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(54) METHOD AND SYSTEM FOR MANUFACTURING CONCRETE REVETMENT ELEMENTS

(57) The invention relates to a method for manufacturing concrete revetment part-elements, the method comprising of:
- placing a concrete arranging unit above a mould resting on a flat support element and provided with one or more continuous openings;
- arranging concrete material in the one or more continuous openings;
- placing at least one press on the concrete material in the at least one continuous opening, wherein the press comprises at least a relatively shallow portion and at least a relatively deep portion;
- pressing the press into the opening for the purpose of causing lateral displacement of concrete material from positions under the shallow portion to positions under the deep portion;
- removing the thus resulting revetment part-element from the mould.

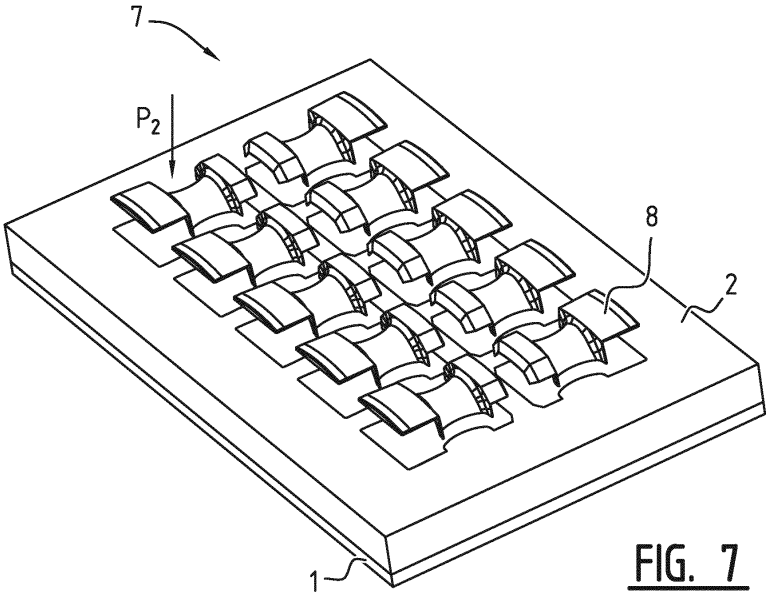

FIG. 7

EP 3 354 432 A1

Description

[0001] The invention relates to a method and a system for manufacturing concrete revetment part-elements, and to a thus manufactured revetment element.

[0002] For the purpose of revetting slopes of embankments, such as dikes, seawalls and the like, use can be made of concrete paving stones, also referred to as concrete revetment elements. These revetment elements are placed on the surface (for instance directly on the slope or on a separate substrate) in a determined relation and protect the slopes against external influences, for instance against the action of water (for instance under the influence of the wave action) of a water mass (sea, lake, waterway) present adjacently of the embankment or excavation.

[0003] Different types of paving stone are applied in practice, such as block-like paving stones and column-like paving stones. The different types of paving stone are used to realize different types of revetment, more particularly a closed revetment (also referred to as closed slope) and an open revetment (also referred to as an open slope).

[0004] It is known to make use of a large number of concrete paving stones, which are placed in a relation of rows such that the sloping side of the embankment or excavation is revetted over at least a part of its surface. The relation in which the paving stones are placed in combination with the type of paving stone can result in the above stated different types of revetment. The above stated block-like paving stones are used for the purpose of realizing a closed slope, i.e. an inclining surface where the water flows substantially only against the upper side (i.e. side directed toward the water). These paving stones have a cross-section such that they can be placed against each other substantially without intermediate space. In the case that a water defence is revetted this means that the water tends not to flow along the sides of the block-like paving stones, or does so only to a very small extent.

[0005] Use can be made of above stated column-like paving stones or column-like revetment elements for the purpose of providing an open slope. These column-like revetment elements are formed such that an intermediate space forms between the revetment elements placed adjacently of each other. Water can flow via this intermediate space, which can result in lower overpressure under the revetment elements as a result of water movements. For the purpose of realizing an open slope use can also be made of a type of revetment element formed with a relatively wide head part, a relatively narrow neck part and then again a relatively wide foot part. When the revetment elements are placed adjacently of each other the neck parts form an intermediate space which forms as it were a laterally extending channel along which water can flow. The head parts have here a cross-sectional surface area such that openings are present between the revetment elements. These openings form a connection to the above stated channel so that water can flow from the water mass, via the openings and into the channel (or the channels), and this water can conversely also flow out of the channel again. Water can further flow in between the foot parts.

[0006] The above stated flowing of water subdues the effects of the water on the revetment, which has a positive effect on the defensive capacities of the revetment. An example of such revetment elements is described in the Netherlands patent NL 2004345, the content of which should be deemed incorporated herein. These known revetment elements can be embodied as two half part-elements which are placed with their flat sides against each other during use so as to form an assembled revetment element together. Such concrete revetment elements however have the drawback that they are difficult to produce due to their specific form and dimensions. In practice this means that the production costs of the revetment elements are high.

[0007] Known from US 2011/0155308 A1 is a machine for forming a concrete block, wherein a quantity of flexible (compressible) material is added to the concrete material. The presence of the flexible material requires a special forming technique. Use is made of a mould on which a press can be placed. The press is however wider here than the opening in the mould so that the press rests only on top of the poured concrete and the edges of the mould, without any significant compressive force being exerted on the concrete. This method is however not suitable for forming a concrete block of the usual concrete material (without addition of flexible material), wherein the concrete material has to be compressed with great compressive force at a determined moment.

[0008] US 5 139 721 A1 describes another machine for producing concrete blocks. This machine is not suitable for producing specifically formed revetment elements, for instance elements with a relatively narrow neck part and relatively wide foot and head parts. US 6 425 751 B1 also describes a machine which is not suitable, or less so, for revetment elements of such specific form.

[0009] It is an object of the invention to provide an improved method for manufacturing concrete revetment part-elements, whereby high-quality revetment elements can be realized at relatively low manufacturing cost.

[0010] According to a first aspect of the invention, this object is achieved with a method for manufacturing concrete revetment part-elements, the method comprising of:

- placing a concrete arranging unit above a mould resting on a flat support element and provided with one or more continuous openings;
- arranging concrete material in the one or more continuous openings;
- placing at least one press on the concrete material in the at least one continuous opening, wherein the press comprises at least a first press part for forming a relatively deep portion and at least a second press

part for forming a relatively shallow portion of the part-element;

- pressing the press into the opening for the purpose of causing lateral displacement of concrete material from positions under the at least one second press part to positions under the at least one first press part;
- removing the thus resulting revetment part-element from the mould, wherein a continuous opening defines a form with an upper mould part and a lower mould part, wherein pressing of the press into the continuous opening comprises of pressing the press through the upper mould part until the lower edge of the press has reached the lower mould part, and wherein a press has a substantially hollow form, such that when the lower edge has reached the lower mould part the depth at the position of a shallow portion is more than 30%, more than 50% or even more than 60% smaller than the depth at the position of a deep portion.

[0011] In determined embodiments, in which the mould is formed for the purpose of providing a continuous opening which defines a form with an upper mould part with a cross-section constant in downward direction and a lower mould part with a cross-section increasing (i.e. becoming greater) in downward direction, pressing of the press into the opening comprises of pressing the press through the upper mould part until the lower edge of the press has reached (the upper side of) the lower mould part.

[0012] When carrying the press along the upper mould part a great pressing or compressive force is exerted on the concrete material. This pressing or compressive force is sufficiently great (and significant) for the press to realize the desired specific final form of the revetment element in one downward movement. This enables a quick and efficient manufacture of the revetment elements.

[0013] Because it has been found possible during pressing down of the press to displace the concrete material to sufficient extent from the one position (for instance under the press part forming a relatively shallow cavity) to the other (for instance under the press parts forming relatively deep cavities), the concrete material can be distributed so well that the complex form of this revetment element, with a relatively wide foot and head and a relatively narrow neck, can also be realized. This enables a rapid series production of a large number of revetment elements at low cost. This displacement of the concrete material is also possible in embodiments in which the concrete material to be arranged in the openings is relatively dry, preferably earth-moist. In determined embodiments it is even possible to displace the concrete material over a distance of at least 20%, at least 30% or even at least 40% of the length of the opening (corresponding to the height of the revetment element to be formed).

[0014] The concrete material can be arranged in the continuous opening as single layer, although in other embodiments two or more layers of concrete material are arranged in the openings, for instance a base layer of a first composition and a cover layer of a second, differing composition. The two layers can consist of concrete mixtures of different composition. In other embodiments other material can also be applied in addition to the concrete material.

[0015] In the described method the revetment part-element remains lying on the flat support plate. This means that each revetment part-element has a flat underside with which the part-element can be combined into a single revetment element in simple manner, i.e. by means of placing two part-elements with their flat sides against each other.

[0016] In embodiments of the invention the continuous opening defines a form with an upper mould part and a lower mould part. These mould parts can have the same form and dimensions, but in determined embodiments the lower mould part takes an at least locally wider form than the upper mould part. Pressing of the press into the opening can then be performed by means of pressing the press through only the upper mould part until the lower edge of the press has reached the lower mould part. The form of a first part of the revetment part-element is determined by the form of the press and the form of a second part of the revetment part-element is determined by the form of the lower mould part. In other words, the upper part of the revetment part-element acquires the form of the inner side of the press, the lower part of the revetment part-element acquires the form of the inner side of the lower mould part and of the flat support element. A relatively complex form, particularly a form with one or more very wide parts and one or more very narrow parts, can unexpectedly still be realized in this way with this relatively simple manufacturing technique.

[0017] The upper mould part can particularly have a cross-section constant in downward direction, and the lower mould part has a cross-section increasing in downward direction. In determined embodiments part of the curvature of the revetment element can thus be realized by the curved inner surface of the press, while the remaining part of the curvature of the revetment element is realized by the curved inner surface of the mould.

[0018] In determined embodiments the curvature of the press at the position of the lower edge is essentially equal to the curvature of the wall of the opening at the position of the transition between the upper and lower mould part in order to form a good transition in the formed product.

[0019] In embodiments of the invention the flat support element is held stationary during pressing of the press along the upper mould part, while the mould itself is displaced upward while the revetment part-element is removed from the mould. In this way the raw castings, i.e. the formed part-elements, remain stationary on the plate during forming and releasing, and the risk of imperfections in the raw casting is small.

[0020] During the upward displacement of the mould

the flat support element preferably remains stationary. The press preferably also remains stationary so that, if the revetment part-element tends to "stick" to the wall of the opening, the stationary press prevents the revetment part-element being carried along by the mould during the upward displacement of the mould. Other embodiments are however also possible, for instance embodiments wherein the flat support element with the part-elements placed thereon are displaced downward in order to remove the part-elements from the mould.

[0021] The press has a substantially hollow form. In order to obtain the desired form and dimensions of the revetment element with the relatively wide head and foot part relative to the narrow neck part, the depth (d_2) at the position of a shallow portion (cavity) (29) can be more than 30%, more than 50% or even more than 60% smaller than the depth (d_1, d_3) at the position of a deep portion (30, 31). With these differences in depth it is also possible to allow a sufficient quantity of concrete material to run to the correct cavities in order to distribute the concrete material substantially uniformly over the content of the press.

[0022] As already indicated above, the revetment element has a foot part and a head part with a surface area in cross-section which is much greater (for instance more than 20%) than the cross-section of the neck part (more particularly the minimum value of the cross-section, usually midway between the head and foot part). When the revetment elements are further placed in their relation (rows and columns) each head part has one or more connecting openings between the upper side of the head part and the neck part. The overall surface area of the connecting openings is preferably at least 5% of the cross-section of the head part (and preferably a maximum of 20%), more preferably more than 10% of the cross-section of the head part, in order to ensure a correct degree of throughflow of water to and from the channel formed by the neck parts.

[0023] During arranging of concrete material in the one or more continuous openings the mould is and/or the presses are preferably set into vibration for a short time, preferably for a period of less than 0.5 seconds. This ensures that the quantity of concrete material to be arranged in the openings is greater than when no vibration takes place, without the concrete material compacting too much here, which could have the result that the concrete material can no longer be sufficiently displaced in the opening in the subsequent processing stage in which the press is pressed into the openings. During this subsequent processing stage the concrete material can also be set into vibration once again (main vibration), for instance by means of having the mould and/or the press vibrate. This main vibration (with a predetermined frequency and duration) ensures that the concrete material is sufficiently compacted to remove the revetment part-element from the mould relatively quickly, preferably within a period of time of several seconds, for instance within 10 seconds, more preferably within 5 seconds and still more preferably within 2 seconds, wherein the part-element can rest directly on the surface, for instance the flat support element, in self-supporting manner.

[0024] In determined embodiments the mould is provided with at least a first pair of (two) rows of continuous openings. In such embodiments the method can comprise of:

- simultaneously manufacturing at least one pair of rows of revetment part-elements;
- tilting the revetment part-elements of the first row and of the second row of the pair of rows of revetment part-elements;
- placing tilted revetment part-elements from the first row and from the second row with their flat sides against each other.

[0025] The two part-elements placed against each other form a single revetment element. The method makes it possible to deliver the final product (i.e. the revetment element) immediately after manufacture of the part-elements, for instance when the part-elements are still on the flat support element. The revetment element can be transported and placed at the intended position immediately.

[0026] In a further embodiment at least an adhesive layer is applied between the flat sides of revetment part-elements, and the part-elements are fixed with the adhesive layer to each other for the purpose of forming an adhered, for instance a glued, revetment element. Such a revetment element can be transported in simple manner, and the chance of displacement of the part-elements relative to each other, for instance under the influence of the wave action, is reduced in operative state.

[0027] According to a second aspect of the invention a system for manufacturing concrete revetment part-elements is provided, the system comprising:

- a number of flat support elements;
- a conveyor for transporting the flat support elements;
- a mould provided with one or more continuous openings, wherein a continuous opening defines a form with an upper mould part and a lower mould part;
- a concrete arranging unit to be arranged above the mould resting on a flat support element and configured to arrange concrete material in the one or more continuous openings;
- one or more presses, wherein each of the presses has at least a first press part for a relatively deep portion and a second press part for a relatively shallow portion;
- displacing means for displacing the presses and/or the mould, wherein the displacing means are configured to place at least one press on the concrete material in the at least one continuous opening, to press the press into the opening through the upper mould part and to thereby cause lateral displacement of concrete material from positions under the at least

one second press part to positions under the at least one first press part until the lower edge of the press has reached the lower mould part, and to remove the thus resulting revetment part-element from the mould, wherein the press has a substantially hollow form, wherein the depth at the position of a shallow portion is more than 30%, more than 50% or even more than 60% smaller than the depth at the position of a deep portion.

[0028] In an embodiment of the invention a continuous opening in the mould defines a form comprising an upper mould part and a lower mould part. The displacing means can be configured here to displace the press and/or the mould so that the lower edge of the press is moved along the upper mould part until the lower mould part is reached. When the lower mould part is reached, the part-element has acquired its desired final form and is ready for further processing.

[0029] In determined embodiments an upper mould part is formed which has a cross-section constant in downward direction. A lower mould part can further be formed which has a cross-section increasing in downward direction. The press preferably connects to the wall of the upper mould part with the smallest possible gap so that the quantity of concrete material which can be pressed upward through the gap is small and only a limited concrete edge is thus visible at the position of the joint on the resulting concrete surface.

[0030] Provided in determined embodiments are an upper mould part with substantially straight walls and a lower mould part with hollow walls over at least a part of the surface. The rounding (curvature) of the hollow walls preferably connects to a corresponding rounding of the press itself. In determined embodiments the curvature of the press at the position of the lower edge is more particularly essentially equal to the curvature of the wall of the opening at the position of the transition between the upper and lower mould part.

[0031] The part-element can be removed from the mould in different ways. In a determined embodiment of the invention the displacing means are configured to realize this by means of displacing the mould itself upward. The flat support element, and preferably also the press, remain stationary during the upward displacement of the mould.

[0032] In embodiments of the invention a press has a substantially hollow form, wherein the depth at the position of a shallow portion is more than 30%, more than 50% or even more than 60% smaller than the depth at the position of a deep portion. These differences in depth in combination with the form of (the lower mould part) of the continuous opening enable manufacture of a revetment part-element with the desired form.

[0033] In a determined embodiment the system comprises a vibration mechanism for setting the one or more guides and/or the mould into vibration so that the concrete material in the mould is compacted until it has reached the desired quality.

[0034] In further embodiments the concrete material comprises earth-moist and/or self-compacting concrete (SCC) so that the concrete material arranged in the mould requires a very short or even essentially no drying time in order to provide a revetment element which can be further processed immediately.

[0035] Further advantages, features and details of the present invention will be elucidated on the basis of the following description thereof. Reference is made in the description to the accompanying figures, in which:

Figure 1 shows a schematic perspective view of an embodiment of a manufacturing system according to the invention in a first manufacturing stage;
Figures 2-5, 7-9 show the respective views of the embodiment of figure 1 in subsequent stages of the manufacture;
Figure 6A is a perspective view of a press according to an embodiment of the invention;
Figure 6B is a cross-section through the press of figure 6A;
Figure 10 shows a perspective view in a further stage of manufacture;
Figures 11 and 12 show schematic cross-sections through the mould and a press, respectively before the press has been pushed into the upper mould part and after the press has been pushed along the upper mould part.

[0036] The system according to embodiments of the invention is intended for the manufacture of a revetment element 20 (figure 10) constructed from two revetment part-elements 21 and 22 placed against each other. A revetment element 20 comprises a head part 25, a neck part 26 and a foot part 27. The foot part and a head part have a surface area in cross-section which is more than 20% greater than the cross-section of the neck part, so that the neck parts of adjoining elements can realize a water outlet channel of sufficient capacity. When there is moreover sufficient throughflow area between the water mass and the water outlet channel via the head parts, for instance a throughflow area of at least 5% of the cross-section of the head part (and preferably a maximum of 20%), a correct degree of throughflow of water to and from the channel formed by the neck parts can be ensured.

[0037] In a first stage of the manufacturing process a row of flat support elements 1 is supplied on a feed conveyor (not shown). These flat support elements can preferably consist of a flat wooden board, although other types of material are of course also possible. A steel mould 2 is placed on top of the flat support element 1, as shown in figure 2. Steel mould 2 comprises a number of continuous openings 3. Two rows, each of five continuous openings, are provided in the shown embodiment. It will be apparent that the number of rows and the number of openings per row can vary in other embodiments.

[0038] Once mould 2 has been placed on flat support element 1 a quantity of concrete 6 can be arranged from above (P_1) in each of the continuous openings 3 from the upper side using a concrete arranging unit 4 (shown schematically in figure 3), more specifically via a number of nozzles 5 thereof. Because mould 2 is arranged on the flat support element 1, concrete 6 will press partially on the upper side of the flat support element 1 and partially against the side walls of continuous openings 3 in mould 2. The filling of continuous openings 3 is continued until sufficient concrete has been arranged in the continuous openings. Figure 4 for instance shows that a quantity of concrete is arranged in the continuous opening which is such that the upper side of concrete 6 lies substantially flush with the upper side of mould 2.

[0039] The concrete arranged in the mould is preferably earth-moist concrete. Earth-moist can for instance be referred to when the concrete is in a relatively dry consistency class C1. The consistency of 'earth-moist' concrete can be expressed in the 'degree of compactability' and falls within consistency class C1 (in determined embodiments the degree of compactability is greater than 1.45 and smaller than 1.26). The consistency can be determined in accordance with the standard NEN-EN 12350-4 "Testing fresh concrete - Part 4: Degree of compactability".

[0040] The advantage of applying this relatively dry concrete is that the product can be removed from the mould immediately or very quickly (i.e. within several seconds) and can be further processed in lying position. Further processing can mean displacing the product to a drying space where the product can undergo a first drying. After having hardened sufficiently, the products can be grasped and tilted, for instance from the lying to the upright position.

[0041] In respect of the application of earth-moist concrete material, the skilled person will know that this earth-moist concrete generally cannot be used for manufacturing products with complex forms in a mould with press. The problem may occur that the mould is not filled properly and/or that the concrete in the mould has hardened such that giving it a complex form, for instance a form with a relatively narrow neck part and a relatively wide head and/or foot part, is no longer readily possible.

[0042] A pretreatment therefore takes place in a preferred embodiment by means of pre-vibrating the concrete in the mould. This pre-vibration preferably takes place at a relatively low frequency (characteristically about 50 Hz) and for a short period of time (pretreatment time characteristically shorter than 1 second, or less than 0.5 seconds or even several tens of ms). One of the reasons for pre-vibrating the concrete is to ensure that a sufficient quantity of concrete is arranged in the mould. The pretreatment may however not last too long so as to prevent the concrete becoming too hard. The pretreatment time is therefore relatively short.

[0043] In a subsequent stage, as shown in figure 5, a number of presses 8, 8' is displaced downward from above (direction P_2). The number of presses 8 corresponds to the number of continuous openings 3 in mould 2. A more detailed view of such a press is shown in figure 6.

[0044] In embodiments of the invention use is made of self-compacting concrete material. Self-compacting concrete is a type of concrete with a high fluidity, which in principle need not be further compacted after pouring. When applying such a type of concrete, compaction of the concrete, such as by means of vibrating it, is not necessary, or at least to lesser extent.

[0045] Figure 6A shows a press 8, for instance consisting of a metal or similar material, which forms a cavity in which concrete can be received. Figure 6B shows the same press 8 in cross-section, as well as the upper side of support element 1. The press comprises a first press part 12 for forming a cavity 30 for the head part, a second press part 10 for forming a cavity 29 for the neck part and a press part 11 for forming a cavity 31 for the foot part. Figure 6B shows that the maximum depth d_1 at the position of cavity 30 of the head part and the maximum depth d_3 at the position of cavity 31 for the foot part is greater than the depth d_2 at the position of the neck part. This is of course necessary in order to form the neck part of the revetment element, since this neck part has a much smaller cross-section than the head part or the foot part.

[0046] As shown in figure 5, presses 8 and presses 8' are placed with their press parts 29, intended for the respective head parts, toward each other. The reason for this is that revetment part-elements, once manufactured, are hereby easier to assemble, as will be explained below. Figure 5 shows that the rows of presses 8, 8' are embodied such that a single press 8, 8' is associated with each continuous opening 3 in mould 2. The displacing means whereby the presses can be displaced downward (direction P_2) are not shown for the sake of simplicity of the drawing in figure 5. Such constructions for displacing a number of presses downward and upward and further description thereof can be dispensed with.

[0047] Figure 7 shows the stage in which each of the presses 8 has come to lie with its respective lower edge 12, more particularly the lower edge at the position of the central cavity, at the height of the upper surface of mould 2. The presses are then pressed further (direction P_2) so that lower edge 12 of each of the presses 8 shifts along side walls 13 of each of the continuous openings 3 until the position shown in figure 8 is reached.

[0048] The form and dimensions of each of the presses 8 are adjusted to that of the continuous opening 3. It is hereby possible for lower edge 12 of a press to shift closely along wall 13 of continuous opening 3 and it is prevented or at least counteracted that concrete seeps along an intermediate space or gap between the press and wall 13 of continuous opening 1. Finally, mould 2 and presses 8, 8' are displaced upward and the formed part-elements 21, 22 remain resting on support element 1 until the stage shown in figure 9 is reached.

[0049] Pressing of a press through opening 3 is further

shown in figures 11 and 12. Figure 11 is similar to figure 7, in which the press, at least the lower edge thereof, lies at the height of the upper surface of the mould. When the press is pressed further downward concrete will be received in the cavities of the press. As shown in figure 11, this means that when the second press part 10 touches the upper side of concrete 6, this portion of the press will push away part of that concrete in lateral directions (P_3, P_4) in the direction of cavity 30 for the head part and/or cavity 31 for the foot part. In other words, the pressure of the central part (i.e. the second press part 10) of the press at the position of cavity 29 will cause concrete to be displaced and to come to lie in cavities 30, 31 for the purpose of forming respectively the head and foot part of the part-element.

[0050] Figure 11 shows that continuous opening 3 in mould 2 forms a first mould part 15 and a second mould part 16. In the first mould part 15 the form and dimensions of continuous opening 3 correspond substantially to those of the press so that the press slides closely along side wall 13 of continuous opening 3. At the position of the second, lower mould part 16 lying under the first mould part 15 a recess 17 is arranged at one or more locations in wall 13. This recess 17 generally has a curved form. The form is preferably adjusted to that of press 8. This can for instance mean that the form of the second mould part connects in continuous manner (i.e. essentially in non-stepped manner) to the form of the press. In a further preferred embodiment the forms of the press and the second mould part are adjusted to each other such that the resulting revetment element has no or substantially no ridge at the position of the connection of the press to the mould part. The curvature of a part of a foot or head part which is formed in the second mould part can for instance connect directly to the curvature of the part of the foot or head part formed by the press. In the embodiment shown in figure 11 the opening close to edge part 18 of press 8 is roughly equal to that of the first mould part 15. When lower edge 12 of the press has now reached the transition between the first and second mould parts 15, 16 the displacement of press 8 stops. Together with the lower mould part 16 press 8 forms the contour of the revetment element to be manufactured, as shown in figure 12.

[0051] In an embodiment of the invention the concrete 6 in opening 3 is set into vibration during the downward displacement of press 8. In determined embodiments the (main) vibration has a higher frequency than the vibrations in the pretreatment. In a specific embodiment the main vibration has a frequency of about 60 Hz. The duration of the main vibration is moreover longer than that of the pre-vibration, characteristically several seconds. During vibration it is ensured that, despite the fact that the concrete is relatively dry, parts thereof are still displaced to other areas to a sufficient degree by the force of the press so that the space in the mould, under the press, can be filled well, also in the case of products with complex form. Compaction of the concrete further occurs during the vibration so that a product of sufficient cohesion is realized, can be removed from the mould without problem and can be arranged lying on a surface.

[0052] Setting into vibration can take place by means of having the press vibrate, having the mould vibrate or by having both the press and the mould vibrate. Once the stage shown in figure 12 has been reached and the concrete has hardened sufficiently, characteristically within several seconds, mould 2 and press 8 can be removed by means of displacing the two upward until the situation shown in figure 10 is achieved. A number of concrete revetment elements is now formed on the flat support element 1, this in two rows of mutually facing revetment elements. This arrangement makes it possible to grasp heads 25, 25' of part-elements 21, 22, lift them and place them against each other, so that the position shown in figure 10 is reached. In this position the revetment part-elements 21, 22 are combined into revetment elements 20 by means of placing them with their flat sides against each other. In this situation the revetment elements are ready for further transport, for instance in direction P_5 in the direction of a transport station.

[0053] The above stated taking up, tilting and placing against each other of the part-elements can be realized by means of a tilting mechanism (not shown in the figures). More particularly, the tilting mechanism can be configured to tilt the revetment part-elements of a first row and the revetment part-elements of a second row and to place tilted revetment part-elements from the first row and from the second row with their flat sides against each other for the purpose of forming respective revetment elements.

[0054] In a further embodiment the method comprises of placing a row of revetment elements (comprising revetment part-elements placed with the flat sides against each other) on a determined flat support element and then placing a second row of revetment elements on top of the first row of revetment elements. The first row of revetment elements can here for instance rest with the foot part on the surface, while the revetment elements of the second row conversely rest with their head parts on the head parts of the revetment elements of the first row. Other embodiments are of course also possible, for instance embodiments in which the foot parts of the revetment elements of the upper layer rest on the head parts of the revetment elements of the lower layer.

[0055] After being placed on the support surface and after hardening, the revetment elements of the first row are already so strong that revetment elements can be placed on top thereof. By increasing (for instance doubling) the capacity of the support surface the processing and/or transport costs can be further reduced.

[0056] The part-elements can be placed directly against each other. In other embodiments an adhesive applicator unit is provided for applying at least one adhesive layer consisting of adhesive (for instance glue) on the flat side of a revetment part-element. Adjoining part-elements can be glued together in this way. The adhesive

applicator unit is preferably integrated with the tilting mechanism so that the part-elements can be placed upright and can be glued together in one single treatment.

[0057] Although the connection of lower edge 12 of each of the presses 8 on wall 13 of continuous opening 3 is close-fitting, it is still possible for some concrete to be pressed upward between the edge and the wall. This manifests itself in a small upright edge 28 along the outer surface of each of the revetment elements. The edge is however so small that it cannot influence the waterside-protecting action of the elements.

[0058] In an embodiment of the invention press parts 10-12 of the press 8 are embodied such that the depth at the position of shallow portion 29 for forming the neck part of a revetment element is more than 30%, preferably more than 50% or sometimes even more than 60% smaller than the depth at the position of the two deep portions 30, 31. Owing to the described method of pressing the presses only partially into the mould, and the special forms of the press in combination with those of the continuous opening, it is surprisingly still possible to manufacture a good-quality concrete block despite these great differences in depth. The proposed method is quick and simple and enables production of large numbers of concrete blocks at relatively low cost.

[0059] The invention is not limited to the embodiments thereof described here. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Method for manufacturing concrete revetment part-elements (21, 22), , the method comprising of:

   - placing a concrete arranging unit (4) above a mould (2) resting on a flat support element (1) and provided with one or more continuous openings (3);
   - arranging concrete material (6) in the one or more continuous openings (3);
   - placing at least one press (8) on the concrete material in the at least one continuous opening (3), wherein the press comprises at least a first press part (11,12) for forming a relatively deep portion (30,31) and at least a second press part (10) for forming a relatively shallow portion (29) of the part-element (21,22);
   - pressing the press (8) into the opening for the purpose of causing lateral displacement (P_3,P_4) of concrete material from positions under the at least one second press part (10) to positions under the at least one first press part (11,12);
   - removing the thus resulting revetment part-element (21, 22) from the mould (2), wherein a continuous opening defines a form with an upper mould part (15) and a lower mould part (16), wherein pressing of the press (8) into the continuous opening (3) comprises of pressing the press through the upper mould part (15) until the lower edge (12) of the press has reached the lower mould part (16), and wherein a press has a substantially hollow form, such that when the lower edge (12) has reached the lower mould part (15) the depth at the position of a shallow portion (29) is more than 30%, more than 50% or even more than 60% smaller than the depth at the position of a deep portion (30, 31).

2. Method as claimed in claim 1, wherein during arranging of concrete material (6) in the one or more continuous openings (3) the mould is set into vibration, preferably for a period of less than 0.5 seconds.

3. Method as claimed in claim 1 or 2, comprising of causing vibration of the press and/or the mould while the press is being pressed through the opening, further preferably comprising of

   - causing vibration with a duration and frequency such that the revetment part-element (21, 22) can be removed from the mould within a period of time of several seconds; and
   - removing the revetment part-elements from the mould after said period of time by means of placing them from the mould onto the flat support surface.

4. Method as claimed in claims 2 and 3, wherein the frequency of vibrations while the press is being pressed through the opening, is higher than the frequency of vibrations during arranging of concrete material in the continuous opening and/or wherein the duration of vibrations while the press is being pressed through the opening, is longer than the duration of vibrations during arranging of concrete material in the continuous opening.

5. Method as claimed in any of the foregoing claims, wherein the mould is provided with at least a first pair of rows of continuous openings, the method comprising of:

   - simultaneously manufacturing at least one pair of rows of revetment part-elements;
   - tilting the revetment part-elements (21) of the first row and the revetment part-elements (22) of the second row;
   - placing tilted revetment part-elements from the first row and from the second row with their flat sides against each other for the purpose of forming respective revetment elements (20), preferably comprising of placing a row of revetment elements, comprising revetment part-elements placed with the flat sides against each other, on

a flat support element and then placing a second row of revetment elements on top of the first row of revetment elements.

6. Method as claimed in any of the preceding claims, comprising applying at least an adhesive layer between the flat sides of revetment part-elements and fixing the revetment element parts to each other with the adhesive layer for the purpose of forming a revetment element.

7. Method as claimed in any of the foregoing claims, comprising of displacing concrete material in lateral direction (P_3,P_4) over a distance of at least 20%, at least 30% or even at least 40% of the length of the opening (3) during displacing of the press (8) until the lower mould part (16) is reached.

8. Method as claimed in any of the preceding claims, wherein the concrete material is earth-moist concrete material and/or self-compacting concrete (SCC) material.

9. System for manufacturing concrete revetment part-elements (21,22), the system comprising of:

- a number of flat support elements (1);
- a conveyor for transporting the flat support elements (1);
- a mould (2) provided with one or more continuous openings (3), wherein a continuous opening defines a form with an upper mould part (15) and a lower mould part (16);
- a concrete arranging unit (4) to be arranged above the mould (2) resting on a flat support element (1) and configured to arrange concrete material (6) in the one or more continuous openings (3);
- one or more presses (8), wherein each of the presses has at least a first press part (11,12) for a relatively deep portion (30,31) and a second press part (10) for a relatively shallow portion (29);
- displacing means for displacing the presses (8) and/or the mould (2), wherein the displacing means are configured to place at least one press on the concrete material in the at least one continuous opening (3), to press the press (8) into the opening through the upper mould part (15) and to thereby cause lateral displacement (P_3,P_4) of concrete material from positions under the at least one second press part (10) to positions under the at least one first press part (11,12) until the lower edge of the press has reached the lower mould part (16), and to remove the thus resulting revetment part-element (21) from the mould (2), wherein the press (8) has a substantially hollow form, wherein the depth at the position of a shallow portion (29) is more than 30%, more than 50% or even more than 60% smaller than the depth at the position of a deep portion (30, 31).

10. System as claimed in claim 9, comprising a vibration mechanism for setting the one or more presses and/or the mould into vibration, wherein the vibration mechanism is preferably configured to vibrate the presses and/or mould with a frequency during pressing the press through the opening (3) that is higher than the frequency during arranging of concrete material in the continuous opening.

11. System as claimed in claim 10, wherein the vibration mechanism is configured to cause the presses and/or mould to vibrate longer during pressing the press through the opening than during arranging of concrete material in the continuous opening.

12. System as claimed in any of claims 19 or 10, wherein the concrete material is earth-moist concrete material and/or self-compacting concrete (SCC) material.

13. System as claimed in any of the claims 19-12, comprising a tilting mechanism configured to tilt the revetment part-elements (21) of a first row and the revetment part-elements (22) of the second row and to place tilted revetment part-elements from the first row and from the second row with their flat sides against each other for the purpose of forming respective revetment elements (20).

14. System as claimed in any of claims 9-13, comprising an adhesive applicator unit for applying at least one adhesive layer on the flat side of a revetment part-element (21,22).

15. System as claimed in any of the claims 9-14, which is configured to perform the method as claimed in any of the claims 1-8.

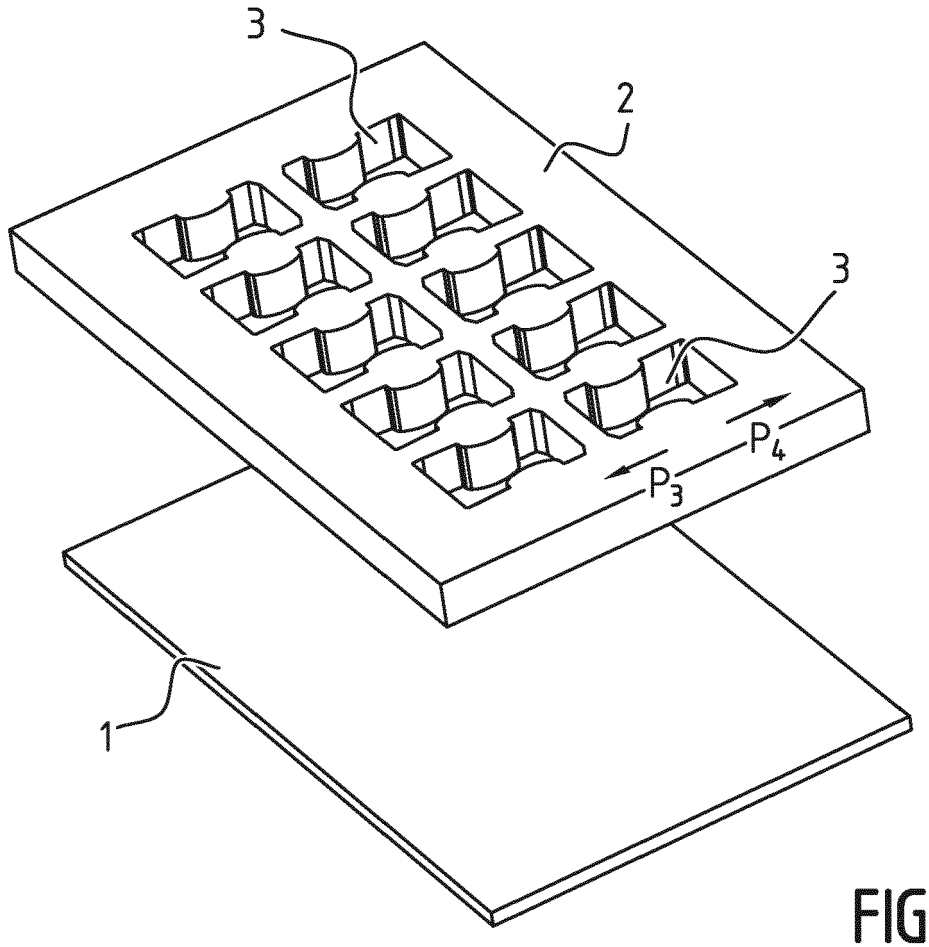

FIG. 1

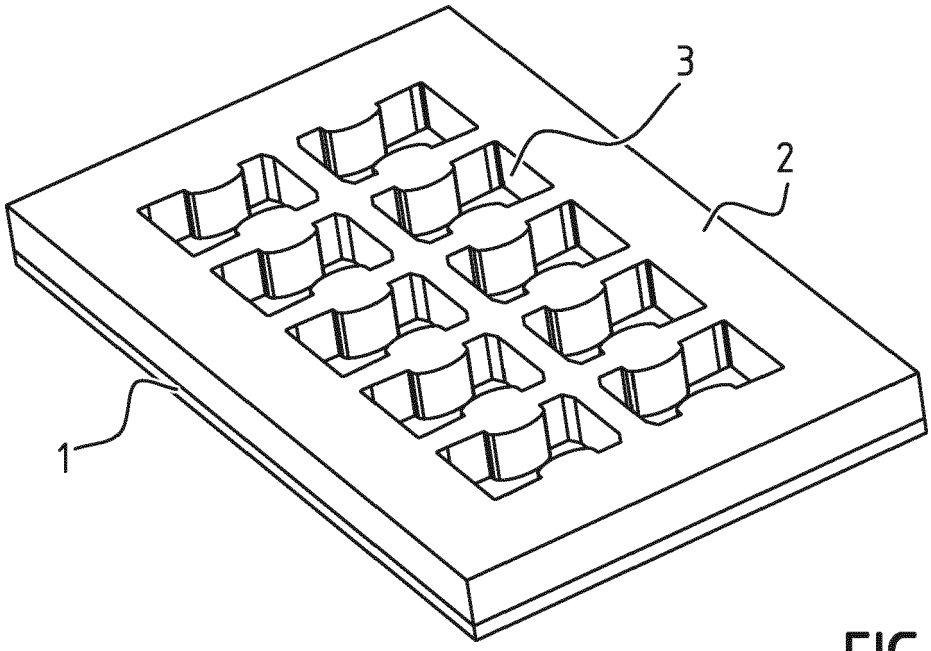

FIG. 2

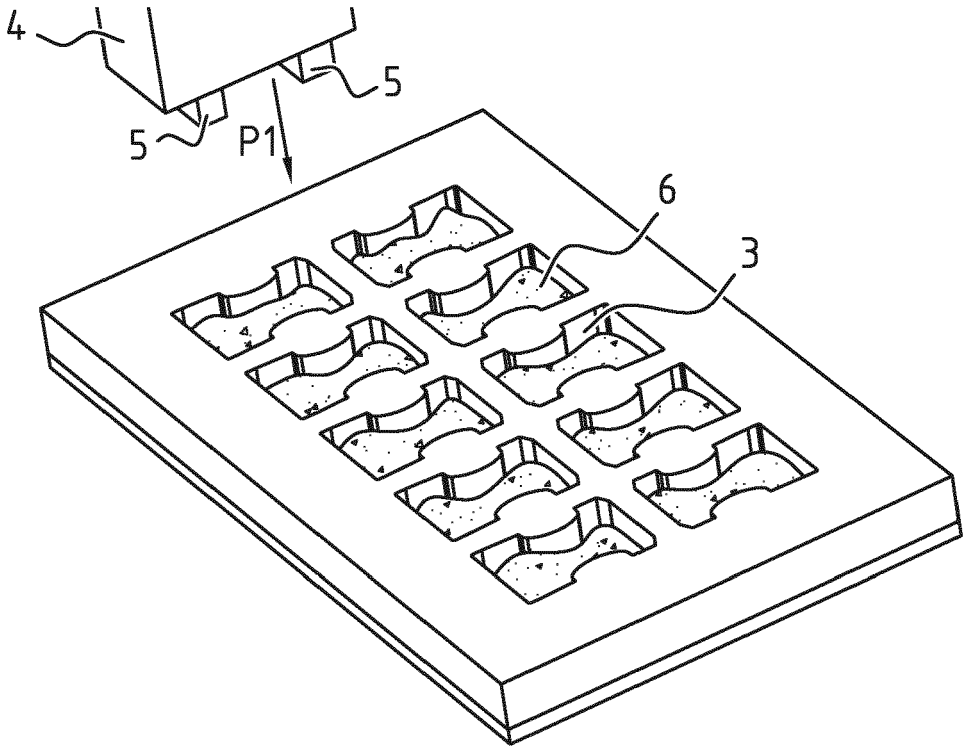

FIG. 3

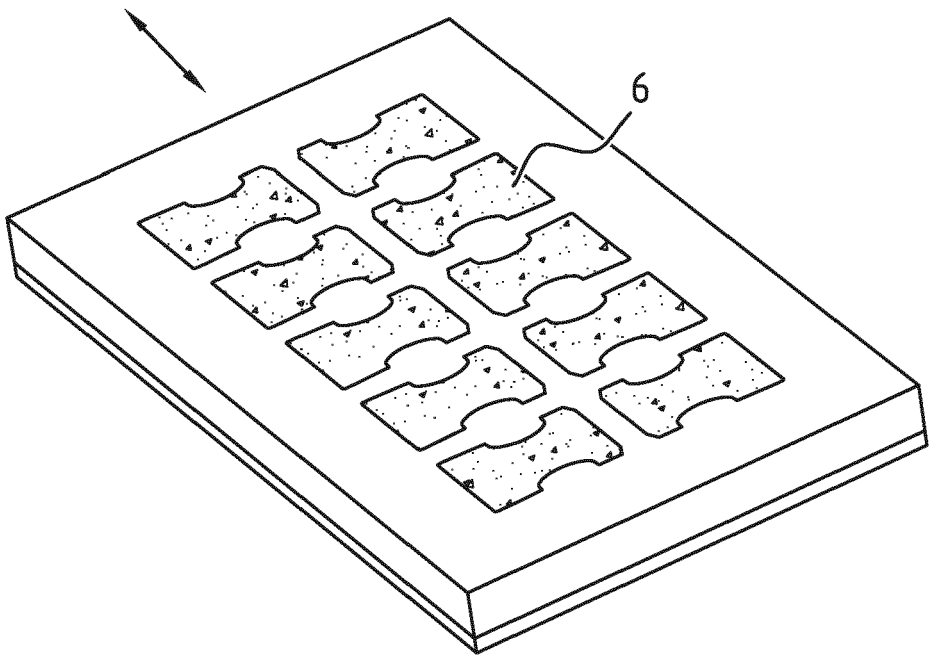

FIG. 4

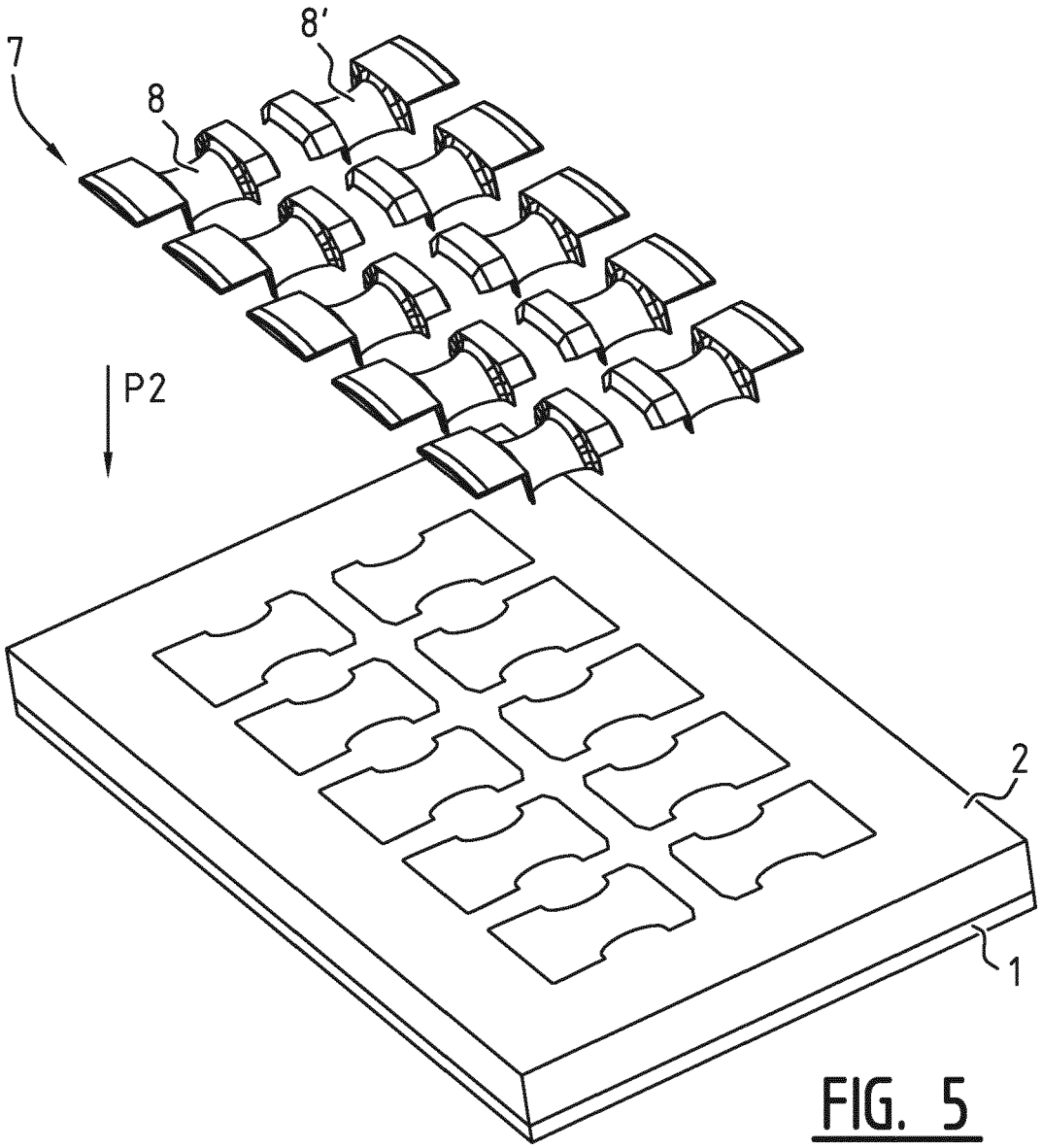

FIG. 5

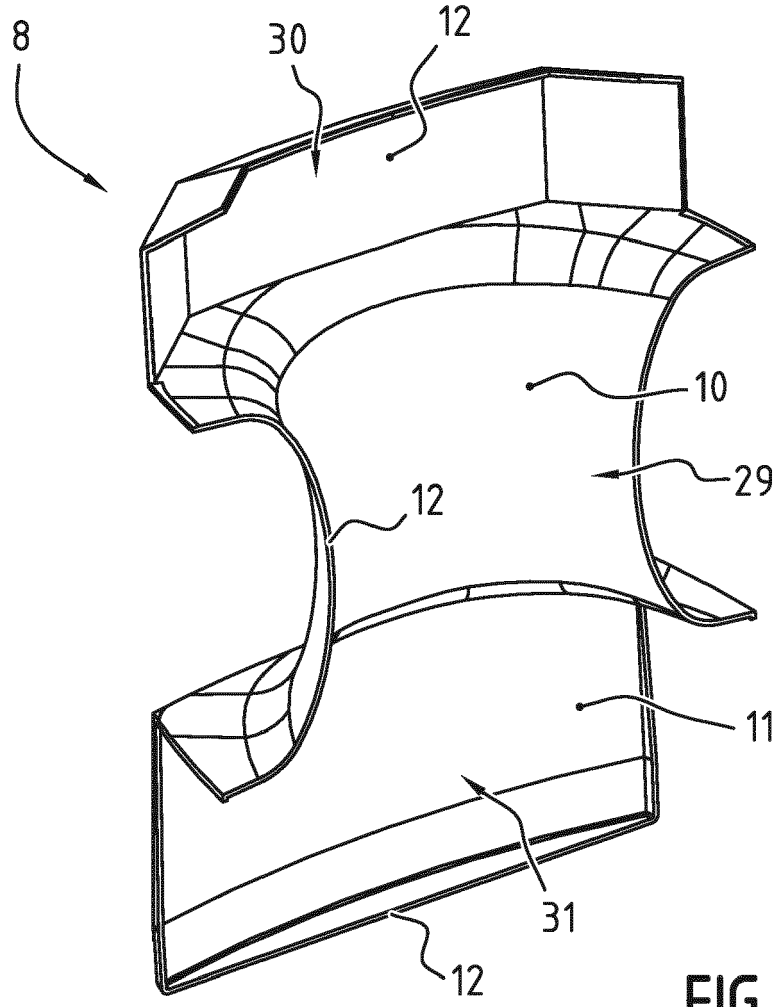

FIG. 6A

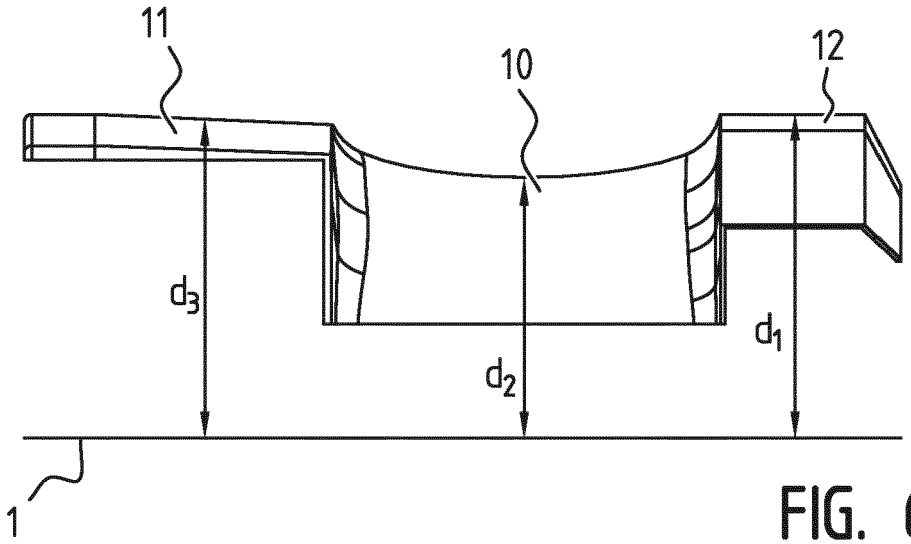

FIG. 6B

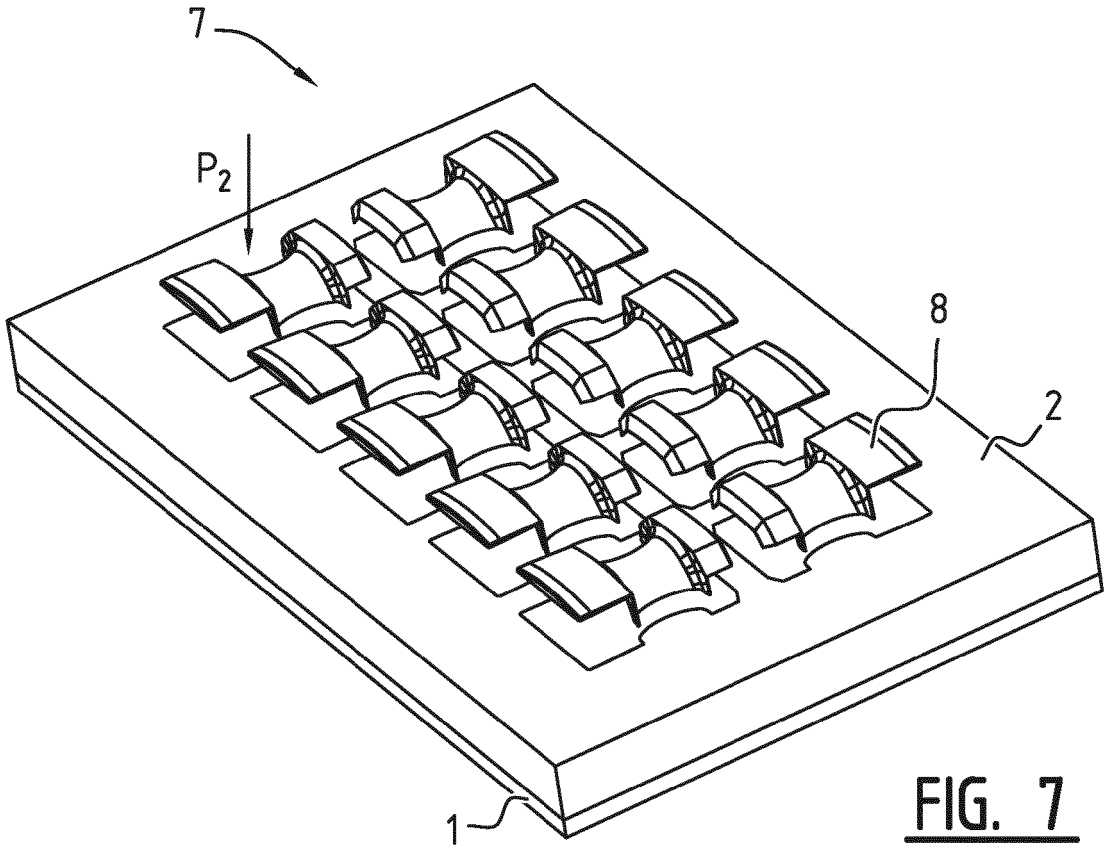

FIG. 7

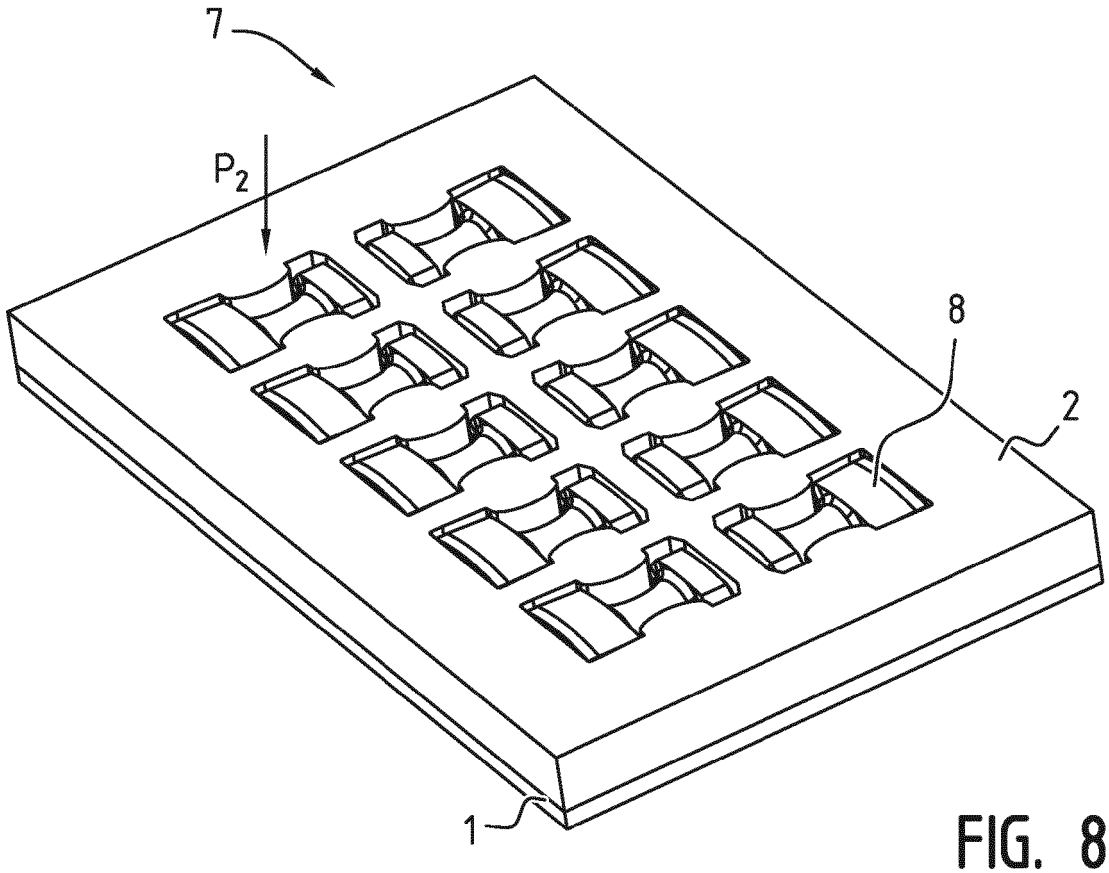

FIG. 8

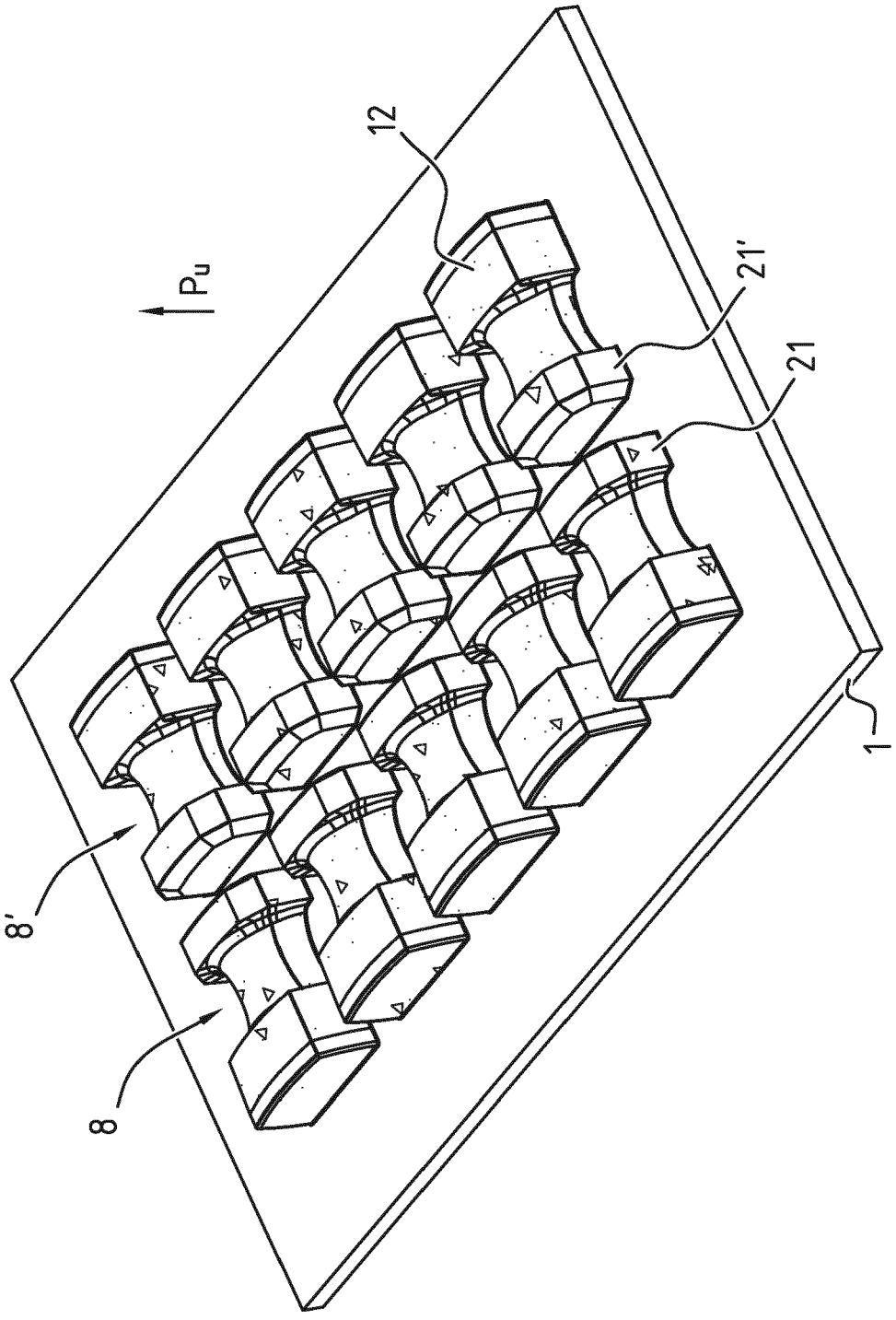

FIG. 9

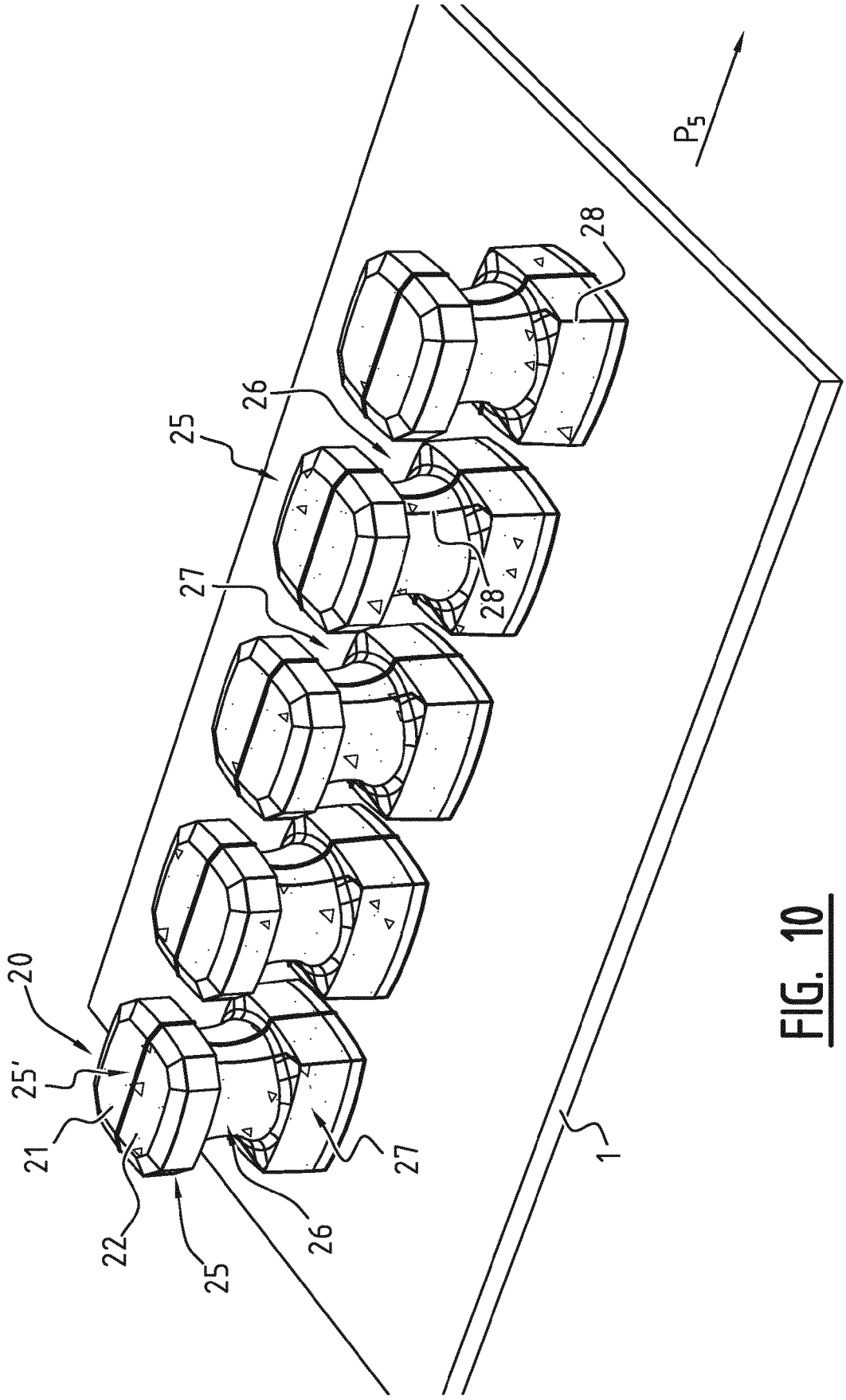

FIG. 10

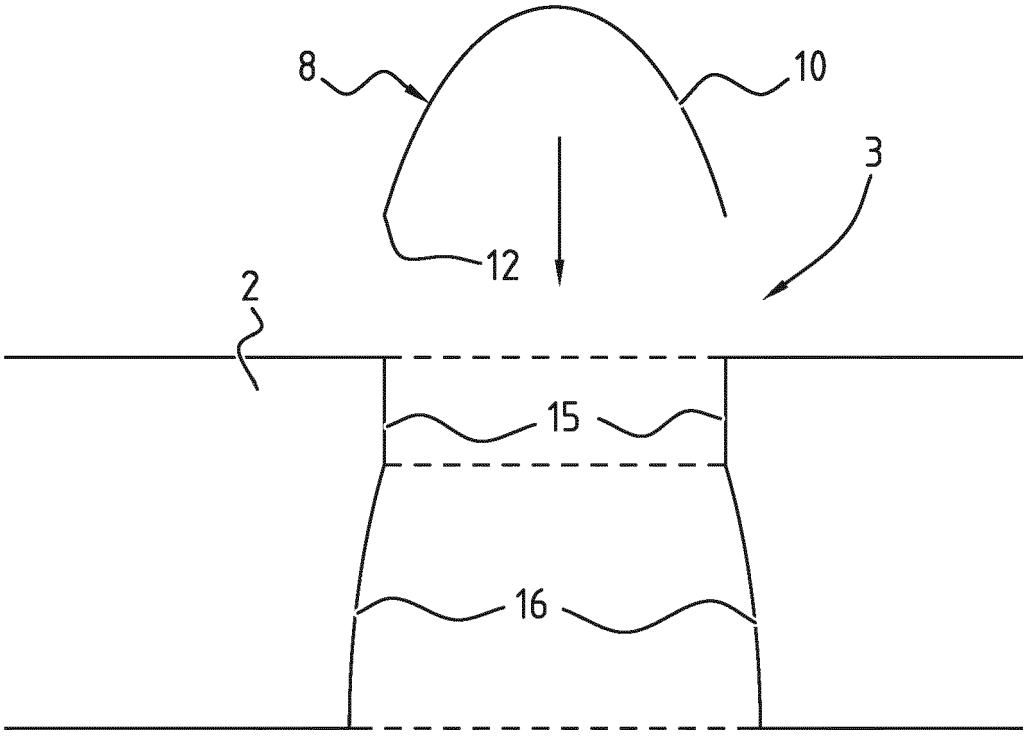

FIG. 11

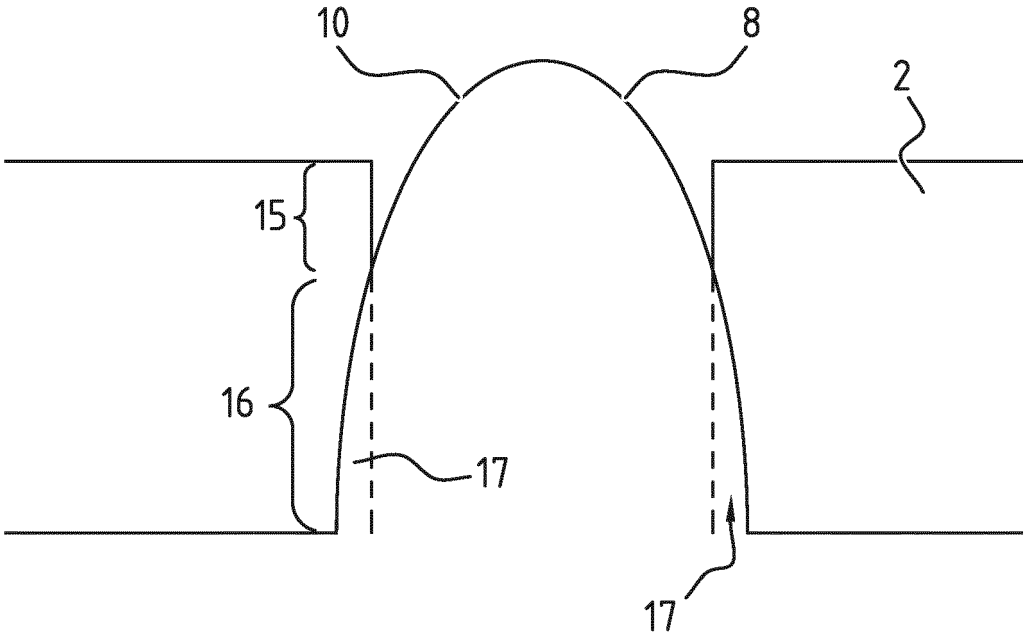

FIG. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 3953

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 6 425 751 B1 (BERGERON RENE [CA] ET AL) 30 July 2002 (2002-07-30) * column 3, line 40 - column 6, line 11; figures 1-6 * -----	1-4, 7-12,15 5,6,13, 14	INV. B28B3/02 B28B15/00 E02B3/14 E02B3/12
A	US 2011/155308 A1 (DARDANIS BRANDON J [US] ET AL) 30 June 2011 (2011-06-30) * paragraph [0052] - paragraph [0082]; figures * -----	1-15	
A	US 5 139 721 A (CASTONGUAY BERTIN [CA] ET AL) 18 August 1992 (1992-08-18) * column 3, line 65 - column 4, line 34; claim 1; figures 1,2,8,9 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B28B
E02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 May 2018	Orij, Jack

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

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30-05-2018

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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