to slow down wave tongues flowing up and down along the dam (200).

2. The dam according to claim 1, wherein the rings (301) are arranged on the inclined flank (202) of the dam (200), wherein the rings (301) each have a central axis Y which extends substantially at right angles to a bottom surface (311) and/or top surface (310) of the respective ring (301), wherein the central axis Y of the rings extends approximately at right angles to the flank (202).

3. The dam according to claim 1 or 2, wherein each ring (301) has a circumferential edge (314) which at least for the most part surrounds an opening (313) and is preferably closed in the circumferential direction around the opening (313), wherein the opening (313) is at least open at the top, so that water can flow into it.

4. The dam according to any one of the preceding claims, wherein the rings (301) have a substantially circular, oval or elliptical cross section, at right angles to the central axis Y.

5. The dam according to any one of the preceding claims 1-3, wherein the rings have a substantially polygonal cross section, at right angles to the central axis Y.

6. The dam according to any one of the preceding claims, wherein the rings each have a bottom surface (311) and a top surface (310), wherein the bottom surface and the top surface (311, 310) are approximately parallel to each other.

7. The dam according to any one of the preceding claims 1-5, wherein the rings each have a bottom surface (311) and a top surface (310), wherein the bottom surface and the top surface (311, 310) mutually include an angle,

wherein preferably at least the top surface is inclined with respect to the central axis Y.

8. The dam according to any one of the preceding claims, where the rings are set up in rows and/or columns, wherein the rows preferably extend in a direction substantially parallel to a length direction of the dam.

9. The dam according to any one of the preceding claims, wherein in and/or between and/or under the rings a stone setting is arranged, preferably formed from stones laid loosely against each other and against and/or in the rings.

10. The dam according to any one of the preceding claims, wherein the rings (301) are arranged on the flank (202) in a pattern with the rings (301) placed at a distance from each other.

11. The dam according to any one of the preceding claims 1-9, wherein the rings (301) are arranged in a pattern on the flank (202), with at least a number of the rings in each case being in contact with at least one other ring.

12. The dam according to any one of the preceding claims, wherein in at least a number of rings a stone setting is provided, formed from stones which fill up a bottom part of an opening (313) of the ring (301).

13. The dam according to any one of the preceding claims, wherein around at least a number of the rings a substantially closed ring of stones is laid, in particular as part of a stone setting, wherein preferably a part of the stones of one of those rings are also part of a ring of stones around an adjacent ring (301).

14. The dam according to any one of the preceding claims, wherein the rings are arranged on an upper part of the flank of a dike body, wherein a part of the flank located therebelow is at least partly covered by a dike cladding (3) formed with dike cladding elements (100) placed at least relatively close to each other.

15. The dam according to claim 14, wherein the dike cladding elements (100) each comprise a head part (101), a foot part (102) and, located therebetween, a body part (103), wherein the head part (101) and the foot part (102) have a non-circular cross section, viewed in a plane at right angles to a body axis X-X through the cladding element (100), wherein the or each unround cross section has at least one greatest inscribed dimension or long axis A_1, and at least one smallest inscribed dimension or short axis A_2, wherein the head part (101) and the foot part (102) are placed relative to each other such that viewed in top plan view the long axes A_1, A_2 of the respective cross sections mutually include an angle.

16. A method for making the dam according to claim 1, wherein the dam is equipped with rings according to claim 1.

17. A ring for use in the formation of a dike cladding for a dam according to any one of claims 1-15.

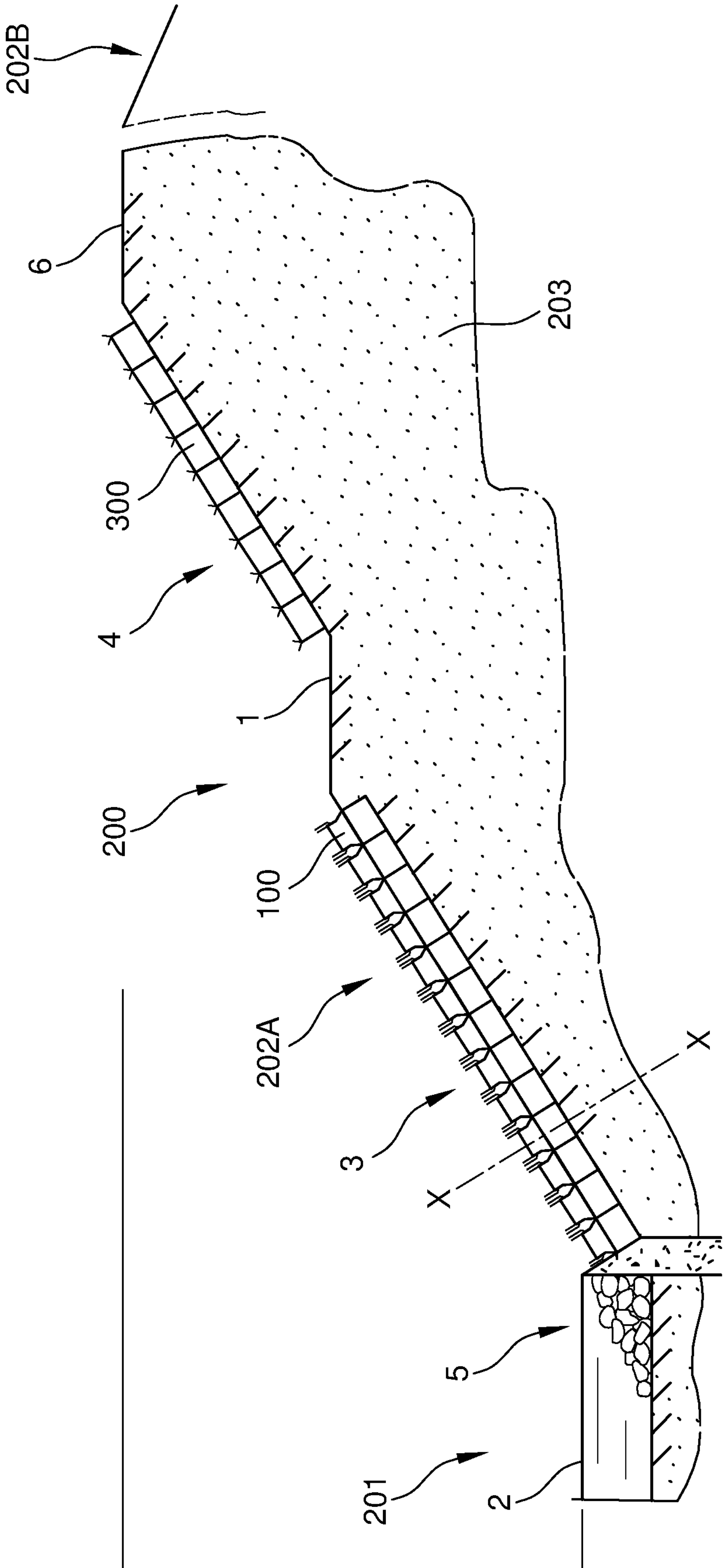

Fig. 1

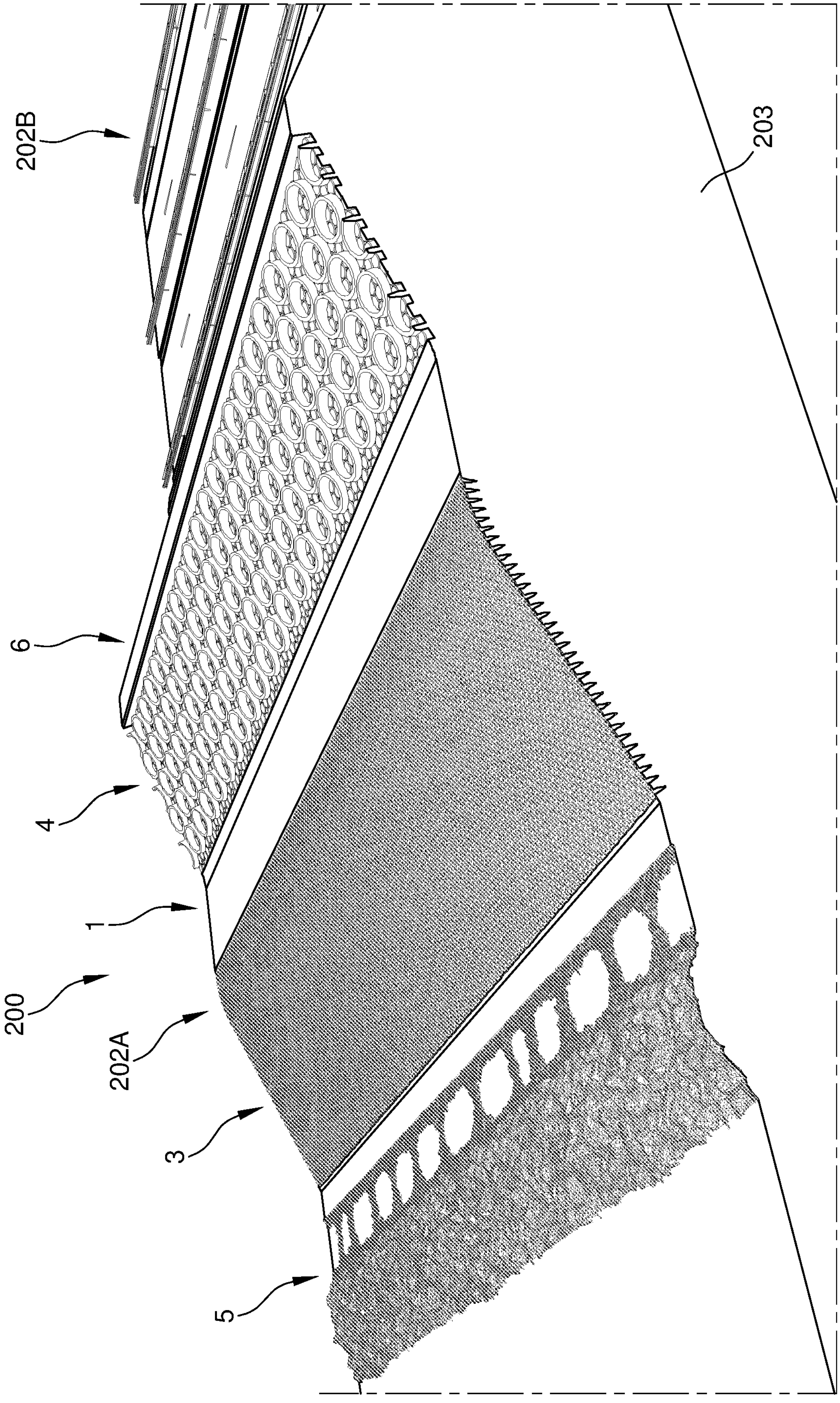

Fig. 1A

Fig. 1B

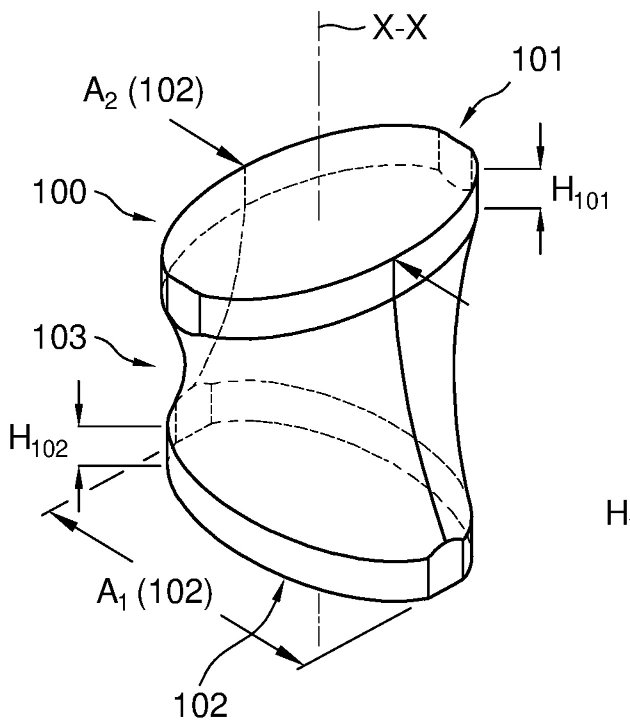

Fig. 2

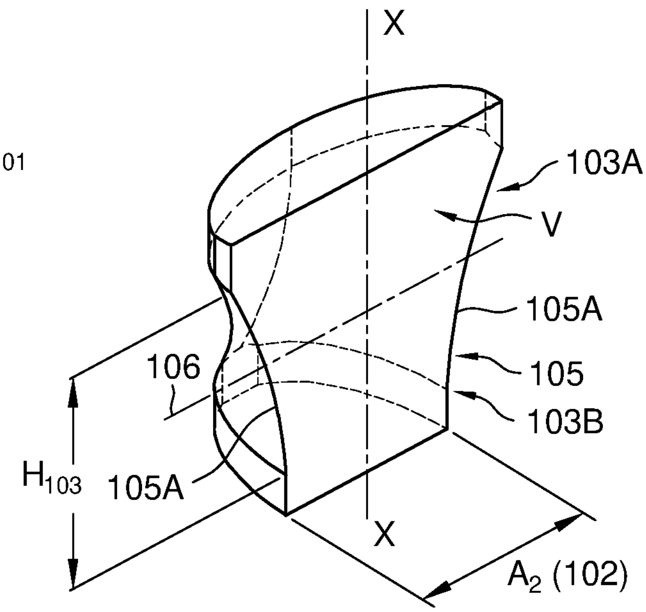

Fig. 3

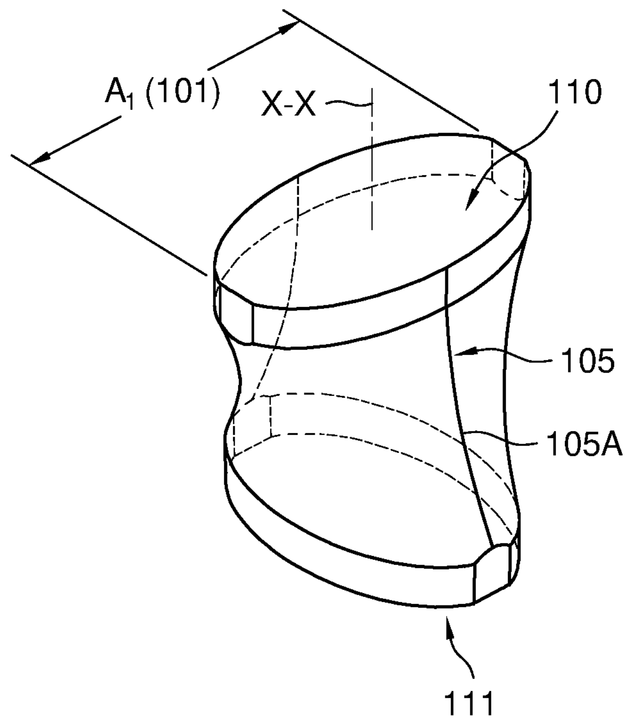

Fig. 4

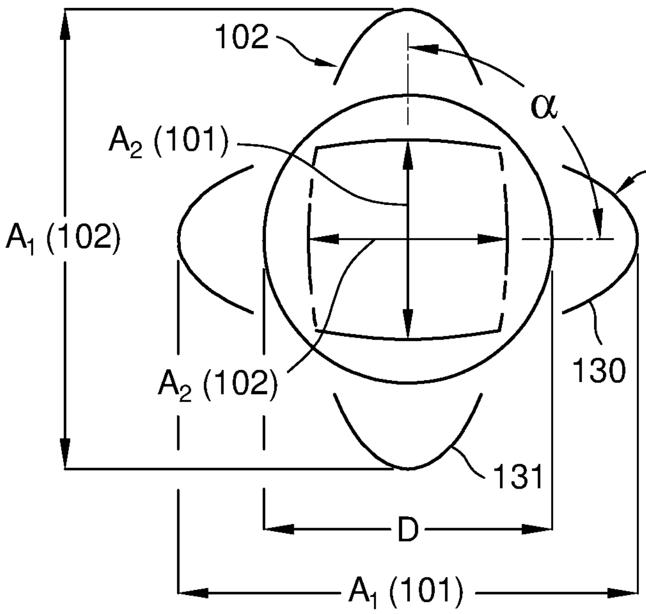
102
α
A_2 (101)
101
A_1 (102)
A_2 (102)
130
131
D
A_1 (101)

Fig. 5

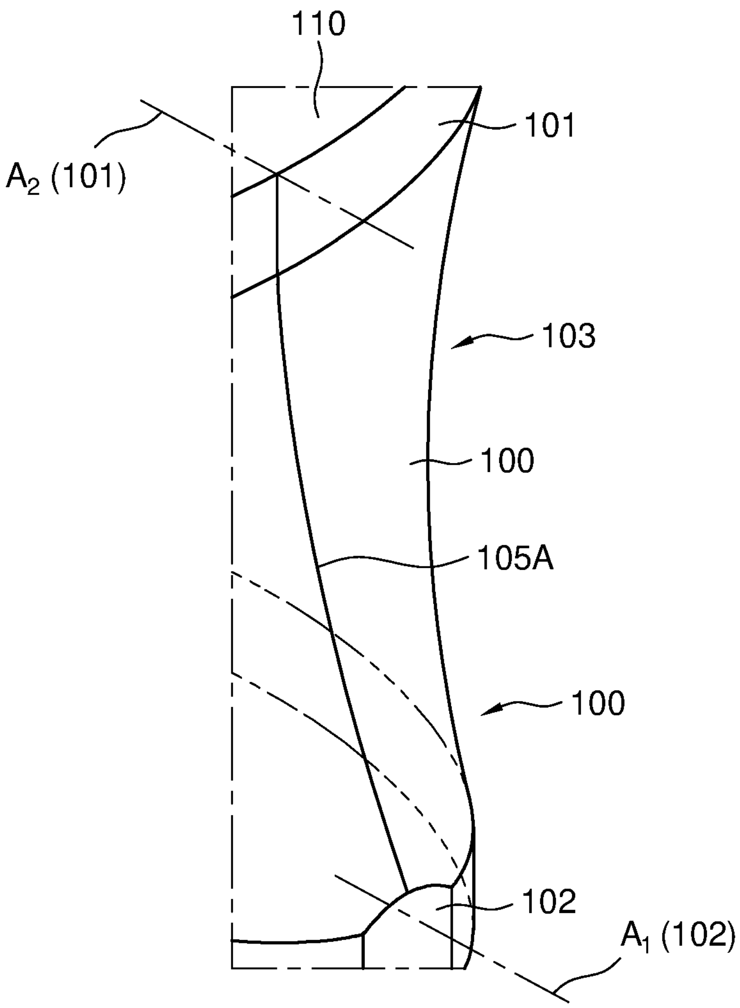
110
101
A_2 (101)
103
100
105A
100
102
A_1 (102)

Fig. 6

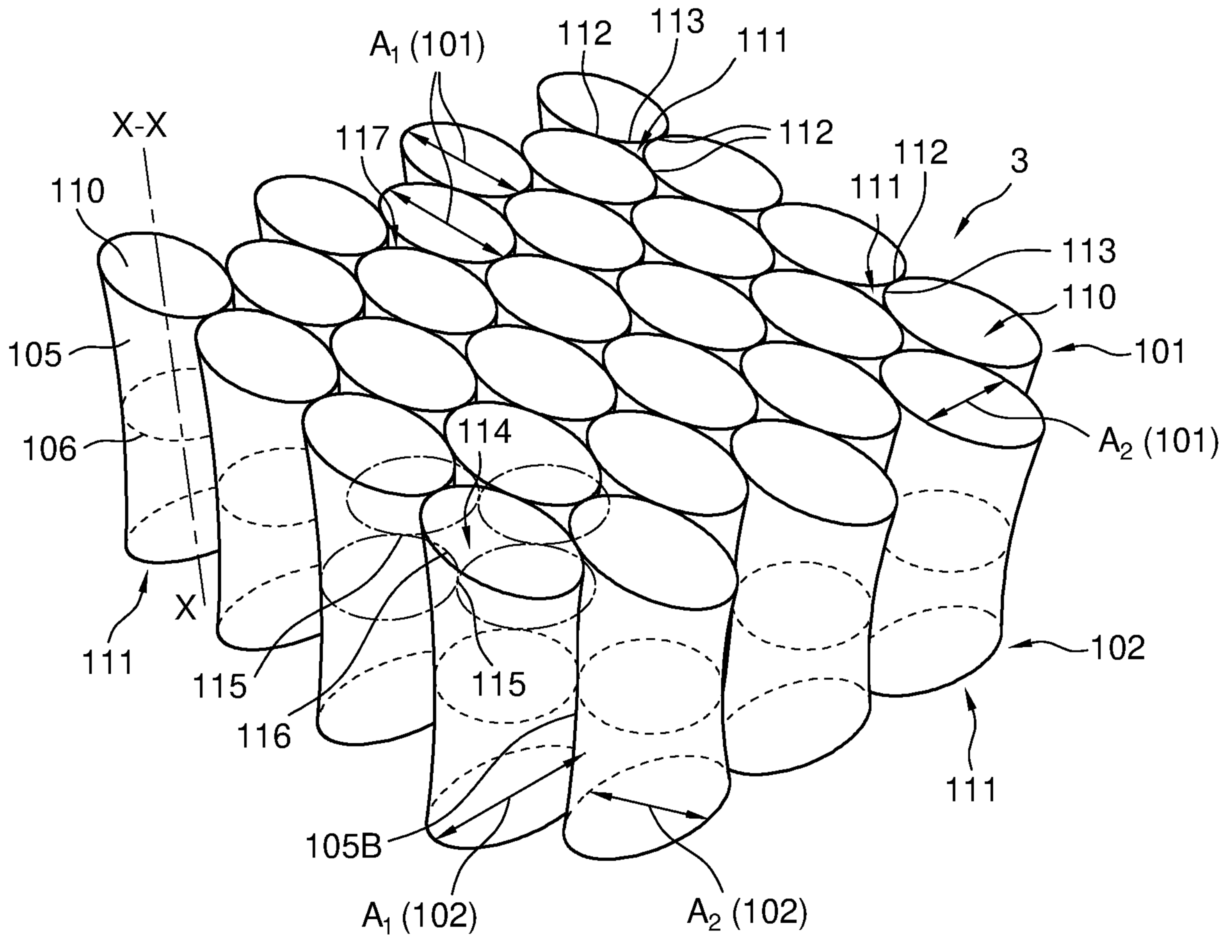
A1 (101)
112
113
111
X-X
117
112
112
3
110
111
113
110
105
101
106
A2 (101)
114
X
102
111
115
115
116
111
105B
A1 (102)
A2 (102)

Fig. 7

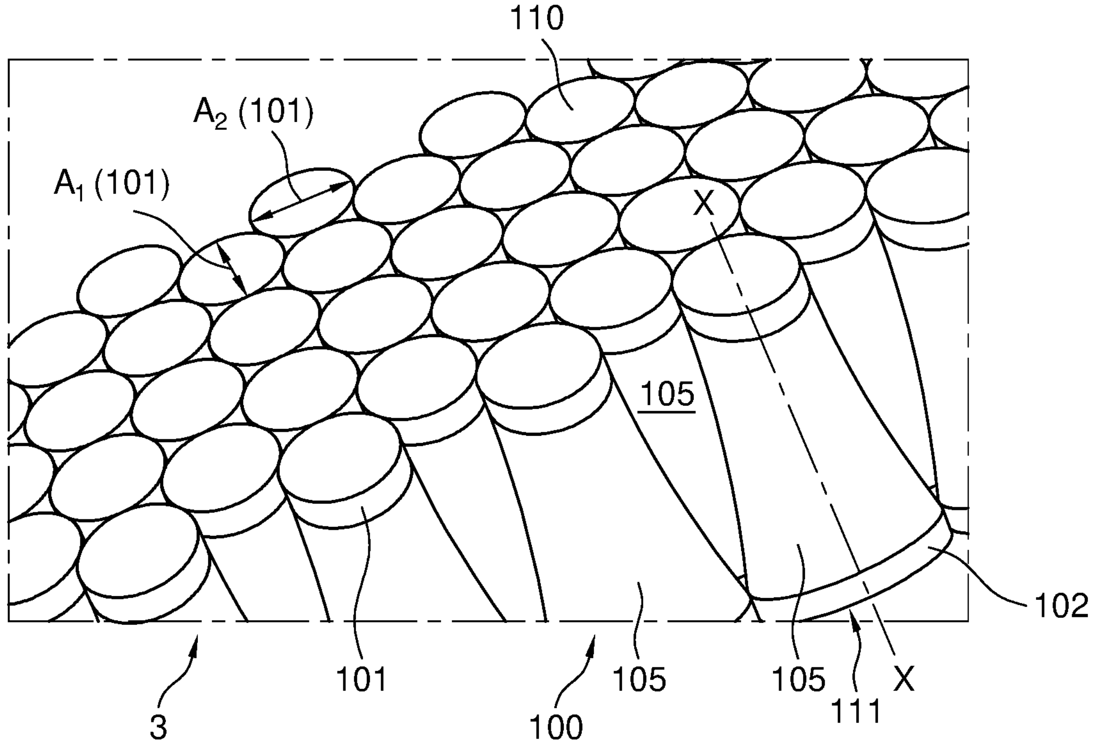
110
A2 (101)
A1 (101)
X
105
101
105
105
102
3
100
111
X

Fig. 8

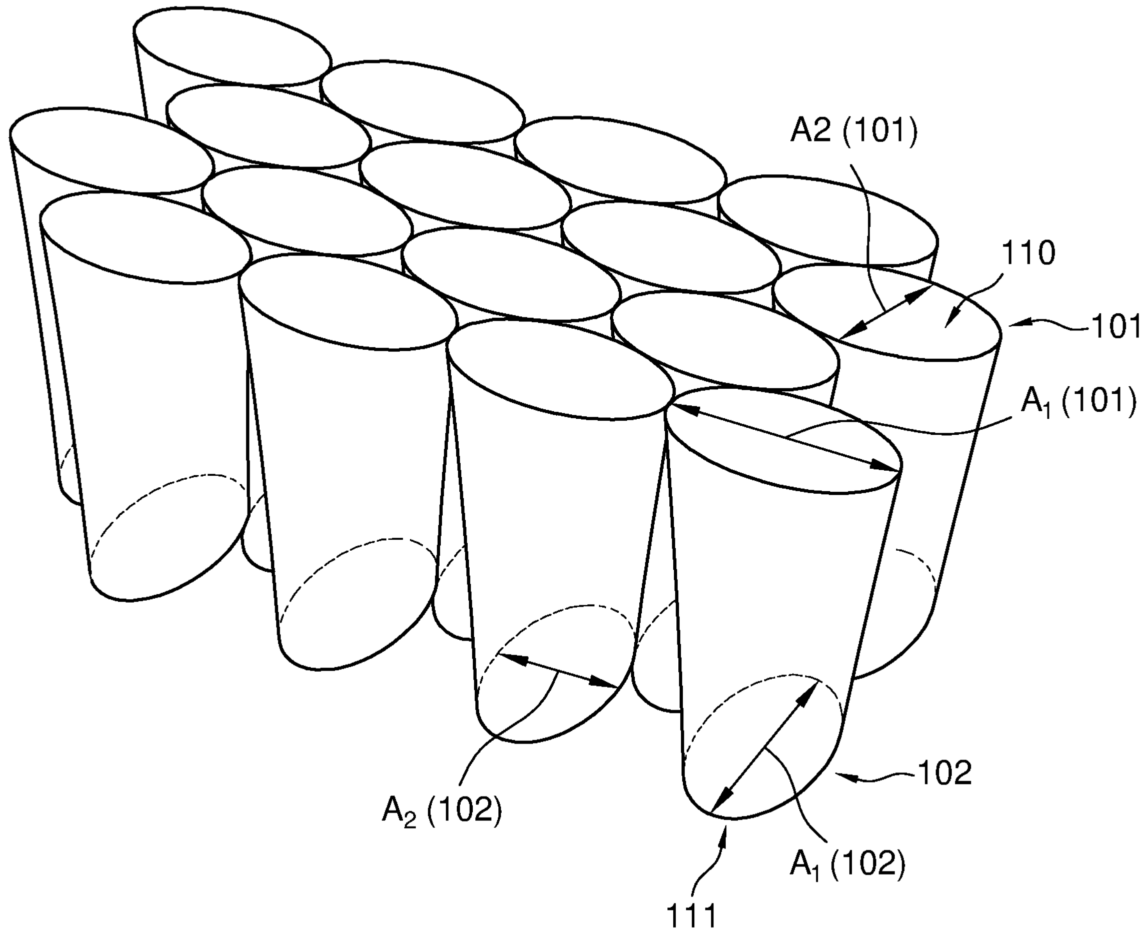

Fig. 9

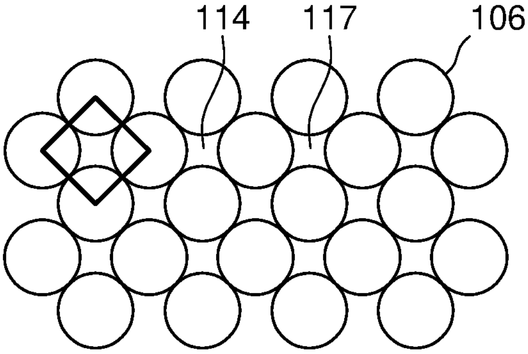

Fig. 10

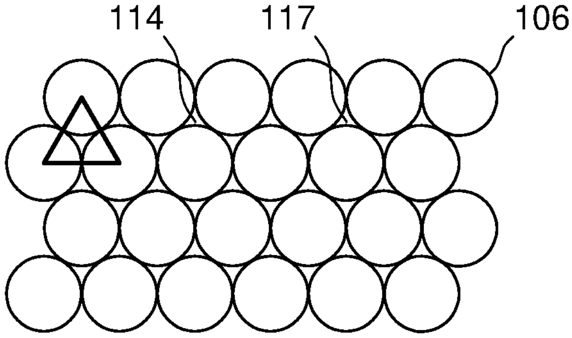

Fig. 11

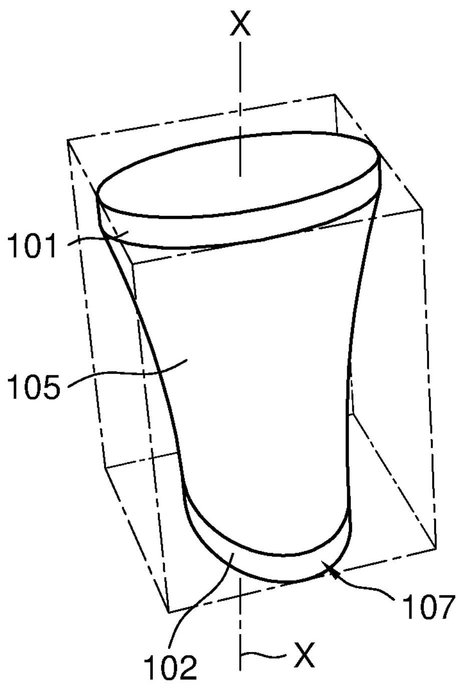

Fig. 12

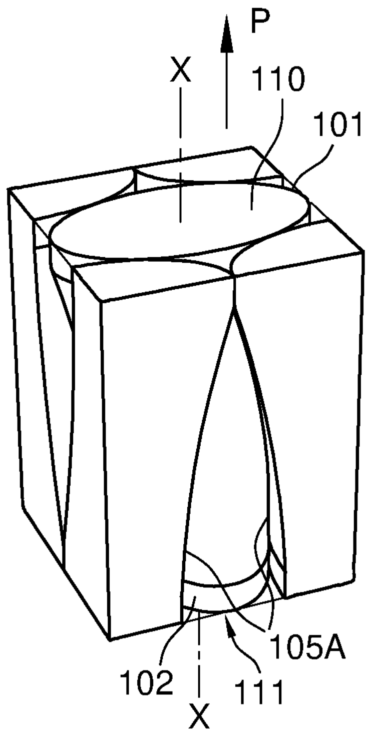

Fig. 13

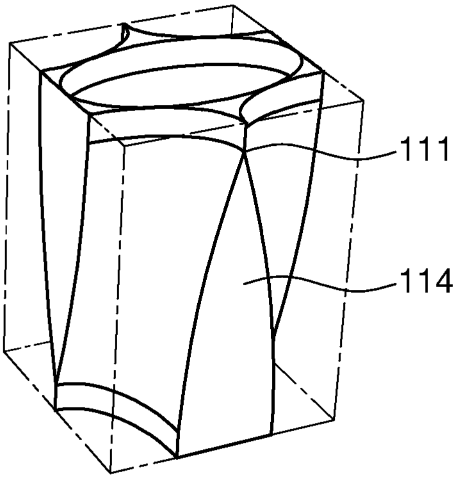

Fig. 14

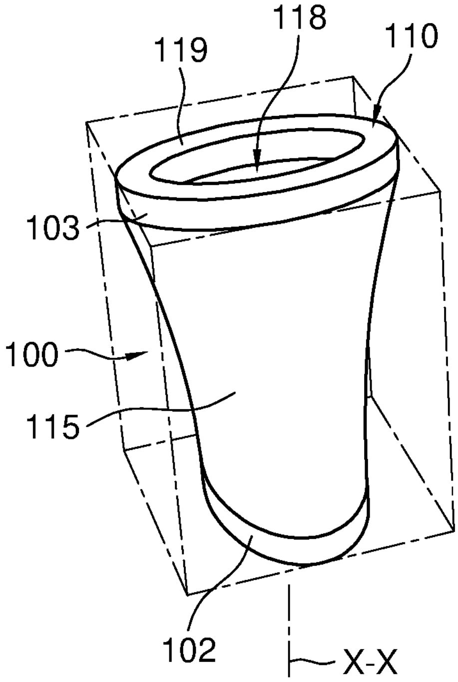

Fig. 15

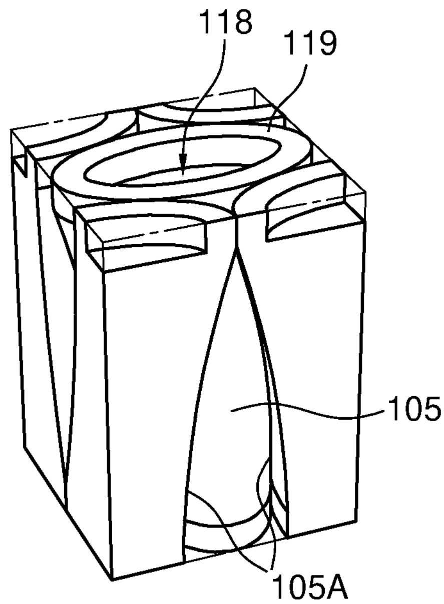

Fig. 16

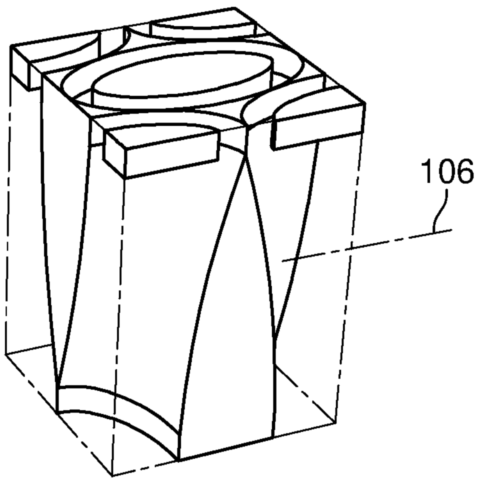

Fig. 17

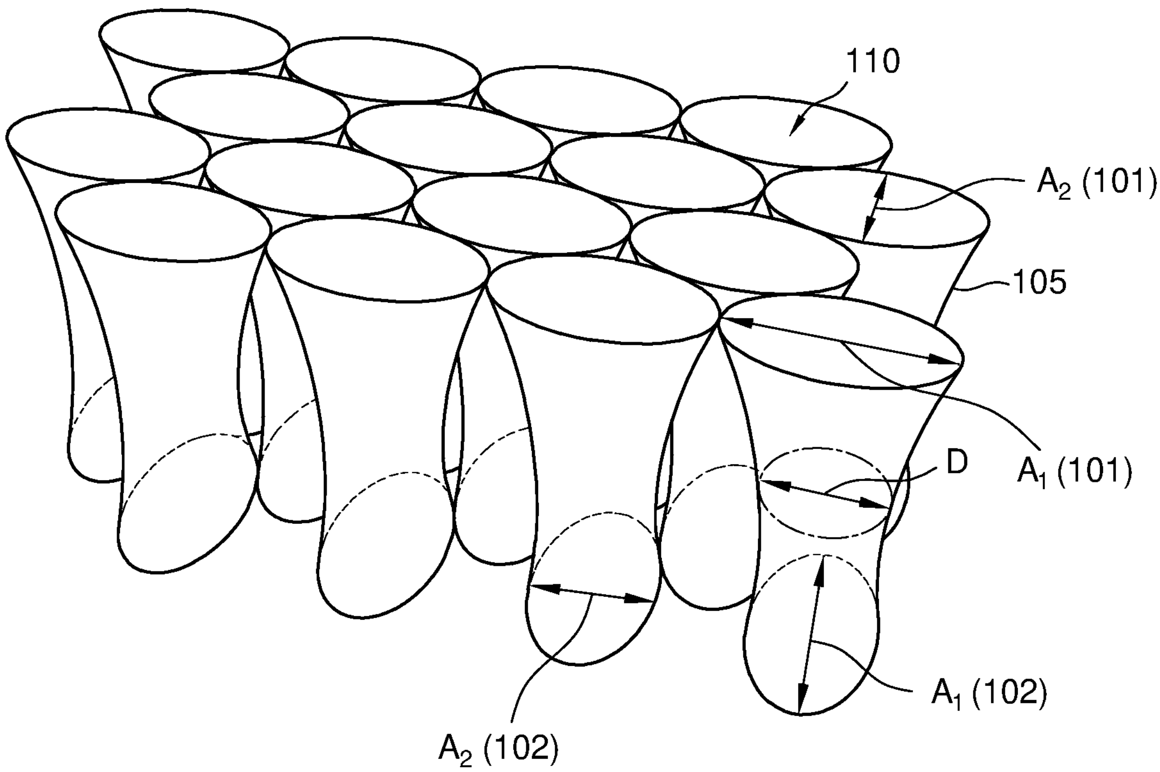

Fig. 18

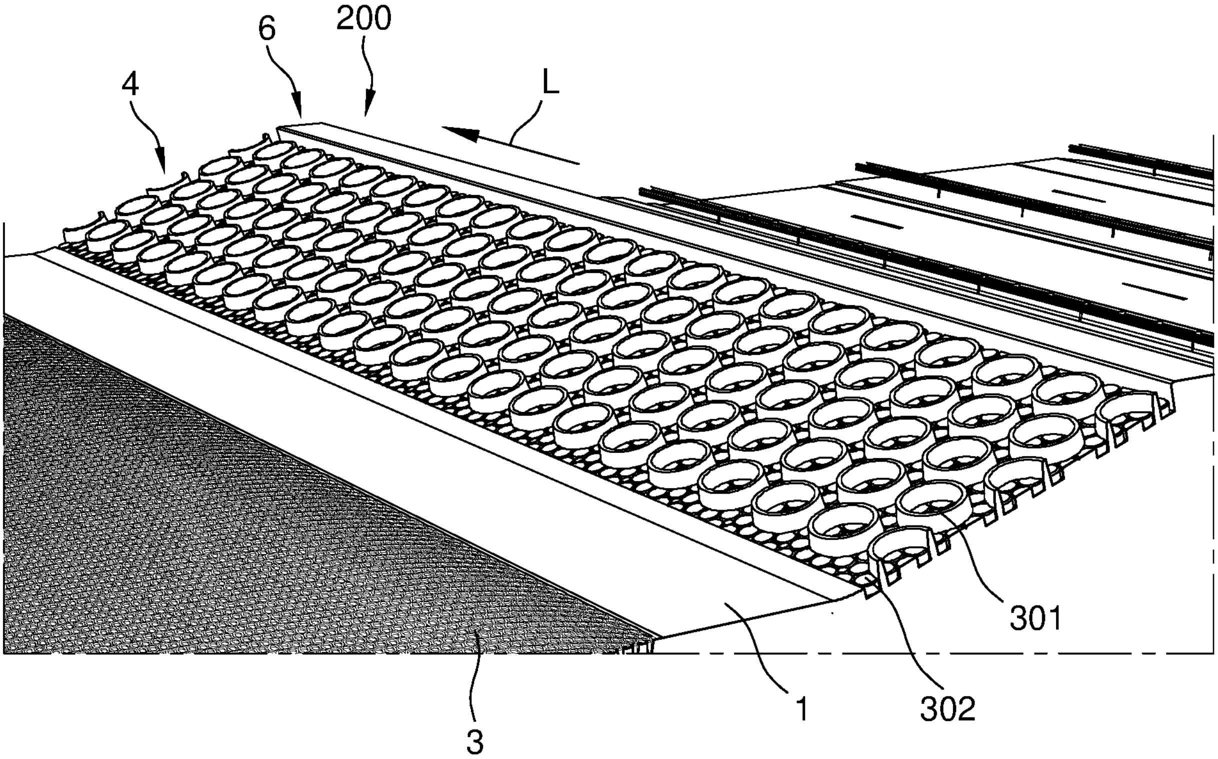

Fig. 19

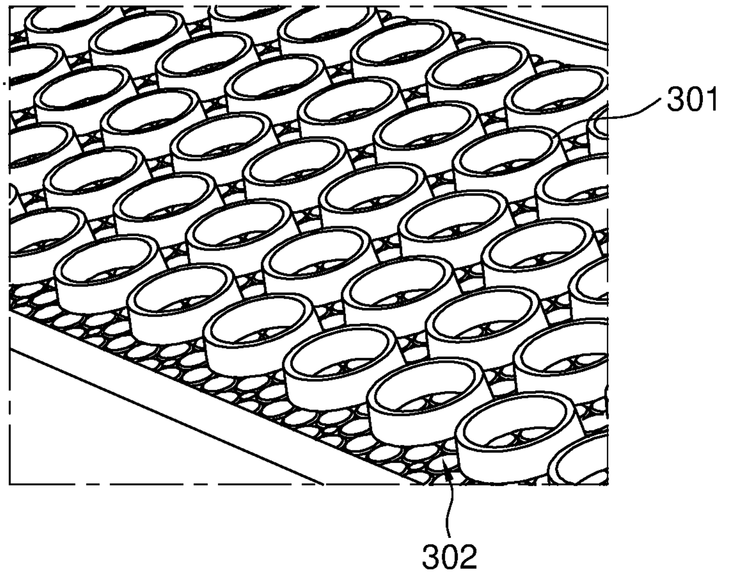

Fig. 20

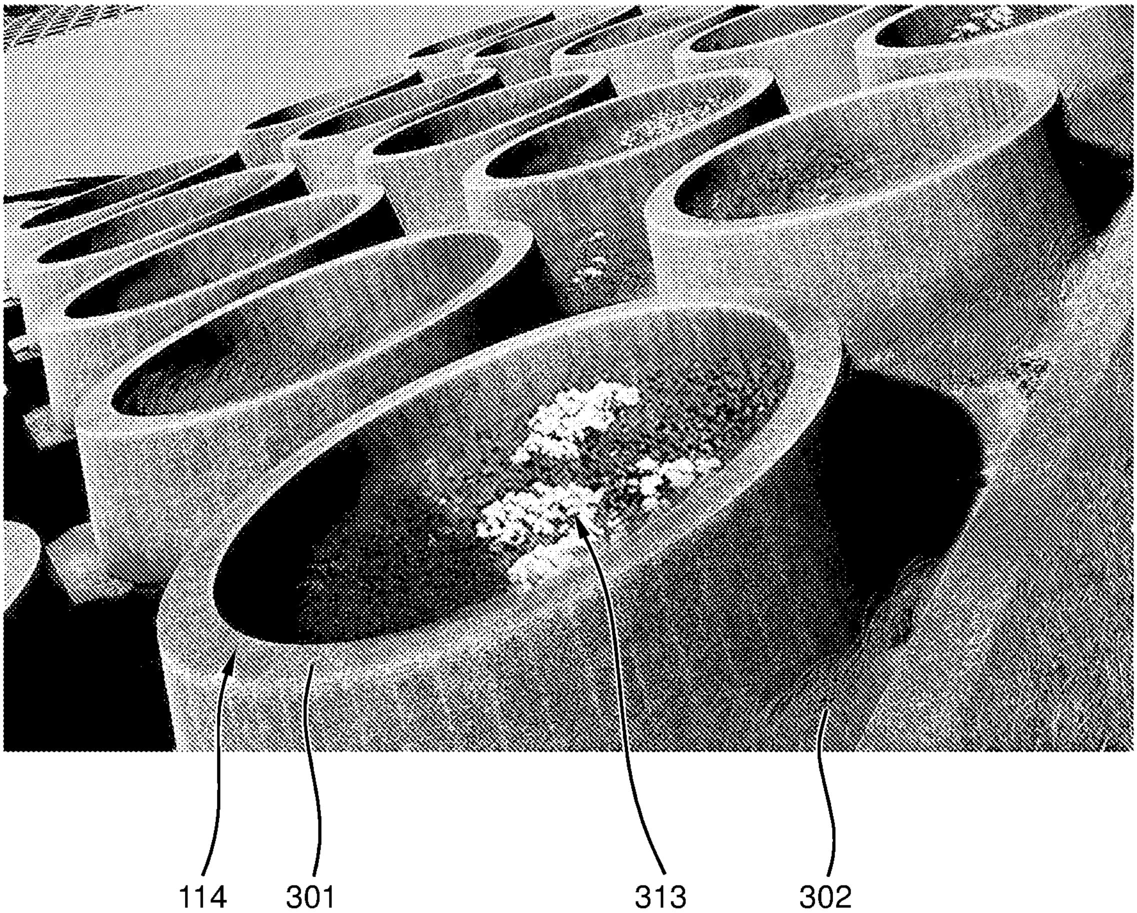

Fig. 21

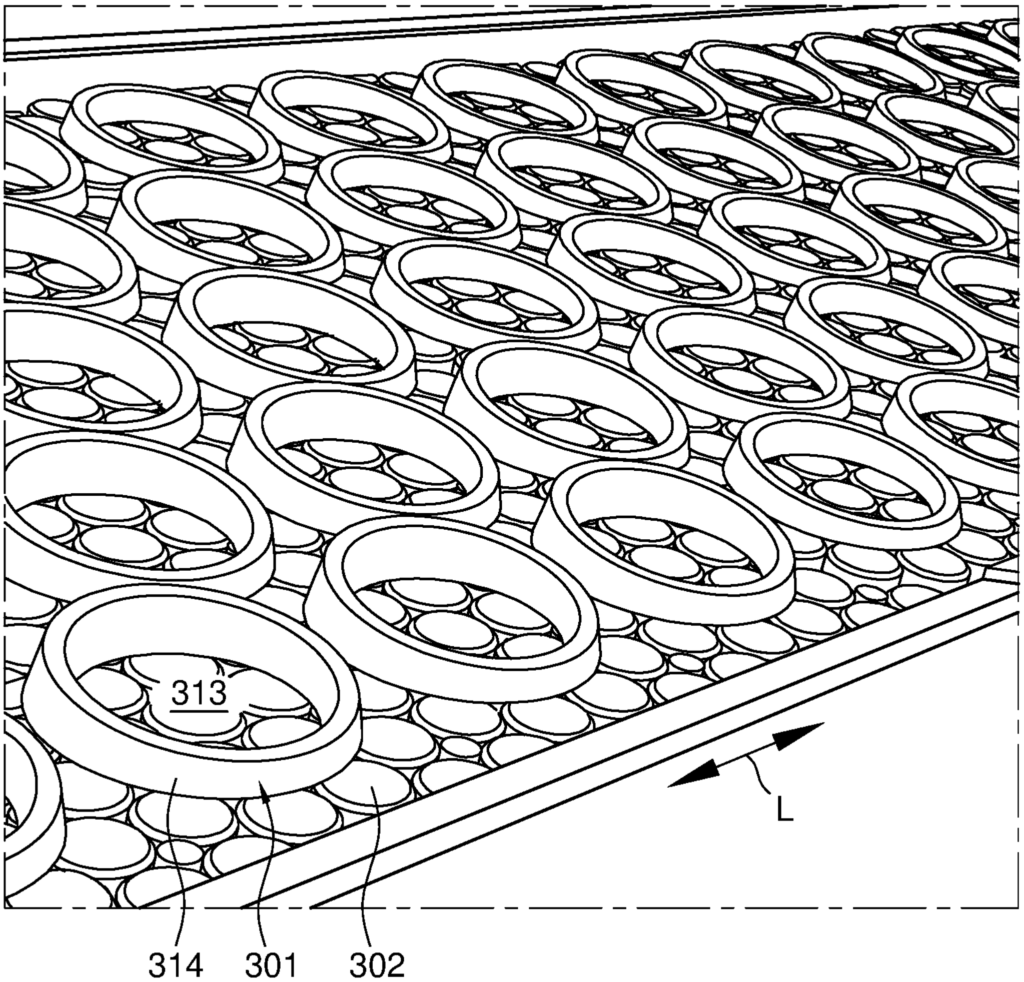

Fig. 22

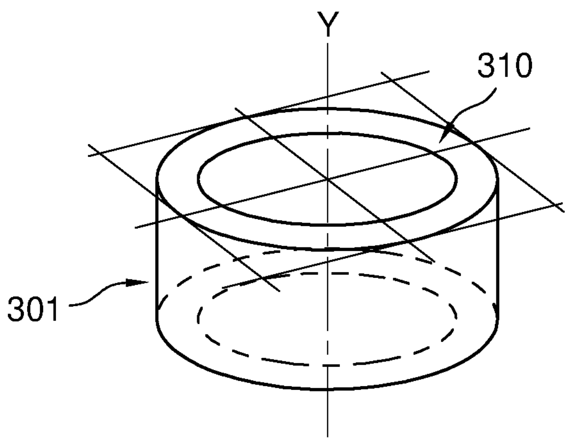

Fig. 23

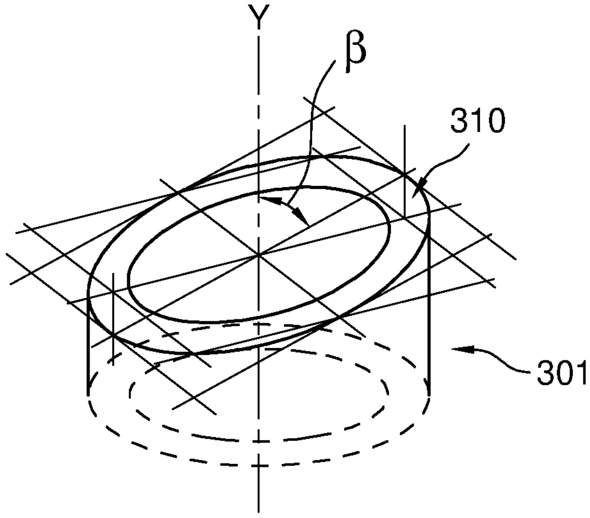

Fig. 24

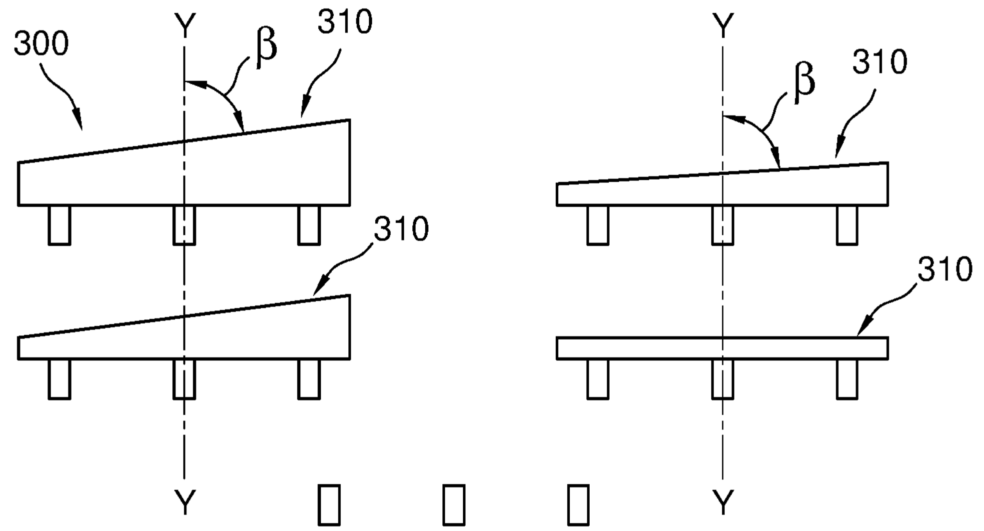
300
Y
β
310
310
310
310
Y
Y
Y
β

Fig. 25

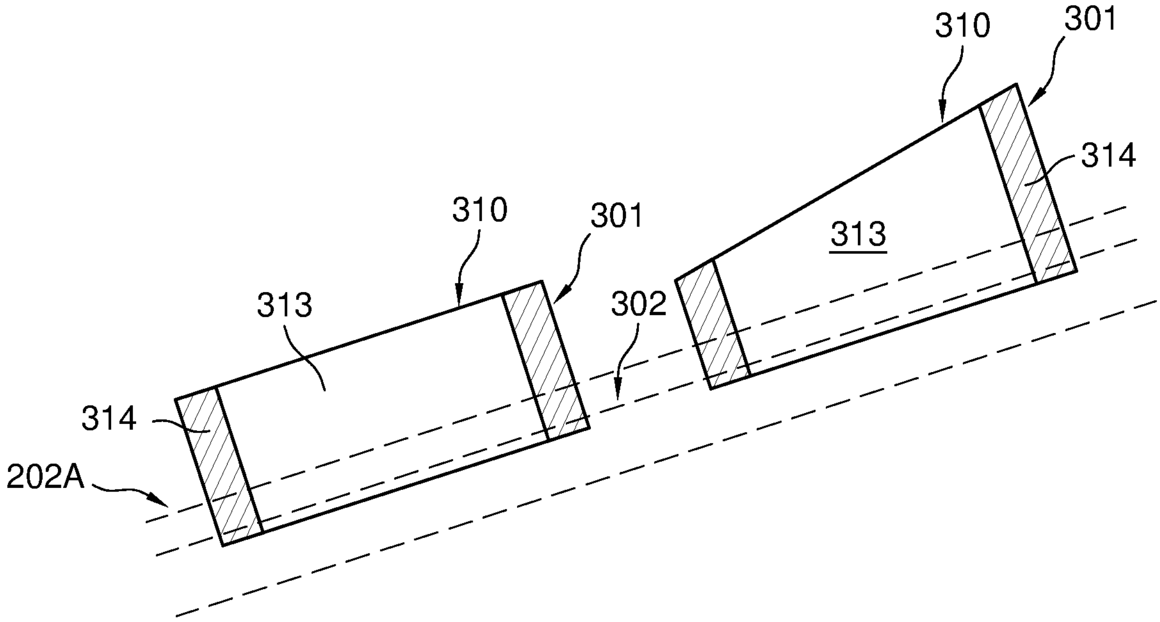
310
301
314
313
310
301
313
302
314
202A

Fig. 26

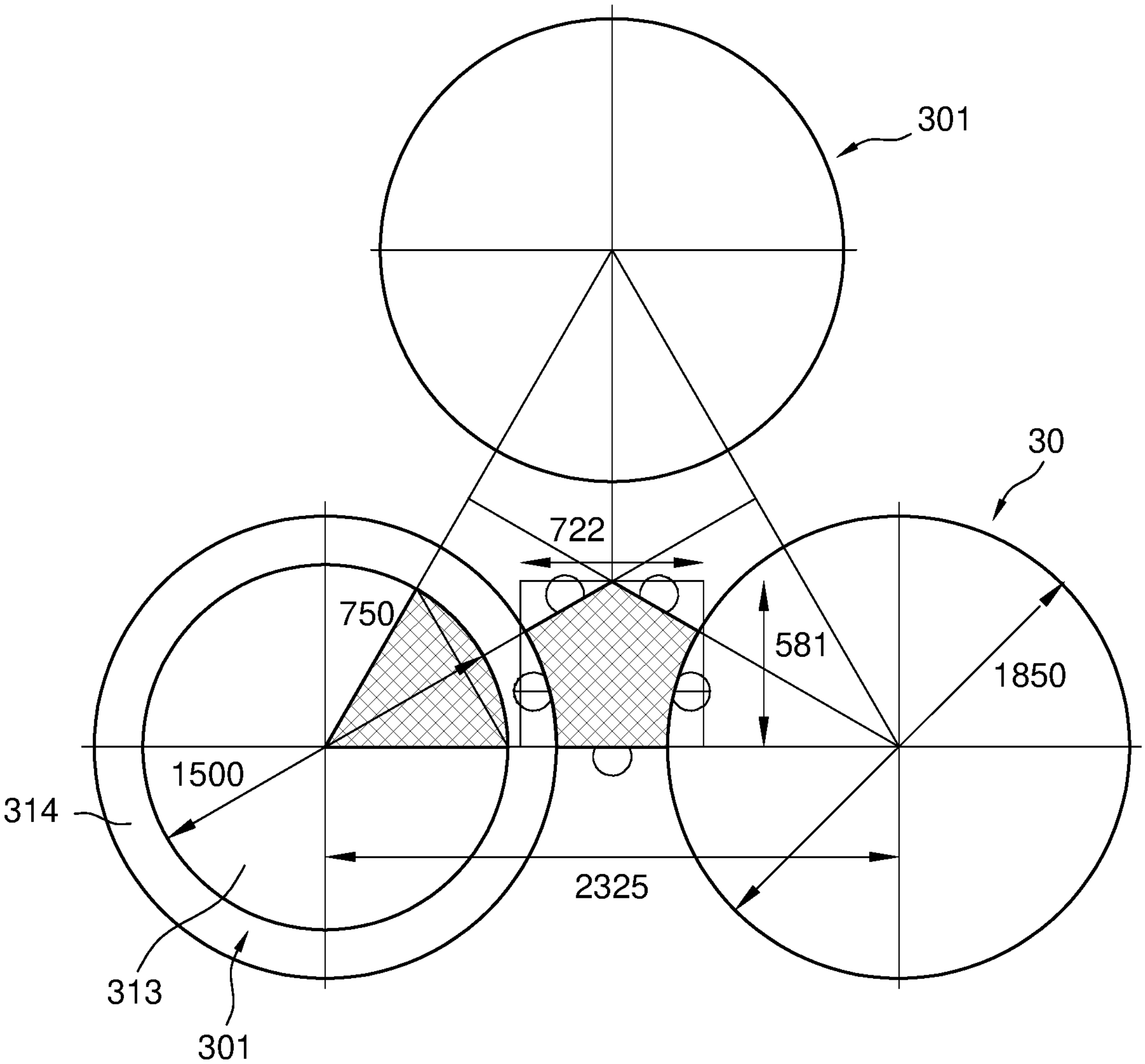

Fig. 27

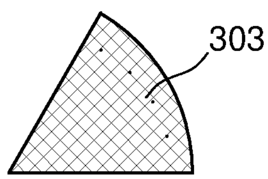

Fig. 28

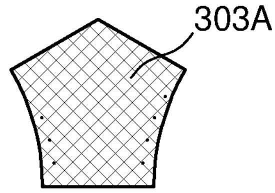

Fig. 29

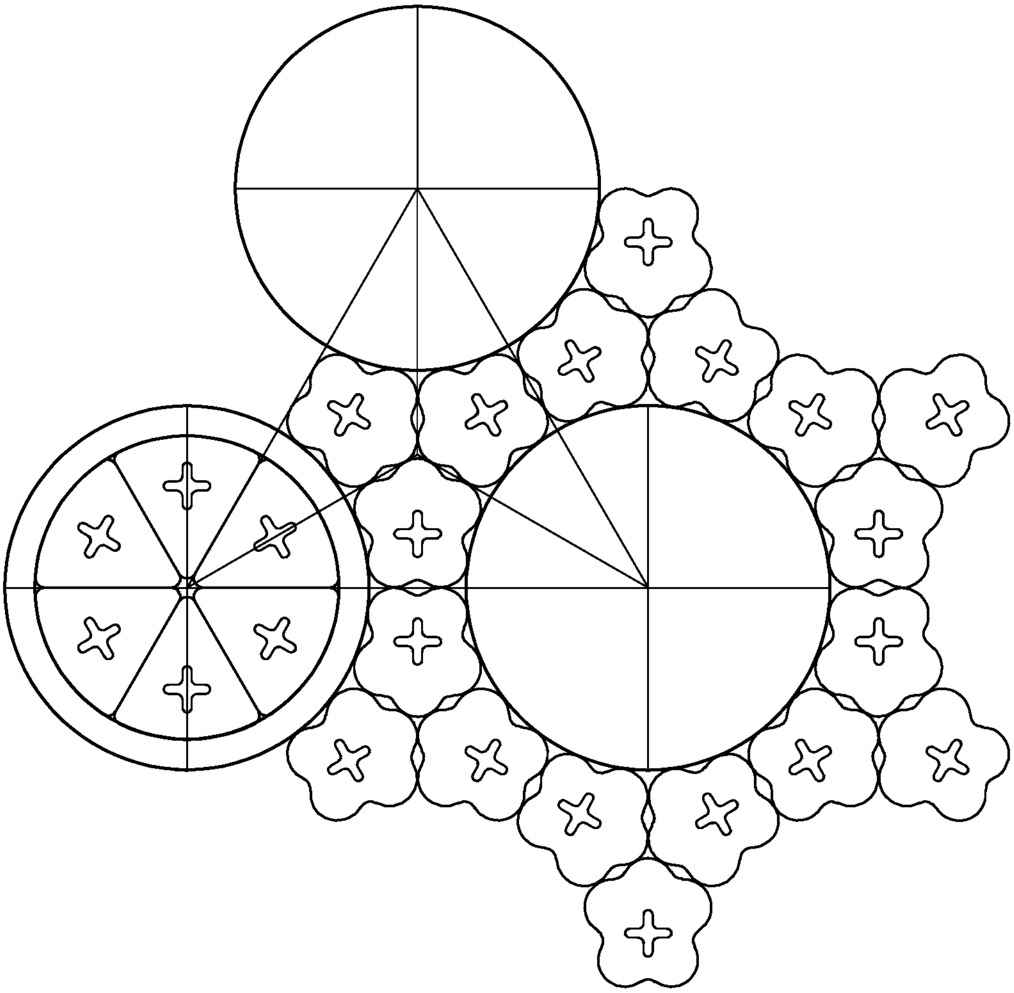

Fig. 30

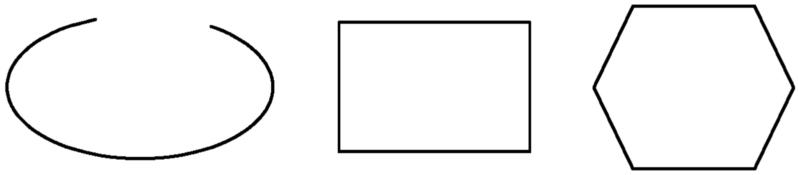

Fig. 31

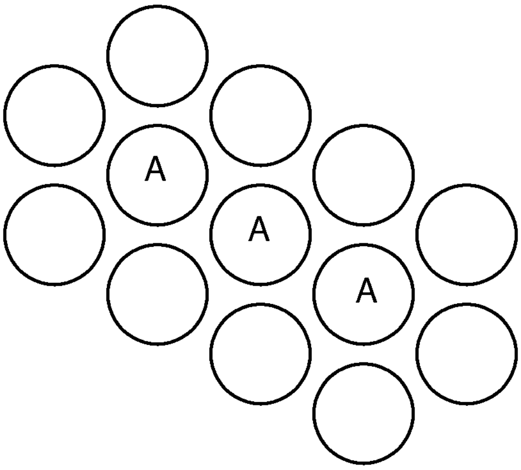

Fig. 32

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2018/050729

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02B3/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 990 247 A (PALMER ROBERT Q) 9 November 1976 (1976-11-09) cited in the application column 1, line 7 - column 2, line 39 column 3, line 57 - column 4, line 20 column 5, line 46 - column 6, line 51; figures	1-4,6-17
X	US 3 096 621 A (FRANCOIS DANEL PIERRE) 9 July 1963 (1963-07-09) cited in the application column 5, line 6 - column 9, line 61; figures	1-3,5-17

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 February 2019	26/02/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Van Bost, Sonia

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2018/050729

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/108931 A1 (HILL HANS [NL]) 9 September 2011 (2011-09-09) page 1, line 3 - line 9 page 4, line 19 - line 30 page 8, line 2 - page 11; figures -----	1,14,15
A	FR 2 678 965 A1 (VINCENT GEORGES [FR]; TOURMEN LOUIS [FR]) 15 January 1993 (1993-01-15) page 1 - page 5; figures -----	1,14,15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2018/050729

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US 3096621	A	09-07-1963	NONE			
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			TN	SN92053	A1	08-06-1993
			WO	9301359	A1	21-01-1993