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(71) Applicant: **Stora Enso Oyj**

**00101 Helsinki (FI)**

(72) Inventor: **Sjögren, Mikael**

**31452 Unnaryd (SE)**

(74) Representative: **Forsberg, Anna Karin**

**Stora Enso OYJ**

**Group Intellectual Property**

**Box 9090**

**65009 Karlstad (SE)**

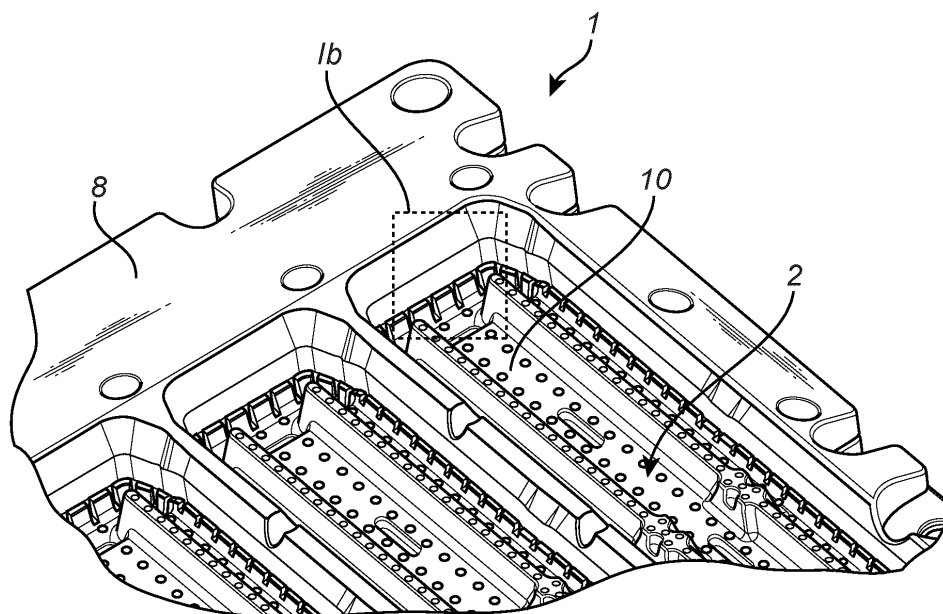
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(54) **A TOOL FOR WET MOLDING A FIBER-BASED PRODUCT**

(57) The present invention relates to a tool for use in a process of molding a product from a fibrous pulp slurry, said tool comprising:

-a mold body having a three-dimensional forming side comprising at least one bottom section, essentially vertical sidewalls surrounding said bottom section, and a flange extending horizontally from an upper portion of said sidewalls; said mold body comprising a plurality of suction channels evenly distributed across said forming

side and arranged to generate a suction at the surface of the forming side upon coupling the mold body to a vacuum suction source during use; wherein at least one of said suction channels comprises a slit opening located at the intersection between the essentially vertical sidewall and the horizontal flange, such that said slit opening is facing both said vertical sidewall and said horizontal flange. The present invention also relates to a method for producing a molded product.



**Fig. 1a**

## Description

### Technical field

[0001] The present invention relates to a tool and a method for molding a three-dimensional product from pulp slurry.

### Background

[0002] There is a growing interest for producing cellulose-based articles and products, e.g. containers, packaging applications, tableware, trays, technical products, electronic equipment and/or consumer goods. Several advantages are associated with the use of natural fibers for manufacturing packages. Being a renewable resource, natural fibers provide a sustainable alternative to other packaging materials such as aluminum and plastics, and furthermore natural fibers are both recyclable and biodegradable allowing for composting. Natural fibers include cellulose fibers of any natural origin, such as derived from wood pulp and/or plants.

[0003] One way of producing items from fibers is by molding pulp. For instance in wet forming, an aqueous pulp suspension is applied onto a forming tool/drying mold to form a fiber layer followed by compression-molding performed under elevated temperatures, resulting in a dried fiber product having a shape complementary to the shape of the forming mold. Typically, said molding tool is perforated or porous so that water and steam can be removed from the wet pulp during forming. During forming procedure, a quick and efficient removal of water is advantageous in order to achieve a competitive product in terms of e.g. price and energy consumption.

[0004] An example of a molding tool is seen in WO2009/105027A1, describing a device and method for compression molding a fiber tray of cellulose. Another porous drying mold is seen in WO2020/141208A1, wherein a pair of molds, one being porous, presses a layer of pulp to a three-dimensional product.

[0005] It is a known problem in the field of molding pulp that the porous tools become clogged upon use, i.e. that fibers unintentionally enters the vacuum-passages and prevents air from passing. Such clogging leads to the need for frequent and time-consuming cleaning. In case cleaning is neglected and the pores are plugged, the result is poor suction function and this leads to uneven and/or inferior fiber layer.

### Object of the invention

[0006] It is an object of the present invention to provide a molding tool, preferably a wet molding tool, which resolves or at least minimizes the above-mentioned problems, and enables increased productivity of qualitative fiber articles and reduces number of interruptions caused by clogged tooling equipment.

## Summary of the invention

[0007] The object of the invention is obtained by means of a tool according to the appended claims.

[0008] In accordance herewith, there is provided a tool for use in a process of molding a product from a fibrous pulp slurry, said tool comprising:

- a mold body arranged with a three-dimensional forming side, said forming side comprising at least one bottom section, essentially vertical sidewalls at least partially surrounding said bottom section, and a flange extending horizontally from an upper portion of said sidewalls, said mold body comprising a plurality of suction channels evenly distributed across said forming side and arranged to generate a suction at the surface of the forming side upon coupling the mold body to a vacuum suction source during use;

wherein at least one of said suction channels comprises a slit opening located at the intersection between the essentially vertical sidewall and the horizontal flange of said forming side, such that said slit opening comprises open portions both in said vertical sidewall and in said horizontal flange.

[0009] Thus, according to a preferred aspect of the invention, the slit opening is located at the edge which forms the intersection between said essentially vertical sidewall and said horizontal flange, and hereby the slit opening comprises portions facing both the vertical sidewall of the mold as well as the horizontal flange of the mold. Consequently, the suction flow generated through said slit opening, upon coupling the mold body to a vacuum suction source, will comprise both horizontal and vertical flow directions via said same, common suction opening.

[0010] As will also be better understood from further details later in this description, the at least one slit opening is formed as an elongated cutout, also describable as an elongated slot, at said circumferential edge of the mold. The resulting suction channel will allow for a continuous vacuum flow with no interruptions across said opening.

[0011] References herein to terms such as "vertical", "horizontal", etc. are made by way of example, and not by way of limitation, to establish a frame of reference. The term "horizontal" as used herein is defined as a plane parallel to a conventional plane, regardless of three-dimensional spatial orientation. The terms "vertical" refers to a direction in the frame of reference perpendicular to the horizontal, as just defined.

[0012] According to one aspect of the invention, the tool further comprises at least one water-permeable mesh arranged to complement the three-dimensional shape of said mold forming side, said mesh being arranged to retain pulp fibers. During production, the mesh is placed on top of the forming side of the mold whereupon the tool is immersed in an aqueous pulp slurry and

vacuum is generated through the suction channels resulting in that fibers are drawn onto the mesh forming a fiber layer, while water is removed via said suction channels of the mold.

**[0013]** The outline of the mold and, in particular, the slit opening located at the edge between the essentially vertical sidewall and the horizontal flange of said mold body, leads to several advantages associated with production of molded fiber articles when using said mold.

**[0014]** Thanks to the new slit openings, an improved suction flow with a more efficient vacuum distribution will be generated at the sidewall sections as well as at the edge section where said sidewalls meet the flange portion of the mold. The slit openings are arranged to guide the vacuum flow so that the flow field created in the vicinity of their respective orifices is void of stagnation points which would otherwise lead to thin and weak accumulation of fibers. The invention leads to an even and efficient vacuum suction force also at corners and edges of the three-dimensional forming side of the mold, resulting in an even fiber layer drawn from the slurry onto the mesh, across the entire surface.

**[0015]** Another advantage relates to the maintenance of the equipment. The slit openings have been proven to allow for quick and efficient cleaning of the mold in between use, meaning that clogged fibers that have unintentionally entered the suction channel of said slit can be washed away more easily compared to standard molds.

**[0016]** This adapted design contributes to a strong and efficient suction and therefore to quick and predictable formation of fiber layer in the final product.

**[0017]** According to another aspect of the invention, the mold body is made of cast metal, preferably aluminum. Preferably, the mold body is a solid metal body comprising a plurality of boreholes forming said suction channels. The boreholes extend through said solid metal body, leading from the forming side of the mold to the opposite back side thereof, allowing for the passage of vacuum from said forming side to said back side. The boreholes may be drilled boreholes, also sometimes referred to as drilled through holes.

**[0018]** According to another aspect of the invention, the mold body is manufactured by means of 3D printing.

**[0019]** According to another aspect of the invention, the tool further comprises a cover plate arranged to set the outer contour of the product to be formed.

**[0020]** The present invention also relates to a method for producing a molded product from fiber-containing pulp slurry comprising the steps of:

- providing a mold body having a three-dimensional forming side comprising at least one bottom section, essentially vertical sidewalls surrounding said bottom section and a flange extending horizontally from an upper portion of said sidewalls, said mold body comprising a plurality of suction channels evenly distributed across said forming side arranged to

deliver a suction to the surface of the forming side upon coupling the mold body to an activated vacuum suction source during use; wherein at least one of said suction channels is positioned so that its suction opening is located at the intersection between the essentially vertical sidewall and the horizontal flange of said mold body, such that said suction opening is facing both said vertical sidewall and said horizontal flange;

- positioning a water-permeable mesh arranged to retain pulp fibers and designed to complement the three-dimensional shape of said forming side, adjacent to said forming side;
- positioning a cover plate on said mold body such that the flange is at least partially covered, thereby exposing at least the bottom section and essentially vertical sidewalls;
- immersing at least the forming side into an aqueous fiber-containing pulp slurry;
- activating the vacuum suction source so to that a vacuum suction is generated at the forming side via said suction channels, leading to that pulp fibers are drawn onto said mesh forming a fiber layer with a shape complementary to the shape of the mesh;
- withdrawing the tool from said pulp slurry and drying said fiber layer to obtain a three-dimensional molded fiber product.

**[0021]** In summary, the tool described in the invention resists clogging, simplifies cleaning, and ensures an even fiber layer across the entire end product. This reduces waste by significantly lowering the number of discarded articles and enables the production of high-quality molded fiber articles.

**[0022]** Further features and advantages obtained thanks to the invention will be explained in the following.

**[0023]** The skilled person understands that many variations of the invention are conceivable without departing from the scope of the application.

#### **Brief description of the figures**

**[0024]** By way of non-limiting examples only, embodiments of aspects of the present disclosure will now be described with reference to the accompanying figures in which:

**Fig. 1a** shows in a schematic way a perspective view of a portion of a tool according to one example of the invention;

**Fig. 1b** is a detailed view according to 1b in Fig. 1a; and

**Figs. 2a-d** show cross sectional views of a slit opening according to one embodiment of the invention.

#### **Detailed description**

**[0025]** The arrangement and method according to the

invention will now be described with reference to the appended figures.

**[0026]** Fig. 1a shows in a schematic way a perspective view of a portion of a tool 1 according to the invention, and Fig. 1b represents a detailed view according to 1b in Fig. 1a. As seen herein, the tool 1 comprises a mold body 10 having a three-dimensional forming side 2. The forming side 2 comprises at least one bottom section 3, essentially vertical sidewalls 4 surrounding said bottom section, and a flange 5 extending horizontally from an upper portion of said sidewalls. The mold body 10 comprises a plurality of suction channels 6 evenly distributed across said forming side 2 and arranged to generate a suction at the surface of the forming side 2 upon coupling the mold body 10 to a vacuum suction source during use. The vacuum suction source is coupled to the back side of the mold body which is opposite to said forming side 2. The mold body 10 can be made of cast metal, such as cast aluminum, and the suction channels can be created by drilling boreholes through the solid mold body 10. The drilled boreholes thus extend from the forming side 2 to the opposite back side of the mold body 10. As seen better in the close-up of Fig. 1b, according to the invention, at least one 60 of said suction channels 6 has a slit opening 61 located at the intersection/edge 11 formed between the essentially vertical sidewall 4 and the horizontal flange 5 of said mold body 10. The slit opening 61 has an elongated cutout which opens towards both said vertical sidewall 4 and said horizontal flange 5. Thus, the at least one slit opening 61 has a multiple suction direction, meaning that when coupled with an activated vacuum source, the suction flow will follow a pattern along at least both vertical and horizontal directions into the same suction channel. This is also further explained in connection to Fig. 2d. In a preferred embodiment, the mold body comprises a plurality of channels 60 having slit openings 61 arranged along said edge 11 of the forming surface 2. Upon coupling the mold body 10 to an activated vacuum suction source, the suction flow generated through the slit opening/s 61 will be directed both vertically and horizontally via the same slit suction opening/s.

**[0027]** The tool 1 further comprises a cover plate 8, also referred to as forming plate or deckle plate. The cover plate 8 is removably attached to the mold body 10 so that the flange 5 of the forming side 2 is at least partially covered, thereby exposing the bottom section 3 and essentially vertical sidewalls 4 of the mold body 10, i.e. exposing the forming side 2 of the tool 1. Hereby, the cover plate 8 has the function of setting the outer contour of the product to be formed.

**[0028]** Figs. 2a-c are cross sectional views of a mold body 10 and a cover plate 8 showing the cross section of a suction channel 60 with a slit opening 61 according to the invention. The slit opening 61 opens toward the forming side 2 of the mold and is arranged at the intersection/edge 11 between the sidewall 4 and the flange 5. As seen e.g. in Fig. 2b, the slit opening 61 comprises an upper top part 62 and a lower base part 63. The width  $w$  of

the slit opening 61 (see Fig. 2c) is preferably between 2-4mm, preferably between 2-3mm. The slit opening 61 leads to a rear suction channel 64 in the form of a bore-hole which in its turn may be coupled to a vacuum source (not shown). The height  $h$  of the slit opening 61 is in the example of Figs. 2a-c essentially corresponding to the height  $H$  of the sidewall 4 of the forming side 2 of the mold body 10. According to a preferred embodiment of the invention, the height  $h$  of the slit opening equals at least 50% of the height  $H$  of the sidewall 4. The specific design of the suction channels 60 with slit openings 61 described herein will lead to efficient suction force at the sidewalls 4 of the forming surface 2 and thereby to formation of evenly distributed fiber layer at the sidewalls of the end product.

**[0029]** Fig. 2d is a schematic cross section, seen from a sideview, of a suction channel 60 with a slit opening 61 according to the present invention. As seen herein, the rear suction channel 64 connects the forming side 2 with the backside 12 of the mold via said slit opening 61. The backside 12 represents the vacuum side  $V$  of the tool 1. The slit opening inlet 61 is configured so that it allows for vacuum to pass without interruption along any direction within an angle segment  $a$  which is defined by the lower base part 63 and the vertical inner wall of the rear suction channel 64. This leads to generation of an efficient suction force at the sidewalls of the forming side 2 of the mold 10 and thereby to forming of evenly distributed fiber layer.

**[0030]** The method for producing a molded product from fiber-containing pulp slurry by means of a tool 1 according to the invention will now be described. A mold body 10 as described above, and as schematically illustrated in Figs. 1a-b, is provided. A water-permeable mesh (not shown) arranged to retain pulp fibers and designed to complement the three-dimensional shape of said forming side 2 is placed on top of said forming side 2. Next, a cover plate 8 is positioned on said mold body 10 and mesh such that the flange 5 is at least partially covered and said mesh is retained and locked in place by said cover 8. It is possible to use more than one mesh superimposed on top of the mold body 10. The tool 1 according to the invention has now been assembled. The tool 1 is then brought into an aqueous fiber-containing pulp slurry such that at least said mesh-covered forming side 2 is immersed. Activation of a vacuum suction source leads to that a vacuum suction is generated at the forming side 2 via said suction channels 6, 60, leading to that pulp fibers are drawn onto said mesh forming a fiber layer with a shape complementary to the shape of the mesh. Once a fiber layer with desired thickness has been accumulated, the tool 1 is withdrawn from said pulp slurry and the fiber layer is dried to obtain a three-dimensional molded fiber product.

**[0031]** The foregoing description of the preferred embodiments of the present invention is provided for illustrative and descriptive purposes. It is not intended to be exhaustive or to restrict the invention to the variants described. Many modifications and variations will ob-

viously be apparent to one skilled in the art. The embodiments have been chosen and described in order best to explain the principles of the invention and its practical applications and hence make it possible for specialists to understand the invention for various embodiments and with the various modifications appropriate to the intended use.

## Claims

1. A tool for use in a process of molding a product from a fibrous pulp slurry, said tool comprising:

- a mold body (10) having a three-dimensional forming side (2), said forming side comprising at least one bottom section (3), essentially vertical sidewalls (4) surrounding said bottom section, and a flange (5) extending horizontally from an upper portion of said sidewalls, and said mold body (10) comprising a plurality of suction channels (6) evenly distributed across said forming side (2) and arranged to generate a suction at the surface of the forming side upon coupling the mold body to a vacuum suction source during use;

**characterized in that** at least one (60) of said suction channels comprises a slit opening (61) located at the intersection between the essentially vertical sidewall (4) and the horizontal flange (5), such that said slit opening (61) is facing both said vertical sidewall (4) and said horizontal flange (5).

2. The tool according to claim 1, wherein, upon coupling the mold body (10) to a vacuum suction source, the suction flow generated through said slit opening (61) comprises both vertical and horizontal direction via the same suction opening (61).
3. The tool according to claim 1, wherein said slit opening (61) has a base width (w) between 2-4mm, preferably between 2-3mm.
4. The tool according to claim 1, wherein the mold body (10) is a solid body made of cast metal, preferably aluminum.
5. The tool according to any one of the previous claims, wherein said suction channels (6, 60) are boreholes.
6. The arrangement according to any one of claims 1-3, wherein the mold body (10) is manufactured by means of 3D printing.
7. The tool according to claim 1, further comprising at least one water-permeable mesh arranged to complement the three-dimensional shape of said forming

side (2), said mesh being arranged to retain pulp fibers.

8. The tool according to claim 1, further comprising a cover plate (8) positioned on said mold body (10) such that the flange (5) is at least partially covered, thereby exposing at least the bottom section (3) and essentially vertical sidewalls (4).

9. A method for producing a molded product from fiber-containing pulp slurry comprising the steps of:

- providing a mold body (10) having a three-dimensional forming side (2) comprising at least one bottom section (3), essentially vertical sidewalls (4) surrounding said bottom section and a flange (5) extending horizontally from an upper portion of said sidewalls, said mold body comprising a plurality of suction channels (6) evenly distributed across said forming side (2) arranged to deliver a suction to the surface of the forming side upon coupling the mold body to a vacuum suction source during use; wherein at least one (60) of said suction channels comprises a slit opening (61) located at the intersection between the essentially vertical sidewall (4) and the horizontal flange (5), such that said suction opening (61) is facing both said vertical sidewall (4) and said horizontal flange (5);

- placing a water-permeable mesh arranged to retain pulp fibers and designed to complement the three-dimensional shape of said forming side (2), on top of said forming side (2);

- positioning a cover plate (8) on said mold body (10) such that the flange (5) is at least partially covered, thereby exposing at least the bottom section (3) and essentially vertical sidewalls (4);

- immersing at least the forming side (2) into an aqueous fiber-containing pulp slurry;

- activating the vacuum suction source so to that a vacuum suction is generated at the forming side (2) via said suction channels (2), leading to that pulp fibers are drawn onto said mesh forming a fiber layer with a shape complementary to the shape of the mesh;

- withdrawing the tool from said pulp slurry and drying said fiber layer to obtain a three-dimensional molded fiber product.

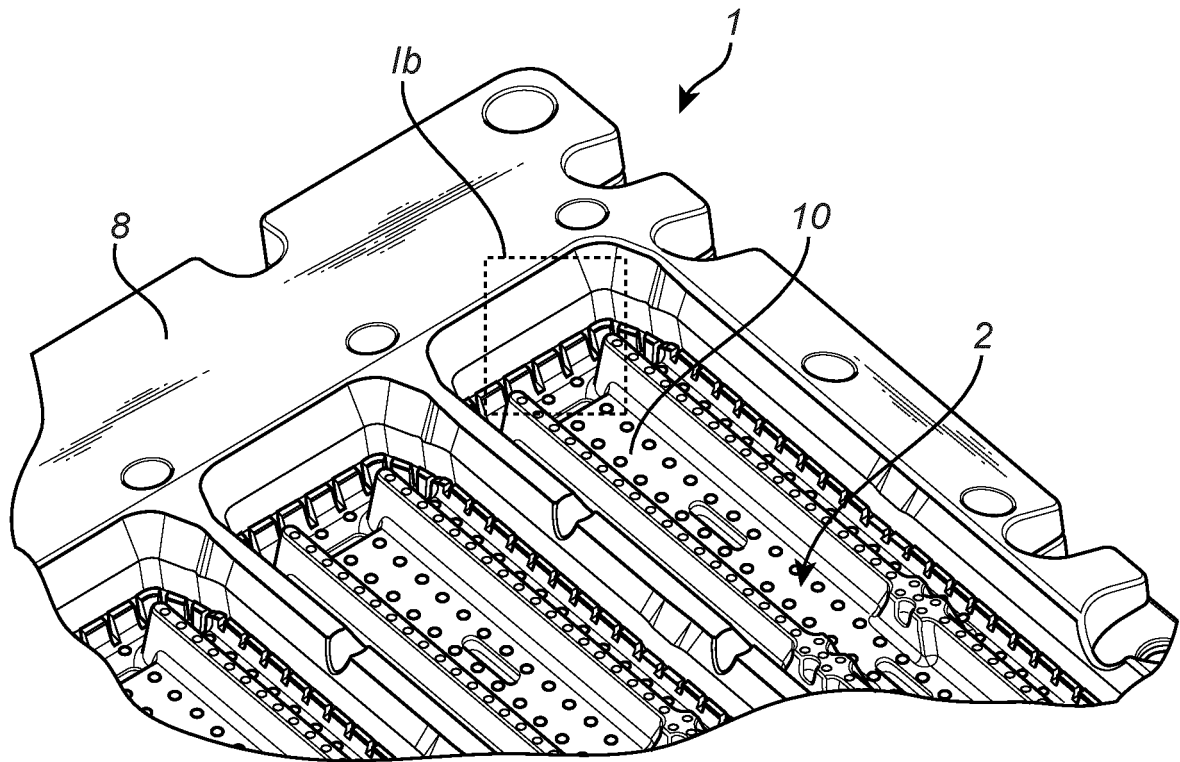


Fig. 1a

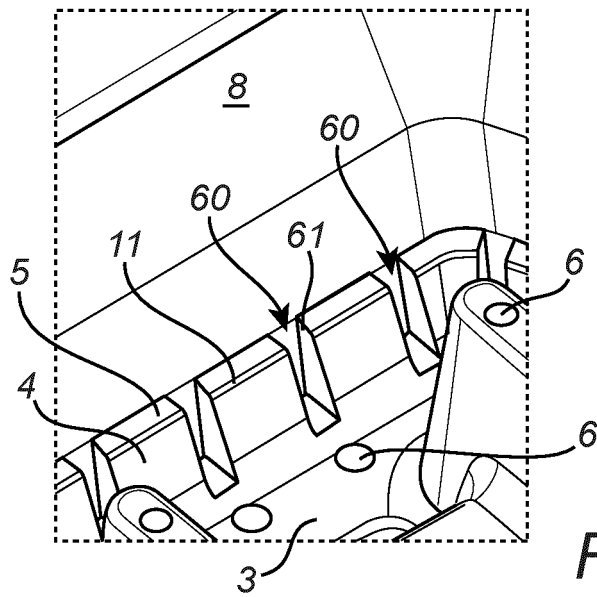


Fig. 1b

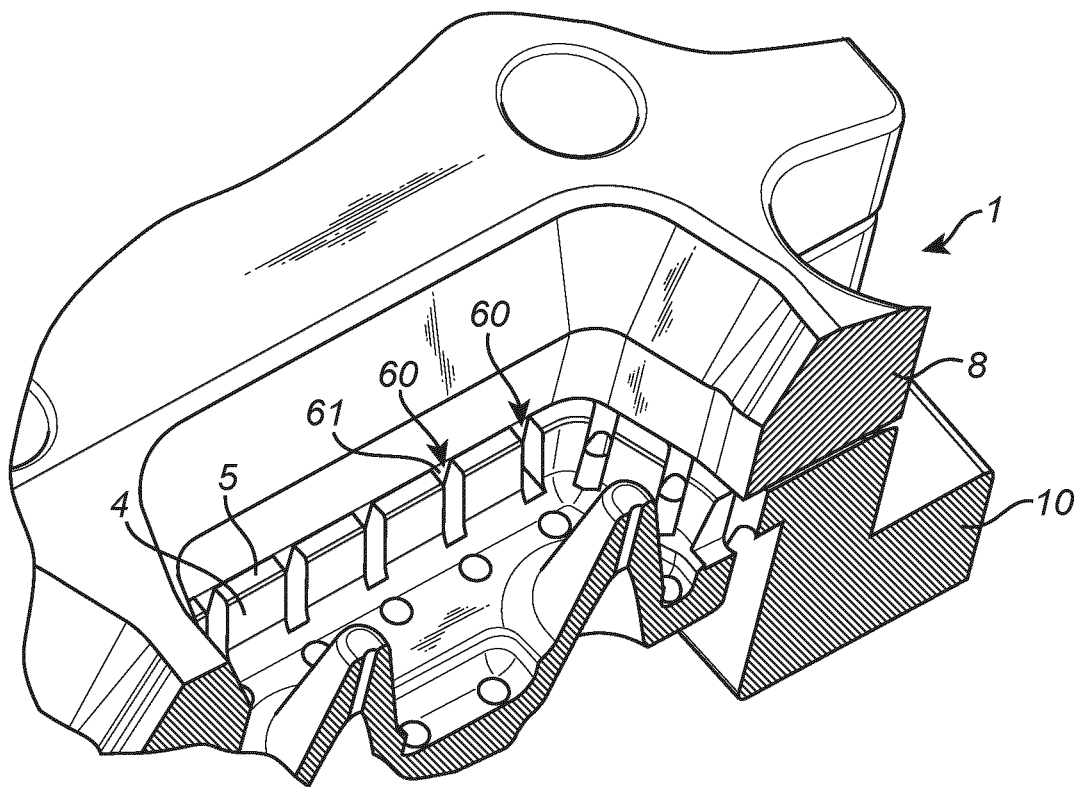


Fig. 2a

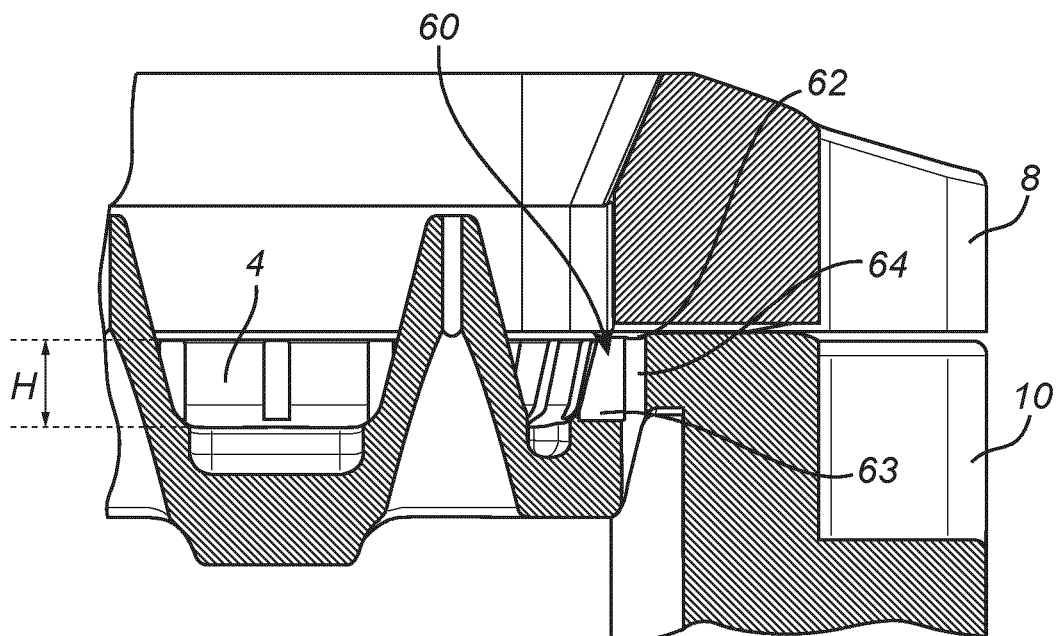
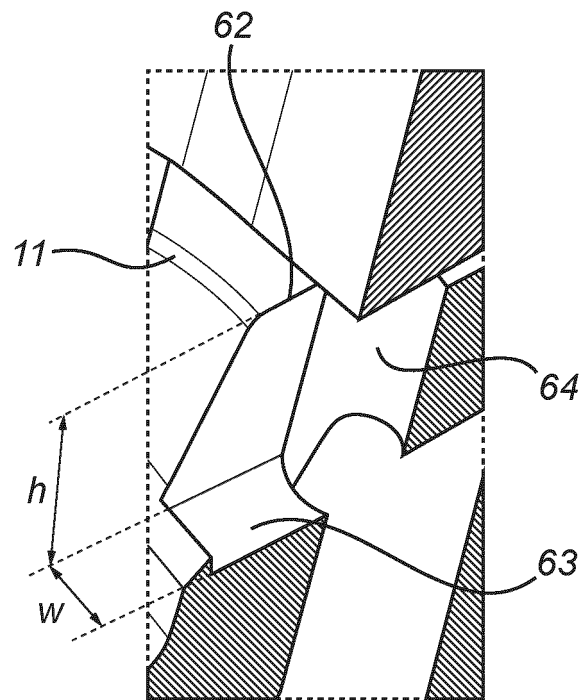
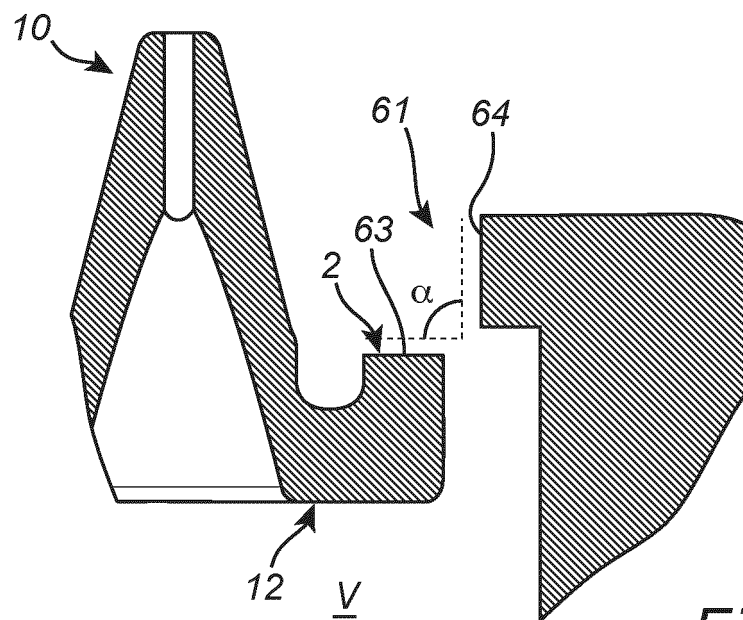


Fig. 2b



*Fig. 2c*



*Fig. 2d*



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