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(54) **A METHOD AND A MACHINE FOR MAKING FIBRE PRODUCTS FROM STOCK**

VERFAHREN UND MASCHINE ZUR HERSTELLUNG VON FASERPRODUKTEN AUS STOFF

PROCEDE ET MACHINE DE FABRICATION DE PRODUITS FIBREUX A PARTIR D'UNE COMPOSITION DE FABRICATION

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the production of fibre products from stock and especially to three-dimensional objects such as egg cartons, and other packaging products but also to objects such as drinking cups for beverages or trays, e.g. food trays.

BACKGROUND OF THE INVENTION

[0002] Fibre products such as for example egg boxes can be made from stock in a process where a fibre layer is created and shaped to a desired form whereafter the so shaped fibre product is dewatered and possibly subjected to some form of post-processing operation.

[0003] US patent No. 6103179 discloses a method for producing a fibre product which is where a first male mould is immersed in a moulding tank containing stock. By means of vacuum, a fibre layer of predetermined thickness for the fibre product is formed. The first male mould is then removed from the moulding tank. A cyclical sequence of movements is performed with a female mould in which, in a first pressing stage, the female mould is brought under force against the male mould so that a first expressing of stock water occurs following which the fibre product is transferred to the female mould which is moved to a second position. The fibre product is then subjected to a second expressing whereafter the fibre product is subjected to final drying using microwave or IR radiation.

[0004] US patent No. 6451235 discloses a method for forming a three dimensional fibre truss from a fibre slurry. In this method, a wet-forming station is used which comprises a substantially rigid moveable wet-forming die with a three-dimensional first forming surface and a substantially rigid fixed wet-forming die with a second forming surface. A deckle comprises a substantially rigid impermeable frame that surrounds a deckle interior space comprising a prismatic volume including a cross-sectional outline that encompasses a peripheral surface of the first die so that the moveable wet-forming die can traverse an axial length of the prismatic volume of the deckle interior space. Within the deckle interior space, above a predetermined area of the second forming surface, there is a slurry space. There are also filling means for adding fibre slurry to the slurry space and a pressing means for urging the moveable wet-forming die along the axial length of the prismatic volume. The method includes adding a predetermined quantity of fibre slurry to the slurry space and compressing at a pre-selected rate the fibre slurry contained in the slurry space. A pre-form fibre truss is then removed from the deckle interior space and moved to a truss finishing station. In the truss finishing station, the moist pre-form fibre truss is compacted further and dried under pressurized constraint between heated forming dies to produce the finished fibre truss. After treatment in the finishing station, a caul carries the finished fibre truss to a post-processing station. The post-processing is stated to include such operations as bonding to skins.

[0005] US patent No. 6582562, corresponding to US 2001 035 275 A1, forms the preamble of present claims 1 and 12 and discloses a method for producing moulded parts from a slurry by the use of first and second mating porous molds. In this method, the first mould is moved into the slurry and a vacuum is supplied to the first mold to cause the slurry to form onto the first mold to a desired thickness. The second mold is heated by hot air from a hot air source and the first and second moild are mated and a vacuum is supplied to the first and second molds during mating of the first and second molds. After this, the molded part is ejected from the first mold and the molded part travels with the second mold. The second mold is moved and the vacuum on the second mold is released to permit the molded part to be separated from the second mold. This can be done in connection with a conveyor belt. It is stated that drying temperatures of 300°F can be used (corresponding to about 149°C).

[0006] US patent No. 6136150 discloses a method and a device for achieving a flow of stock in a moulding tank. It is stated that the moulding tank is used to produce a fibre product such as an egg carton or other packaging product. In this patent, is it proposed that a flow of stock in the moulding tank is pumped into the bottom of the moulding tank and allowed to flow up over the brim of the tank. It is stated that this results in a flow that is directed upwards and that this should be important for forming a fibre layer of even thickness on a male tool used in the method.

[0007] During production of fibre products such as for example egg boxes and drinking cups, it is desirable that the shape of the final product can be controlled in a reliable way. For many applications, it is also desirable that the final product has substantially even strength properties so that the final product does not bend easier in one direction than in another. If heat is used to dewater the fibre product, it is also desirable that the heat does not burn the surface of the fibre product. It is also desirable that vaporized water can be evacuated efficiently.

[0008] It is an object of the present invention to provide an improved method and an improved machine for producing fibre products from stock. In preferred embodiments of the invention, the method is carried out in such a way and the machine is so designed that improved control of the shape of the final product is achieved. In advantageous embodiments of the invention, the final product also obtains substantially even properties of strength. Further objects of the invention include efficient dewatering and avoidance of burning of the surface of the final product.

DESCRIPTION OF THE INVENTION

[0009] The invention relates to a method for producing a fibre product from stock. The inventive method com-

prises providing a first tool that is permeable to air and water and providing a second tool. The second tool is heated to a surface temperature of at least 220°C. A moulding tank is provided and stock is fed to the moulding tank. The first tool is immersed in the stock in the tank and an embryonic fibre product is formed on the first tool by applying suction through the first tool. The first tool is then removed from the stock and the first tool is brought against a second tool such that the formed fibre product is sandwiched between the first and the second tool. The formed fibre product is heated by the second tool such that at least a part of the water in the formed fibre product is vaporized.

[0010] The formed fibre product may subsequently be subjected to at least one additional step of dewatering where the fibre product is sandwiched between a pairs of opposed tools. Water is removed from the fibre product until it has reached a dry solids content of preferably at least 70%. When the fibre product has reached a dry solids content of at least 70%, it may be subjected to final drying by microwaves. Prior to final drying by microwaves, the fibre product can be subjected to steam in order to achieve a more even moisture content.

[0011] In the invention, no stock is fed to the moulding tank during the actual forming step by means of causing stock from a machine vat to by-pass the moulding tank during the forming step. After the forming step, the stock from the machine vat can once again be fed to the moulding tank. The forming step preferably takes 1 - 2 seconds.

[0012] The heating and vaporizing step that is carried out between the first tool and the second tool should preferably last for no more than 1 second. During the forming step, the fibre product is suitably dewatered to a dry solids content of 18 - 22 % by weight, preferably 20 % by weight.

[0013] The stock used can suitably have a dry solids content of 0,4 - 0,7% by weight. Preferably, the stock has a dry solids content of 0,5% by weight. A suitable stock can be made from chemithermomechanical pulp (CTMP).

[0014] The first tool and the second tool should preferably be pressed against each other with a force that generates an overpressure of no more than 1 MPa and preferably no more than 900 KPa. In fact, it can be suitable in some cases to use a very low pressure and the pressure may be in the range of 10 - 900 KPa. It is also conceivable that no mechanical pressure at all is applied.

[0015] Suction should preferably be applied to the first tool also when the fibre product is sandwiched between the first tool and the heated second tool. In preferred embodiments, also the second tool is permeable to air and water. Suction is then applied also to the second tool when the fibre product is sandwiched between the tools so that steam and water is evacuated through both the first tool and the second tool.

[0016] The invention also relates to a machine for producing fibre products from stock. The machine comprises a moulding tank for holding stock and a first tool that is permeable to air and water. The machine further comprises a second tool that is permeable to air and water. The machine has means connected to the first tool for lowering the first tool into the tank and lifting the first tool out of the tank and for bringing the first tool against the second tool. A suction device, i.e. a source of underpressure is connected to the first tool. A source of heat, i.e. a heating device, arranged to heat the second tool and capable of heating the surface of the second tool to a temperature of at least 220°C in order to vaporize water in a wet fibre product when the wet fibre product is sandwiched between the first and the second tool. The machine further comprises a microwave heater for additional removal of water from a fibre product that has previously been dewatered between the first and the second tool. There are also means for transferring a fibre product from the second tool to the microwave heater.

[0017] A machine vat is arranged to supply stock to the moulding tank through a conduit. There is a by-pass conduit that can be used selectively such that stock from the machine vat can be either passed directly to the moulding tank or pumped around in a looped flow.

[0018] In advantageous embodiments, a steam shower can be arranged before the microwave heater so that a fibre product to be passed through the microwave heater can be showered with steam before it is treated by the microwave heater.

[0019] Preferably the first tool comprises particles that have been sintered together to form a porous body. In preferred embodiments, also the second tool comprises particles that have been sintered together to form a porous body. Of course, it should be understood that also other tools than sintered tools could be considered.

[0020] In advantageous embodiments, the first and second tools are mounted on holders that can be rotated between different angular positions.

[0021] In addition to the first and the second tool, additional tools may be arranged in a path from the pair of the first and second tool to the microwave heater, the additional tools forming cooperating pairs of tools where a fibre product may be subjected to additional dewatering and the additional tools further being arranged to convey a fibre product towards the microwave heater.

DESCRIPTION OF THE DRAWINGS

[0022]

Fig. 1	is a schematic representation of the layout of the machine used in the inventive method.
Figs. 2a - 2h	show a sequence where a forming tool is immersed in stock held in a tank.
Fig. 3	shows in greater detail a forming tool immersed in stock.
Fig. 4	shows the forming tool of Fig. 3 where a fibre product has been formed on the tool.
Fig. 5	shows how the first tool mates with the

second tool and how a fibre product is sandwiched between the two tools.

Fig. 6 shows, in perspective, a group of tool holders arranged in a sequence.

Fig. 7 shows the same group of tool holders as in Fig. 6 but here seen from above.

Fig. 8 shows a side view of the tool holders shown in Fig. 6 and Fig. 7.

Fig. 9 shows how ready-dried fibre products are transferred to a conveyor belt.

Fig. 10 shows a part of the machine shown in Fig. 1.

Fig. 11 shows an exploded view of a tool pair used in the present invention.

Fig. 12 shows a cross section of the tool pair shown in Fig. 11.

Fig. 13 shows in greater detail the microstructure of the tools shown in Fig. 12.

Fig. 14 shows, in perspective, a tool holder provided with a plurality of tools.

Figs. 15A - C show properties of moulded product produced according to the invention, in comparison with prior art.

Fig. 16 shows a detail of an advantageous embodiment of a tool used in the inventive method.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Reference will now be made to Fig. 1. In Fig. 1, a machine for producing fibre products is shown. To the left in Fig. 1, a stock preparation section is indicated where pulp bales 20 can be disintegrated and dissolved into stock in a pulper 22 and subsequently passed to a machine vat 7. In the machine vat 7, the stock can be kept in motion by an agitating device 21 to avoid flocculation. From the machine vat 7, the stock can be fed through a conduit 8 to a tank 6 which is used in the process according to the present invention. In the invention, no stock is fed to the moulding tank 6 during the actual forming step. This is achieved, for example, by means of causing stock from the machine vat 7 to by-pass the moulding tank 6 during the forming step. After the forming step, the stock from the machine vat 7 can once again be fed to the moulding tank 6. The forming step can suitably take 1 - 2 seconds. When no pulp is passed to the moulding tank 6, the pulp 19 in the moulding tank 6 can be at rest. This entails the advantage that the fibre product that is formed obtains more uniform properties in all directions since the orientation of the fibres will be more stochastic. To avoid flocculation in the conduit(s) leading to the moulding tank 6, the stock can be sent through a by-pass conduit 9 during forming so that the stock is kept in motion. After a fibre product has been formed on a tool 1 that is immersed in the stock that is kept in the tank 6, the fibre product is dewatered between opposing pairs of tools and subsequently passed to a microwave heating device 17 for final drying. A conveyor belt 15 can be used to transport fibre products 10 to the microwave heater 17. At the end of the production line, there may be a pick-up unit 23 that is used to place the final products 10 in a stack 24. The pick-up unit 23 may have a suction device (not shown) in order to be able to pick up the ready-dried products 10.

[0024] The function of the process will now be explained with reference to Figs. 2a - 2h and Figs. 3 - 5. In Fig. 2a, a first tool 1 is placed on a holder 14 which can pivot on an axle or pin 14. In Fig. 2b, the holder 13 has been pivoted or rotated to a position where the first tool 1 faces the stock 19 that is held in a tank 6. The first tool 1 is mounted on the holder 13 in such a way that is can be lowered into the stock 19. This can be done by special means for lowering and raising the first tool 1 in relation to the holder 13. Such means can include a telescoping hydraulically operated arm 18 which is indicated schematically in for example Fig. 2c. The first tool 1 is now lowered into the stock 19 until it reaches the position indicated in Fig. 2d. This position is showed in greater detail in Fig. 3. As can be seen in Fig. 3, the first tool 1 has a profiled surface 25 that corresponds to the shape of a fibre product to be formed. The first tool 1 is air and water permeable. It is also connected to a source of underpressure, i.e. a suction device 2 that can apply suction through the first tool 1 such that water and fibres are sucked towards the first tool 1. The water will pass through the first tool 1 and can be passed back into the stock 19 through a return conduit (not shown). However, the fibres will stay on the profiled surface 25 of the first tool 1 and form an embryonic fibre product 10 as indicated in Fig. 4. In this way, the first tool 1 serves as a forming tool for initial forming of the fibre products. The stock used is preferably based on be chemithermomechanical pulp (CTMP) but also other pulp that CTMP can be contemplated. CTMP is a preferred pulp in this context since it is relatively easy to dewater stock based on CTMP. The consistency of the stock may be 0,5 % by weight or about 0,5 % by weight. However, other values for consistency may also be contemplated.

[0025] The initial forming step may take about 1- 2 seconds. When the initial forming step is completed, the first tool 1 (the forming tool) is lifted from the stock 19 as indicated in Fig. 2e. The formed fibre product 10 now has a dry solids content of about 20% but dry solids content can also be somewhat lower or somewhat higher, realistically in the range of, for example, 18 - 22 %. As indicated in Figs. 2f - 2h, the holder 13 may then be rotated and the first tool 1 once again moved by the arm 18 away from the body of the holder 13. In Figs. 2f- 2h, the first tool 1 is moved horizontally and to the right in the figures. However, it should be understood that other directions and patterns of movement are also possible. The first tool is moved in order to mate with a second tool 3 as indicated symbolically in Fig. 2h and in greater detail in Fig. 5. During this movement, the suction device 2 continues to be active so that the embryonic fibre product 10 is firmly held by the first tool 1. The second tool 3 has a

profiled surface 26 that matches the profiled surface 25 of the first tool 1. When the first tool 1 meets the second tool 3, the formed fibre product 10 is held between the tools 1,3. In the figures, the first tool 1 is shown as a male tool while the second tool 3 is shown as a female tool. This is believed to the most suitable solution since it makes the forming process easier but the first tool 1 can also be a female tool. A heating device 5 is arranged to heat the second tool 3 such that the profiled surface 26 of the second tool 3 reaches a temperature of preferably at least 220°C. Also temperatures considerably higher than 220°C can be used. A realistic interval for the surface temperature of the second tool 3 may be 220°C - 400°C. Although the surface temperature for the second tool 3 should preferably be at least 220°C in order to achieve effective dewatering, it should be understood that temperatures below 220°C can be contemplated. For example, the temperature could be as low as 200°C. Hence, an interval for the temperature can be 200°C - 400°C. In preferred embodiments, the second tool 3 is also a permeable tool and a suction device 4 may also be connected to the second tool 3 to apply suction through the second tool 3 when the second tool 3 mates with the first tool 1. Due to the high temperature of the second tool 3, water in the fibre product 10 is vaporized. Since at least the first tool 1 is permeable, vapour can escape through the first tool 1. If the suction device 2 of the first tool is active, this will facilitate evacuation of vapour. If the second tool 3 is also permeable, vapour can also be evacuated through the second tool 3 and this is made more efficient if the suction device 4 of the second tool is active. The fibre product 10 is held between the tools 1, 3 during the vaporization. When water is vaporized at such high temperatures, the vaporization process will be violent and sudden. According to a wide-spread theory, the fibre product will be subjected to a process of so called "impulse drying". This implies that vaporized water that leaves the fibre product will also force out such remaining water between the fibres that has not been vaporized. This results in a very effective dewatering. The invention is not bound by any particular theory of exactly what happens under such circumstances. However, practical experience has demonstrated that surface temperatures of 220°C results in very effective dewatering. It has been observed that dryness levels of 50% and more can be obtained already in the first dewatering step between the tools 1, 3. The time in the nip between the tools 1, 3 should preferably be quite short and a time of no more than 1 second can be suitable. In some cases, a time which is less than 1 second can be suitable. The pressure in the nip between the tools 1, 3 should preferably not be higher than 1 MPa. Preferably, the mechanical pressure should not be higher than 900 KPa. For example, the mechanical pressure may be in the range of 10 - 900 MPa. In some cases, the pressure could actually be zero.

[0026] Reference will now be made to Fig. 6. In Fig. 6, it can be seen how several tool holders 13 are arranges in a row. As indicated in for example. Fig. 8, each tool holder 13 is pivotable and has an axle 14 for this purpose. The axle 14 may be rotatable together with the tool holder or the tool holder 13 may pivot on the axle 14. On each of the tool holders 13, there are additional tools 11, 12 such as male tools 11 and female tools 12. Each of the tools 11, 12 can form a nip together with at least one other tool on an adjacent tool holder 13. Each of the tools 11, 12 may be permeable and connected to a suction device just like the first tool 1 and the second tool 3. The tools 11, 12 can be mounted on one or several telescoping arms 18 or on some other actuator to move the tools 11, 12 away from or towards their respective holders 13. In this way, a tool 11 on one holder 13 may be moved horizontally towards a tool 12 on an adjacent holder 13 in order to dewater a fibre product held between the tools 11, 12. The tools 11, 12 and there tool holders 13 also serve as a conveyor for conveying the fibre product 10 towards the microwave heater 17. This functions in the following way. A fibre product 10 is held on a male tool 1, 11 or on a female tool 3, 12 by means of suction through the permeable tool 1, 3, 11, 12. As an example, reference will now be made to a case where the fibre product 10 is initially held on a male tool 1, 11. The arm 18 (or arms 18) moves the male tool 1,11 towards the female tool 3, 12. The fibre product 10 is dewatered. The suction through the male tool 1, 11 is released and the fibre product 10 is now held by suction through the female tool 3, 12. The male tool 1, 11 returns to its original position. The tool holder 13 of the female tool 3, 12 is now rotated 180° such that the fibre product will be facing a new male tool 12. It can now be understood that this process can be repeated in such a way that the fibre product 10 is transferred to the next male tool and further towards the microwave dryer. The tools 11, 12 and their holders 13 are thus arranged to convey a fibre product 10 towards the microwave heater. For additional clarification of the arrangement of the additional tools 11, 12, reference is also made to Fig. 7.

[0027] As can be seen most clearly in Fig. 14, each tool holder 13 can have a plurality of tools 12 arranged next to each other so that a plurality of fibre products 10 can be produced and finished simultaneously. It should be understood that each of the additional pairs of tools 11, 12 can function in the same way as the first tool 1 (the forming tool) and the second tool 3 and that further dewatering can take place in the nips formed between the pairs of additional tools 11, 12. The additional tools 11, 12 this serve both the purpose of dewatering and the purpose of conveying the fibre product(s) 10. In advantageous embodiments of the invention, the pressure between the first tool 1 and the second tool 3 may be kept relatively low while a higher pressure and a lower temperature is used between following tool pairs 11, 12. For example, the higher pressure of up to 1 MPa can be used in a press nip between the last pair of tools 11, 12. It should be understood that, normally, additional dewatering takes place in press nips between the additional tools 11, 12. When more than two press nips are used, the

pressure in the nips could increase from nip to nip such that the lowest pressure is used in the first nip, a higher pressure is used in following nips and the highest pressure in the last nip. The pressure may thus increase in steps from nip to nip.

[0028] With reference to Fig. 9a-9h, a conveyor belt 15 may be located at the end of the tool path. Fig. 9a shows how the last tool holder 13 is in a horizontal position. It should be understood that a fibre product 10 is held by suction to the male tool 11. The tool holder 13 is located above the conveyor belt 15. In Fig. 9b, the tool holder 13 has been rotated so that the tool 11 now faces the conveyor belt 15. The tool 11 moves downwards as indicated in Fig. 9c and the suction is deactivated causing the fibre product to be dropped on the conveyor belt 15. Possibly, air could also be blown through the tool 11 to help the fibre product 10 to leave the tool 11. The fibre product will then be transported towards the microwave heater while the tool 11 returns to its original position as indicated in Fig 9e - 9h.

[0029] In Fig. 10, it can be seen how the microwave heater 17 can be preceded by a steam shower 16 that blows steam on the fibre product 10. The purpose of this is to achieve a more even moisture distribution in the fibre product 10. It should be understood that the use of steam is an optional feature of the invention and it is possible to envisage embodiments of the invention where steam is not used. The fibre product has been dewatered to a dry solids content of at least 70% before it reaches the microwave heater 17.

[0030] The design of the tools 1, 3, 11, 12 according to a possible embodiment of the invention shall now be explained in more detail with reference to Figs. 11 - 13. Fig. 11 is an exploded view of the first tool 1 and the second tool 3. As indicated in Fig. 11, a heater 5 may be placed close to the second tool 3, possibly directly connected to the tool 3 or at a certain distance from the second tool 3. As can be seen in Fig. 12, both tools 1, 3 are provided with channels 27 through which water and air can pass. As indicated in Fig. 12, the tools 1, 3 may comprise different layers 28, 29, 30. These layers are parts of the tool structure that have different permeability. An inner layer 28 forms a base structure with a relatively high degree of permeability. An intermediate layer 29 has a relatively lower permeability and a thin surface layer 30 may have an even lower permeability. The tools may advantageously be made of small metal spheres that have been sintered together to form the different layers. As indicated in Fig. 13, the surface layer 30 may be formed of small spheres 31 while the intermediate layer 29 may be formed by somewhat larger metal spheres 32. The base structure 28 is formed by the largest spheres 33. The smallest particles 31 may have a diameter in the range of 0,01mm - 0,18 mm while the particles 32 in the intermediate layer 29 may have a diameter in the range of 0,18mm - 0,25 mm. The larger particles or spheres 33 in the base layer may have a diameter of 0,71mm - 1 mm. The particles 31, 32, 33 may be the kind of particles that are sold in the form of metal powder and can be obtained from CALLO AB, Poppelgatan 15, 571 39 Nässjö, Sweden. CALLO AB sells a metal powder under the name Callo 25 which is a spherical metal powder with particles having a diameter of 0,09 - 0,18mm. The chemical composition is 89% Cu and 11% Sn. Suitable particles can also be obtained from Makin Metal Powders Limited, Buckley Road, Rochdale, Lancashire OL12 9DT England.

[0031] The porosity of the tool 1 may be about 40%. The value of 40% porosity can apply to all layers. Embodiments of the invention can also be envisaged where different layers of the tool have different porosity.

[0032] The smaller spheres 31 form a fine surface layer that contributes to giving the fibre product a smooth surface while the interior layers 29, 28 improve permeability. The channels 27 that pass through the sintered structure may have pointed tips that reach the surface of the tool which improves permeability.

[0033] Reference will now be made to Fig. 16. In the embodiment of Fig. 16, a part 34 of the surface 25 of the first tool 1 has been covered or coated so as to be impermeable or substantially impermeable. On the impermeable spot 34, no layer of fibres will form. Hence, the fibre product will have a hole with a shape corresponding to the impermeable spot 34. The impermeable spot 34 can be achieved by for example painting a part of the surface 25 or by covering a part of the surface 25 with a sheet of an impermeable material. It should be understood that this feature (an impermeable spot) is entirely optional and that the invention can be practiced without this optional feature. In terms of a method, it should be understood that the invention can be understood as including the (optional) step of using a tool with an impermeable spot 34. The idea of using a tool with an impermeable spot can be used independently of how the tool, the machine or the method is otherwise designed or performed.

[0034] The porous structure provided by the sintered metal particles 31, 32, 33 has the advantage that water and vapour can escape easily through the tools 1, 3,11, 12. This reduces the risk of delamination during the vaporization process. The sintered structure also has the advantage that steam can escape in a very even way over the whole surface of the tool.

[0035] The high temperature entails the advantage that an efficient dewatering is achieved. Pressing with a relatively high pressure before the microwave heater (when the fibre product is wet) entails the advantage that good surface properties can be achieved before microwave drying. Therefore, it will not be necessary to press the fibre product after microwave drying which could be harmful to the fibre product. The microwave heating step entails the advantage of improved hygiene. The use of the high temperature also entails the advantage that the surface of the fibre product becomes more compact which is advantageous in view of bending stiffness.

[0036] It should be understood that, in certain embod-

iments, the microwave heating can be deleted or replaced by some other heating method, for example IR heating.

[0037] It should be understood that the idea of halting the feeding of stock to the mould 6 during forming can be used independently of how the process is otherwise performed.

[0038] The invention also relates to a fibre product that can be obtained by the above described method. In Figs. 15A-15C there are shown properties of a moulded product produced in accordance with the invention. Fig. 15A demonstrates that quality aspects (being of importance in many fields where moulded fibre pulp products are used, e.g. the packaging industry) can be remarkably better for the invention in relation to prior art products, e.g. produced by thermo moulding or conventional pulp moulding. It is believed that one reason for the high quality of a product according to the invention is that a high density can be achieved, in the range of 600 - 900 kg/m^3, without causing any weakness in the fibre net work. According to conventional prior art methods densities above 500 would rarely be achieved, without also obtaining at least on quality aspect below a desirable level. As can be seen in Fig. 15C thermo formed pulp products may obtain a level above 500 kg/ m^3. However when using thermo forming, which includes hot after pressing, the fibre net work will be partly disrupted that drastically decreases some quality aspects, e.g. tensile index. Especially corners and other areas of the body that presents sharp bends/curves will be negatively affected by such hot after pressing, whereas according to the invention corners and areas having a sharp radius also present substantially the same kind of continuous, homogenous web structure as substantially flat areas of the body, which in turn provides equally good quality aspects in substantially all parts of the product. In advantageous embodiments, the fibre web of the product is of even thickness or substantially even thickness. However, it should be understood that fibre products obtained by the method described may, at least in certain cases, have a density lower than 600 kg/m^3 or higher than 900 kg/m^3.

[0039] A further major advantage according to the invention is that very smooth surfaces on both sides of the body may be produced. Products produced according to the invention may easily obtain a roughness in the range of about 750 -1.000 ml/min. (ISO 8791-2, Bendtsen), whereas conventional moulded pulp products at least on one side normally have a roughness well above 1.500 ml/min. It may be mentioned that one of the reasons why conventional products normally present a higher roughness is that most conventional techniques do use a wire mesh to form the surface.

[0040] A further advantage according to the invention is that the product will achieve a high tensile index, normally in the range of 65-100 kNm/kg., which indeed is a significant advantage compared to traditional moulded pulp products. (see Fig 15 B) Moreover also a good tear index is achieved. Another advantage is that the bonding strength of the surface layer will be somehow higher than the bonding strength of an intermediate layer near the centre portion of the web forming the body, since the inventive method will achieve a higher amount of bindings between the fibres in the surface layer. As a consequence there is achieved a similar function as with an I-beam, i.e. the stiffness and the bending resistance is improved.

[0041] Finally it is of course an advantageous aspect of a product according to the invention that it may be achieved without any after pressing which otherwise will increased production costs and as has been mentioned above also negatively effect the at least some or one quality aspect/s. In Fig. 15B it is shown that thanks to all of the advantages mentioned above the tensile index for a product produced according to the invention may have high values independent on the shape of the body, whereas according to conventional methods the products will present decreasing tensile index with increasing complexity of the shape of the body. In table 15C there are presented some empirically found average values for two prior art methods, i.e. conventional pulp moulding and thermo forming, in comparison with the invention. As is evident from this table, products according to the invention may have numerous advantages in relation to quality aspects compared with prior art products.

Claims

1. A method for producing a fibre product from stock, the method comprising the steps of:

a) providing a first tool (1) that is permeable to air and water,
b) providing a second tool (3) and heating the second tool (3) to a temperature of at least 220°C,
c) providing a moulding tank (6) and feeding stock to the moulding tank (6),
d) immersing the first tool (1) in the stock in the tank (6),
e) forming an embryonic fibre product (10) on the first tool (1) by applying suction through the first tool (1),
f) removing the first tool (1) from the stock,
g) bringing the first tool (1) against the second tool (3) such that the formed fibre product (10) is sandwiched between the first and the second tool (1, 3) and heated by the second tool (3) such that at least a part of the water in the formed fibre product (10) is vaporized and
h) dewatering the formed fibre product (10) until it has reached a dry solids content of at least 70% after which the fibre product (10) is subjected to drying by microwaves,

characterized in that, during the forming step, stock

from a machine vat (7) is caused to by-pass the moulding tank (6) such that no stock is fed to the moulding tank (6) and **in that**, after the forming step, the stock from the machine vat (7) is fed to the moulding tank (6).

2. A method according to claim 1, ***characterized in that*** the heating and vaporizing step that is carried out between the first tool (1) and the second tool (3) lasts for no more than 1 second.

3. A method according to claim 1, ***characterized in that*** the forming step lasts 1 - 2 seconds.

4. A method according to claim 1, ***characterized in that*** the fibre product (10) is dewatered in several dewatering steps between opposed tools and subsequently subjected to steam before it is dried by microwaves.

5. A method according to claim 1, ***characterized in that*** the stock has a dry solids content of 0,4 - 0,7% by weight and preferably 0,5% by weight.

6. A method according to claim 1, ***characterized in that***, during the forming step, the fibre product (10) is dewatered to a dry solids content of 18 - 22 % by weight, preferably 20 % by weight.

7. A method according to claim 1, ***characterized in that*** the first tool (1) and the second tool (3) are pressed against each other with a force generating an overpressure of no more than 1 MPa and preferably no more than 900 KPa.

8. A method according to claim 1, ***characterized in that*** the pressure is in the range of 10-900 KPa.

9. A method according to claim 1, ***characterized in that*** the stock is made from chemithermomechanical pulp (CTMP).

10. A method according to claim 1, ***characterized in that*** suction is applied to the first tool (1) also when the fibre product (10) is sandwiched between the first tool (1) and the heated second tool (3).

11. A method according to claim 10, ***characterized in that*** also the second tool (3) is permeable to air and water and that suction is applied also to the second tool (3) when the fibre product (10) is sandwiched between the tools (1, 3) so that steam and water can be evacuated through both the first tool (1) and the second tool (3).

12. A machine for producing fibre products (10) from stock, the machine comprising:

a) a moulding tank (6) for holding stock,
b) a first tool (1) that is permeable to air and water,
c) a second tool (3) that is permeable to air and water,
d) means connected to the first tool (1) for lowering the first tool (1) into the tank (6) and lifting the first tool (1) out of the tank (6) and for bringing the first tool (1) against the second tool (3),
e) a source of underpressure (2) connected to the first tool (1),
f) a source of heat (5) arranged to heat the second tool (3) and capable of heating the surface of the second tool (3) to a temperature of at least 220°C in order to vaporize water in a wet fibre product (10) when the wet fibre product (10) is sandwiched between the first and the second tool (1, 3),
g) a microwave heater (17) for additional removal of water from a fibre product (10) that has previously been dewatered between the first tool (1) and the second tool (3) and
h) means for transferring a fibre product (10) from the second tool (3) to the microwave heater (17),

characterized in that a machine vat (7) is arranged to supply stock to the moulding tank (6) through a conduit (8) and **in that** there is also a by-pass conduit (9) that can be used selectively such that stock from the machine vat (7) can be either passed directly to the moulding tank (6) or pumped around in a looped flow.

13. A machine according to claim 12, ***characterized in that*** a steam shower (16) is arranged before the microwave heater (17) so that a fibre product (10) to be passed through the microwave heater (17) can be showered with steam before it is treated by the microwave heater (17).

14. A machine according to claim 12, ***characterized in that*** the first tool (1) comprises particles that have been sintered together to form a porous body.

15. A machine according to claim 14, ***characterized in that*** also the second tool (3) comprises particles that have been sintered together to form a porous body.

16. A machine according to any of claims 12 - 15, ***characterized in that*** the first and second tools (1, 3) are mounted on holders that can be rotated between different angular positions.

17. A machine according to any of claims 12 - 16, ***characterized in that***, in addition to the first and the second tool (1, 3), additional tools are arranged in a path from the pair of the first and second tool to the mi-

crowave heater (17), the additional tools forming co-operating pairs of tools where a fibre product may be subjected to additional dewatering and the additional tools further being arranged to convey a fibre product (10) towards the microwave heater (17).

Patentansprüche

1. Verfahren zum Erzeugen eines Fasererzeugnis aus einem Rohmaterial, wobei das Verfahren die Schritte umfasst:

   a) Bereitstellen eines ersten Werkzeuges (1), das für Wasser und Luft durchlässig ist,
   b) Bereitstellen eines zweiten Werkzeuges (3) und Heizen des zweiten Werkzeuges (3) auf eine Temperatur von mindestens 220°C,
   c) Bereitstellen eines Formtanks (6) und Zuführen von Rohmaterial zu dem Formtank (6),
   d) Eintauchen des ersten Werkzeuges (1) in das Rohmaterial in dem Tank (6),
   e) Formen eines unausgereiften Faserprodukts (10) auf dem ersten Werkzeug (1) durch Anwenden eines Sogs durch das erste Werkzeug (1),
   f) Entfernen des ersten Werkzeuges (1) aus dem Rohmaterial,
   g) Bewegen des ersten Werkzeuges (1) gegen das zweite Werkzeug (3), sodass das geformte Faserprodukt (10) zwischen dem ersten und dem zweiten Werkzeug (1, 3) gehalten wird und durch das zweite Werkzeug (3) so aufgeheizt wird, dass zumindest ein Teil des Wassers in dem geformten Faserprodukt (10) verdampft wird, und
   h) Entwässern des geformten Faserprodukts (10), bis es einen Trocken-Feststoffgehalt von mindestens 70% erreicht hat, wonach das Faserprodukt (10) einer Trocknung durch Mikrowellen unterworfen wird,

   dadurch gekennzeichnet, dass während des Schritts des Formens bewirkt wird, dass ein Rohmaterial von einer Maschinenwanne (7) um den Formtank (6) herumgeleitet wird, sodass dem Formtank (6) kein Rohmaterial zugeführt wird, und dass nach dem Schritt des Formens das Rohmaterial von der Maschinenwanne (7) dem Formtank (6) zugeführt wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schritt des Aufheizens und Verdampfens, der zwischen dem ersten Werkzeug (1) und dem zweiten Werkzeug (3) ausgeführt, wird nicht länger als 1 Sekunde dauert.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schritt des Formens 1-2 Sekunden dauert.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Faserprodukt (10) in mehreren Entwässerungsschritten zwischen gegenüberliegenden Werkzeugen entwässert und nachfolgend Dampf ausgesetzt wird, bevor es durch Mikrowellen getrocknet wird.

5. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Rohmaterial einen Trocken-Feststoffgehalt von 0,4 bis 0,7 Gew-% und vorzugsweise von 0,5 Gew-% aufweist.

6. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** während des Schritts des Formens das Faserprodukt (10) zu einem Trocken-Feststoffgehalt von 18 bis 22 Gew-% und vorzugsweise von 20 Gew-% entwässert wird.

7. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das erste Werkzeug (1) und das zweite Werkzeug (3) mit einer Kraft gegeneinander gepresst werden, die einen Überdruck von nicht mehr als 1MPa und vorzugsweise von nicht mehr als 900kPa erzeugt.

8. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** sich der Druck in dem Bereich von 10-900kPa befindet.

9. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Rohmaterial aus chemo-thermo-mechanischer Pulpe (CTMP) gemacht ist.

10. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der an dem ersten Werkzeug (1) angewendete Sog auch angewendet wird, wenn das Faserprodukt (10) zwischen dem ersten Werkzeug (1) und dem zweiten geheizten Werkzeug (3) gehalten wird.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** auch das zweite Werkzeug (3) für Luft und Wasser durchlässig ist, und dass der Sog auch auf das zweite Werkzeug (3) angewendet wird, wenn das Faserprodukt (10) zwischen den Werkzeugen (1, 3) gehalten wird, sodass Dampf und Wasser sowohl durch das erste Werkzeug (1) als auch durch das zweite Werkzeug (3) abgesaugt werden können.

12. Maschine zum Erzeugen eines Fasererzeugnisses (10) aus einem Rohmaterial, wobei die Maschine umfasst:

    a) einen Formtank (6) zum Aufnehmen eines Rohmaterials,

b) ein erstes Werkzeug (1), das für Wasser und Luft durchlässig ist,
c) ein zweites Werkzeug (3), das für Wasser und Luft durchlässig ist,
d) Mittel, die mit dem ersten Werkzeug (1) verbunden sind, um das erste Werkzeug (1) in den Tank (6) abzusenken und das erste Werkzeug (1) aus dem Tank (6) herauszuheben, und um das erste Werkzeug (1) gegen das zweite Werkzeug (3) zu bewegen,
e) eine Unterdruckquelle (2), die mit dem ersten Werkzeug (1) verbunden ist,
f) eine Wärmequelle (5), die eingerichtet ist, das zweite Werkzeug (3) zu heizen, und die in der Lage ist, die Oberfläche des zweiten Werkzeuges (3) auf eine Temperatur von mindestens 220°C aufzuheizen, um Wasser in einem nassen Faserprodukt (10) zu verdampfen, wenn das nasse Faserprodukt (10) zwischen dem ersten und dem zweiten Werkzeug (1, 3) gehalten wird,
g) einen Mikrowellenheizer (17), um zusätzlich Wasser aus einem Faserprodukt (10) zu entfernen, das vorher zwischen dem ersten Werkzeug (1) und dem zweiten Werkzeug (3) entwässert wurde, und
h) Mittel zum Übertragen eines Faserprodukts (10) von dem zweiten Werkzeug (3) zu dem Mikrowellenheizer (17),

dadurch gekennzeichnet, dass eine Maschinenwanne (7) eingerichtet ist, um ein Rohmaterial durch eine Leitung (8) dem Formtank (6) zuzuführen und wobei ebenfalls eine Umleitungsleitung (9) vorhanden ist, die selektiv dazu verwendet werden kann, so dass ein Rohmaterial von der Maschinenwanne (7) entweder direkt zu dem Formtank (6) weitergeleitet werden kann oder in einem Schleifenfluss umgepumpt werden kann.

13. Maschine nach Anspruch 12, **dadurch gekennzeichnet, dass** eine Dampfdusche (16) vor dem Mikrowellenheizer (17) angeordnet ist, sodass ein Faserprodukt (10), das durch den Mikrowellenheizer (17) geführt werden soll, mit Dampf geduscht werden kann, bevor es durch den Mikrowellenheizer (17) behandelt wird.

14. Maschine nach Anspruch 12, **dadurch gekennzeichnet, dass** das erste Werkzeug (1) Partikel umfasst, die zusammengesintert wurden, um einen porösen Körper zu bilden.

15. Maschine nach Anspruch 14, **dadurch gekennzeichnet, dass** auch das zweite Werkzeug (3) Partikel umfasst, die zusammengesintert wurden, um einen porösen Körper zu bilden.

16. Maschine nach einem der Ansprüche 12-15, **dadurch gekennzeichnet, dass** das erste und das zweite Werkzeug (1, 3) auf Haltern montiert sind, die zwischen verschiedenen Winkelstellungen gedreht werden können.

17. Maschine nach einem der Ansprüche 12-16, **dadurch gekennzeichnet, dass** zusätzlich zu dem ersten und dem zweiten Werkzeug (1, 3) zusätzliche Werkzeuge in einem Pfad von dem Paar des ersten und zweiten Werkzeugs zu dem Mikrowellenheizer (17) angeordnet sind, wobei die zusätzlichen Werkzeuge zusammenwirkende Paare von Werkzeugen bilden, wo ein Faserprodukt zusätzlichen Entwässerungen unterworfen werden kann, und wobei die zusätzlichen Werkzeuge weiter eingerichtet sind, um ein Faserprodukt (10) in Richtung des Mikrowellenheizers (17) zu befördern.

Revendications

1. Un procédé pour produire un produit fibreux à partir d'une pâte, le procédé comprenant les étapes consistant à :

a) se servir d'un premier outil (1) qui est perméable à l'air et l'eau,
b) se servir d'un second outil (3) et chauffer le second outil (3) à une température d'au moins 220°C,
c) se servir d'une cuve de moulage (6) et alimenter la pâte vers la cuve de moulage (6),
d) immerger le premier outil (1) dans la pâte se trouvant dans la cuve (6),
e) former un produit fibreux embryonnaire (10) sur le premier outil (1) en appliquant une aspiration à travers le premier outil (1),
f) retirer le premier outil (1) de la pâte,
g) porter le premier outil (1) contre le second outil (3) de telle sorte que le produit fibreux formé (10) est pris en sandwich entre le premier et le second outil (1, 3) et qu'il est chauffé par le deuxième outil (3) de telle sorte qu'au moins une partie de l'eau contenue dans le produit fibreux formé (10) soit évaporée, et
h) déshydrater le produit en fibres formé (10) jusqu'à ce qu'il ait atteint une teneur en matière sèche d'au moins 70%, après quoi le produit fibreux (10) est soumis à un séchage par micro-ondes,

caractérisé en ce que, pendant l'étape de formage, de la pâte provenant d'une cuve (7) de la machine est amenée à contourner la cuve de moulage (6) de telle sorte qu'aucune pâte n'est alimentée dans la cuve de moulage (6), et **en ce que**, après l'étape de formage, la pâte se trouvant dans la cuve (7) de la

machine est fournie à la cuve de moulage (6).

2. Un procédé selon la revendication 1, **caractérisé en ce que** l'étape de chauffage et d'évaporation qui est mise en oeuvre entre le premier outil (1) et le second outil (3) ne dure pas plus d'1 seconde.

3. Un procédé selon la revendication 1, **caractérisé en ce que** l'étape de formage dure de 1 à 2 secondes.

4. Un procédé selon la revendication 1, **caractérisé en ce que** le produit en fibres (10) est déshydraté au cours de plusieurs étapes de déshydratation entre des outils opposés et est par la suite soumis à de la vapeur avant qu'il ne soit séché par des micro-ondes.

5. Un procédé selon la revendication 1, **caractérisé en ce que** la pâte a une teneur en matière sèche de 0,4 à 0,7% en poids et de préférence de 0,5% en poids.

6. Un procédé selon la revendication 1, **caractérisé en ce que**, pendant l'étape de formage, le produit fibreux (10) est déshydraté pour atteindre une teneur en matière sèche de 18 à 22%: en poids, de préférence de 20% en poids.

7. Un procédé selon la revendication 1, **caractérisé en ce que** le premier outil (1) et le second outil (3) sont pressés l'un contre l'autre avec une force générant une surpression d'au plus 1 MPa et de préférence non supérieure à 900 KPa.

8. Un procédé selon la revendication 1, **caractérisé en ce que** la pression est dans la plage allant de 10 à 900 kPa.

9. Un procédé selon la revendication 1, **caractérisé en ce que** la pâte est faite à partir de pâte chimico-thermomécanique (PCTM).

10. Un procédé selon la revendication 1, **caractérisé en ce que** l'aspiration est appliquée au premier outil (1) aussi lorsque le produit fibreux (10) est pris en sandwich entre le premier outil (1) et le second outil chauffé (3).

11. Un procédé selon la revendication 10, **caractérisé en ce que** le second outil (3) également est perméable à l'air et l'eau et **en ce qu'**une aspiration est appliquée également au second outil (3) lorsque le produit fibreux (10) est pris en sandwich entre les outils (1, 3) de sorte que la vapeur et l'eau puisse être évacuées à la fois au travers du premier outil (1) et du second outil (3).

12. Une machine pour fabriquer des produits en fibres (10) à partir d'une pâte, la machine comportant :

a) une cuve de moulage (6) pour recevoir la pâte,
b) un premier outil (1) qui est perméable à l'air et à l'eau,
c) un deuxième outil (3) qui est perméable à l'air et à l'eau,
d) des moyens reliés au premier outil (1) pour abaisser le premier outil (1) dans la cuve (6) et pour lever le premier outil (1) en dehors de la cuve (6), et pour amener le premier outil (1) contre le second outil (3),
e) une source de dépression (2) reliée au premier outil (1),
f) une source de chaleur (5) agencée pour chauffer le deuxième outil (3) et capable de chauffer la surface du deuxième outil (3) à une température d'au moins 220°C de manière à évaporer l'eau contenue dans un produit fibreux humide (10) lorsque le produit fibreux humide (10) est pris en sandwich entre le premier et le second outil (1, 3),
g) un appareil de chauffage à micro-ondes (17) pour un retrait supplémentaire d'eau dans un produit fibreux (10) qui a déjà été asséché entre le premier outil (1) et le second outil (3) et
h) des moyens pour transférer un produit fibreux (10) du deuxième outil (3) vers l'appareil de chauffage à micro-ondes (17),

caractérisé en ce qu'une cuve (7) de la machine est agencée pour fournir de la pâte à la cuve de moulage (6) par un conduit (8) et **en ce qu'**il y a aussi un conduit de dérivation (9) qui peut être utilisé de façon sélective de telle sorte que la pâte de la cuve (7) de la machine peut être soit transmise directement à la cuve de moulage (6) ou pompée dans un circuit en boucle.

13. Une machine selon la revendication 12, **caractérisée en ce qu'**une douche à vapeur (16) est disposée avant l'appareil de chauffage à micro-ondes (17) de telle sorte qu'un produit fibreux (10) destiné à être passé à travers l'appareil de chauffage à micro-ondes (17) et peut être exposé à de la vapeur avant qu'il ne soit traité par l'appareil de chauffage à micro-ondes (17).

14. Une machine selon la revendication 12, **caractérisée en ce que** le premier outil (1) comprend des particules qui ont été frittées ensemble pour former un corps poreux.

15. Une machine selon la revendication 14, **caractérisée en ce que** aussi le deuxième outil (3) comprend des particules qui ont été frittées ensemble pour former un corps poreux.

16. Une machine selon l'une des revendications 12 à 15, **caractérisée en ce que** les premiers et deuxième outils (1, 3) sont montés sur des supports qui peuvent être tournés entre des positions angulaires différentes.

17. Une machine selon l'une des revendications 12 à 16, **caractérisée en ce que**, en plus du premier et du deuxième outils (1, 3), des outils supplémentaires sont disposés sur le trajet allant de la paire formée par le premier et le deuxième outil jusqu'à l'appareil de chauffage à micro-ondes (17), les outils supplémentaires formant des paires d'outils coopérants dans lesquels un produit fibreux peut être soumis à un assèchement supplémentaire et les outils supplémentaires étant en outre agencés pour transporter un produit fibreux (10) vers le chauffage à micro-ondes (17).

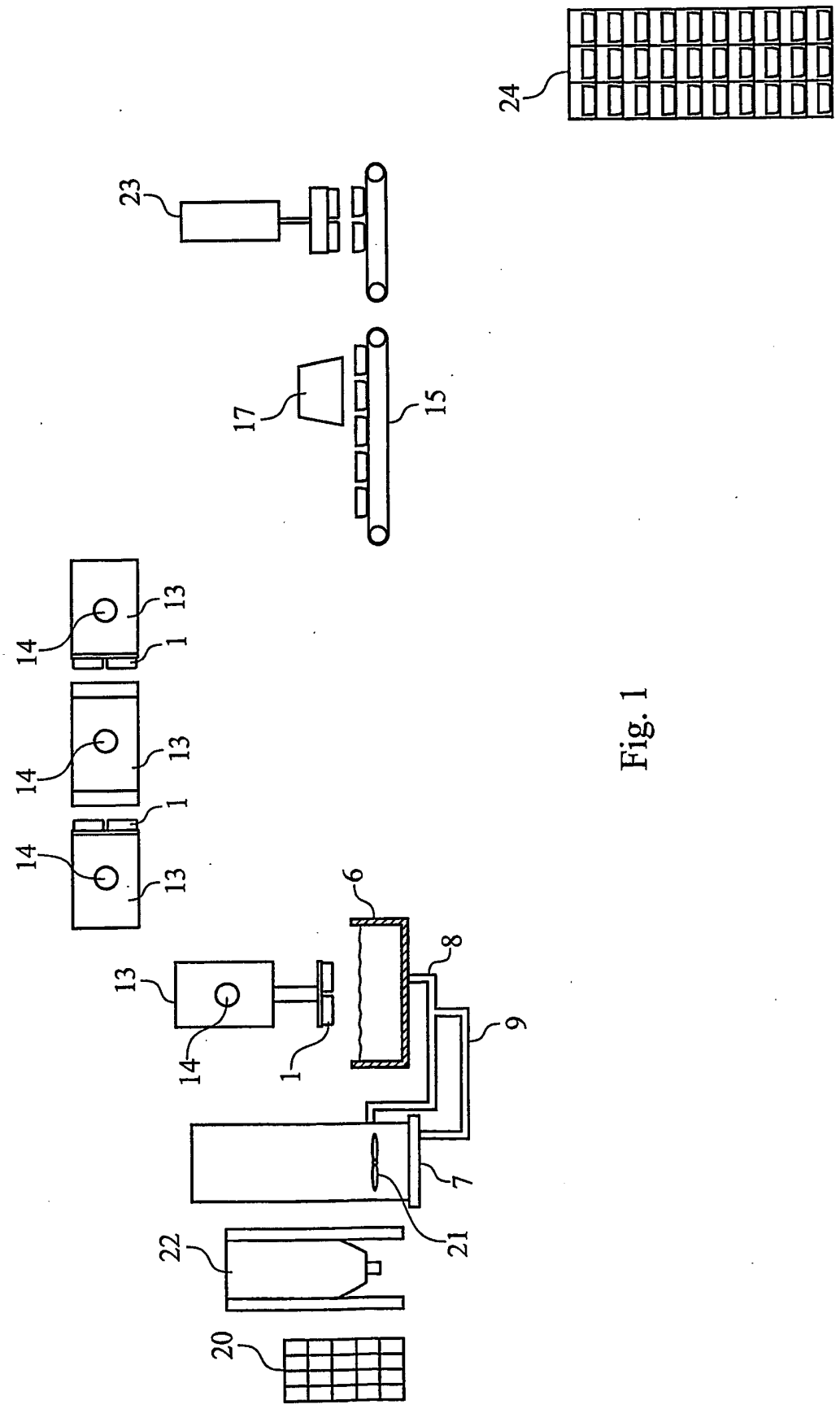


Fig. 1

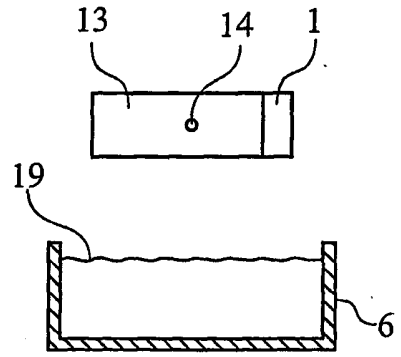


Fig. 2a

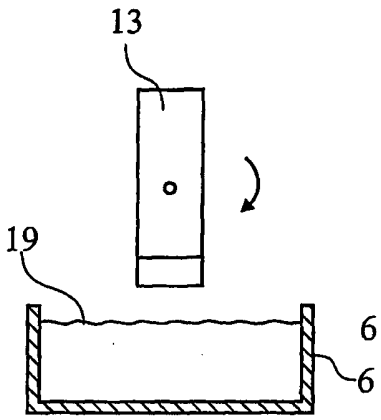


Fig. 2b

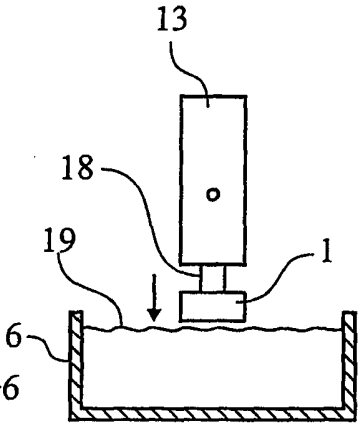


Fig. 2c

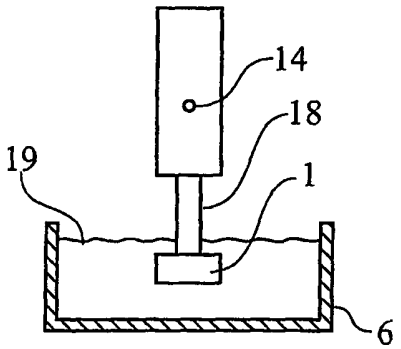


Fig. 2d

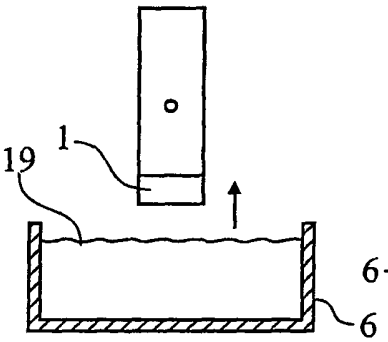


Fig. 2e

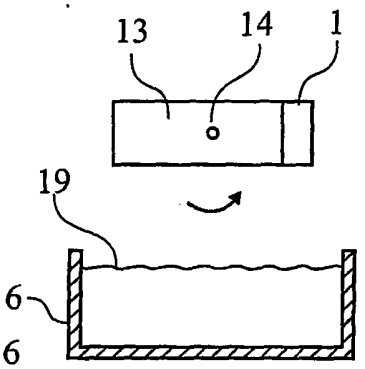


Fig. 2f

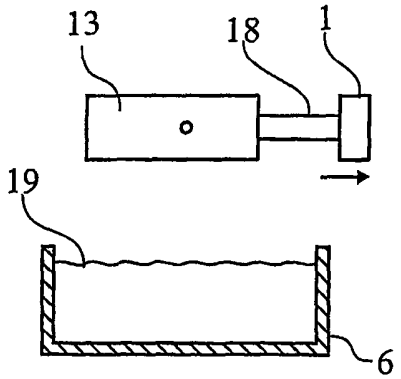


Fig. 2g

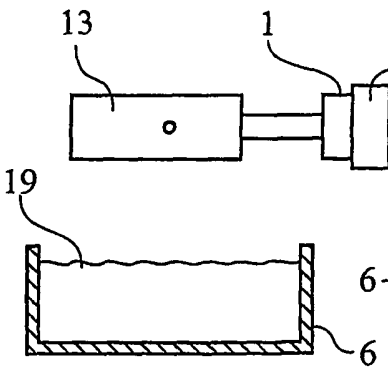


Fig. 2h

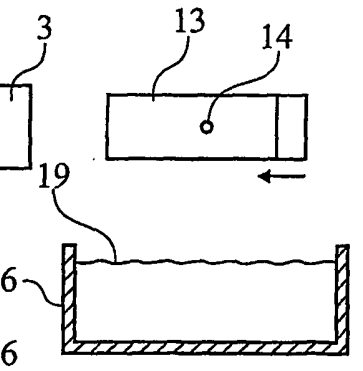


Fig. 2i

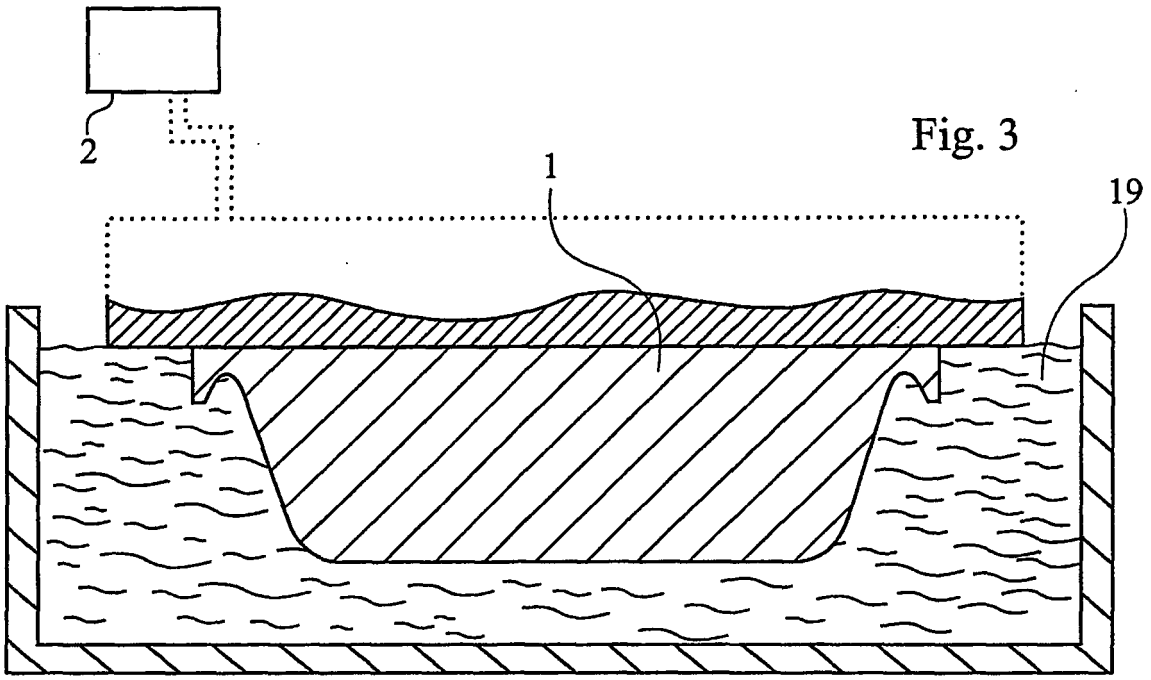


Fig. 3

Fig. 4

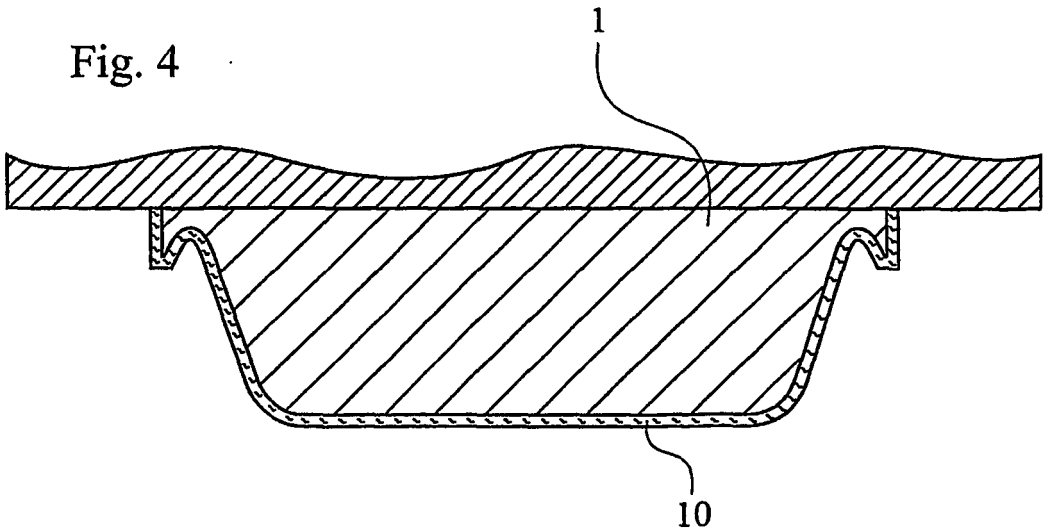
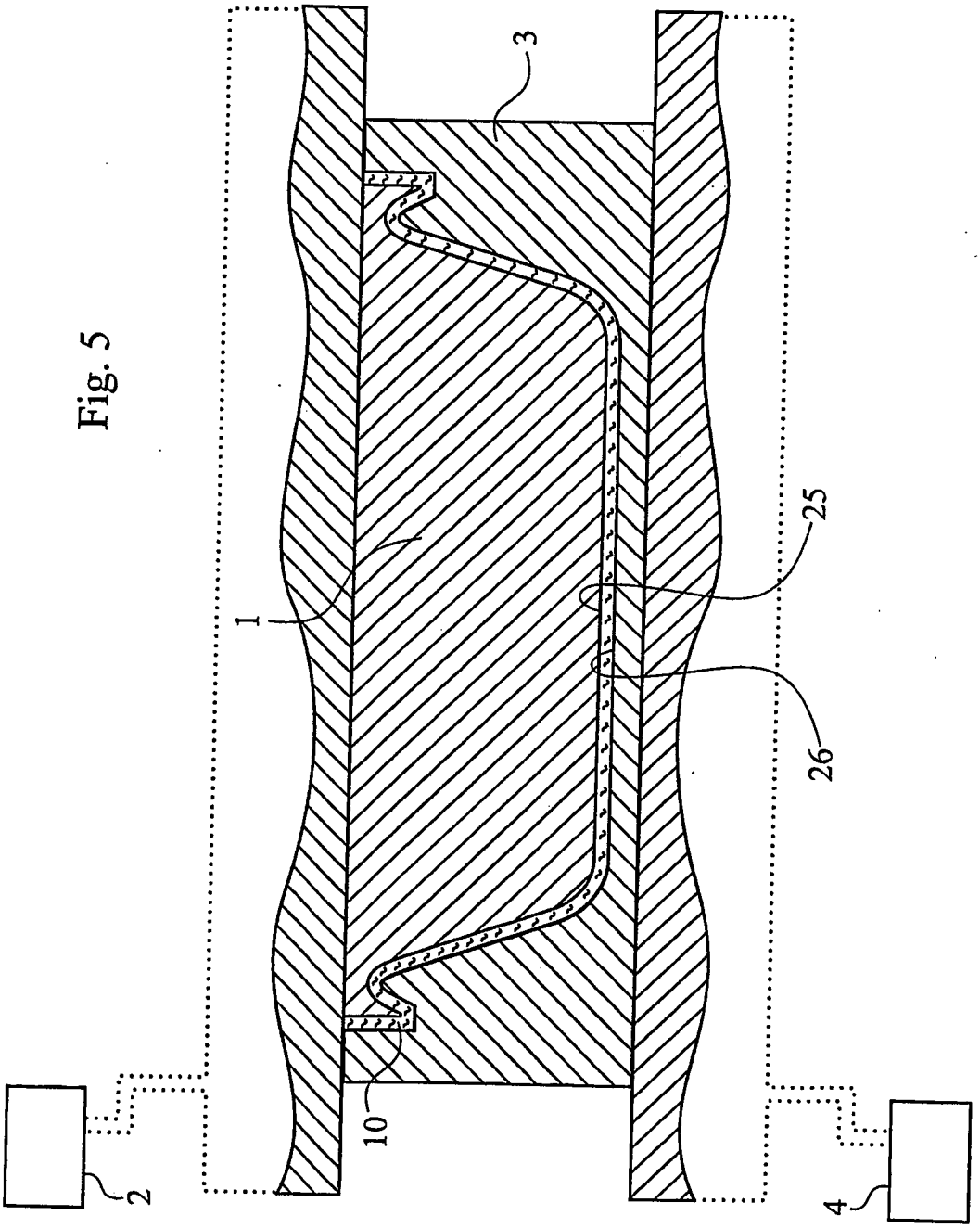


Fig. 5



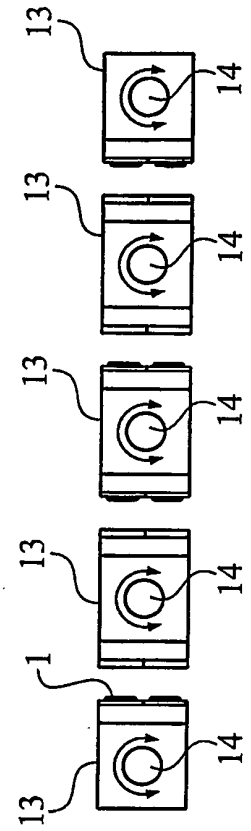


Fig. 8

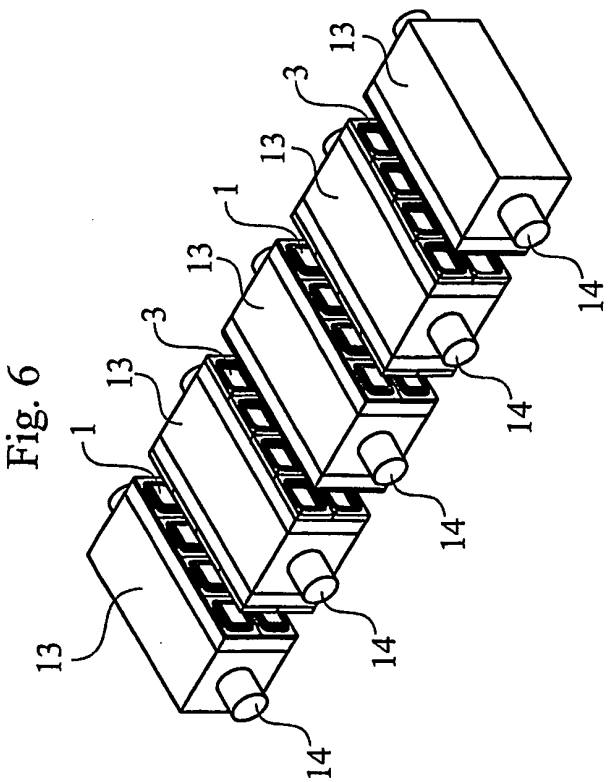


Fig. 6

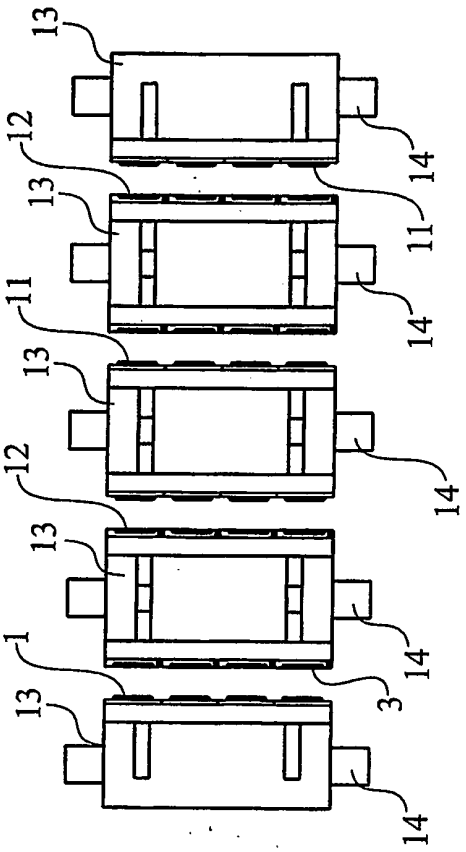


Fig. 7

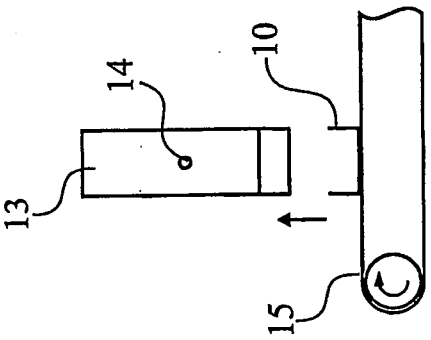


Fig. 9d

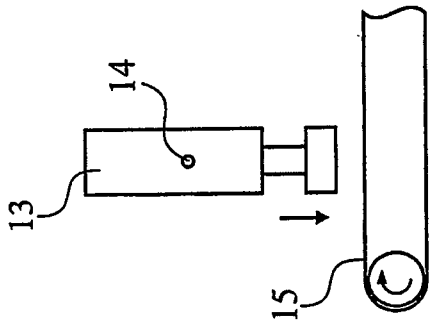


Fig. 9c

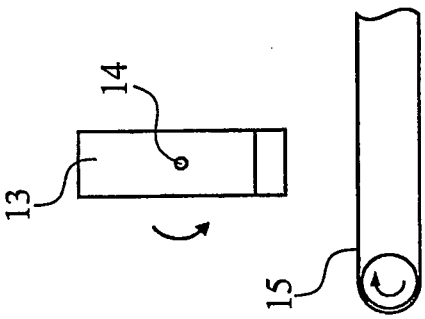


Fig. 9b

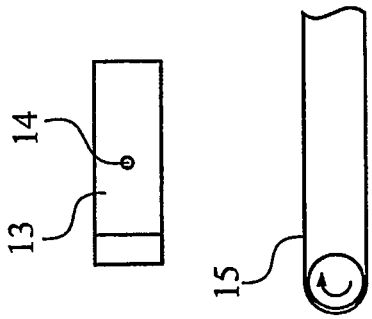


Fig. 9a

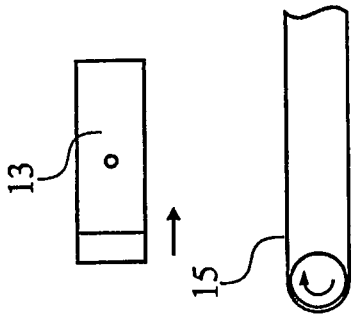


Fig. 9h

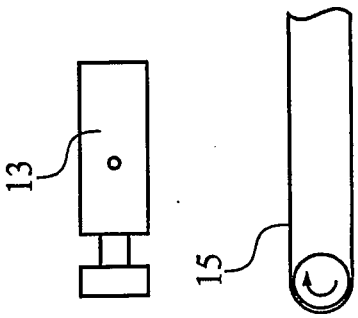


Fig. 9g

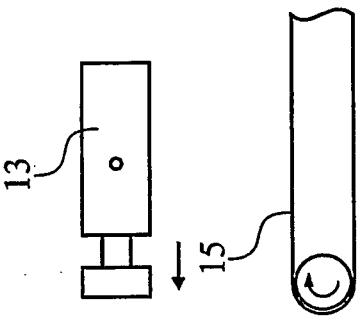


Fig. 9f

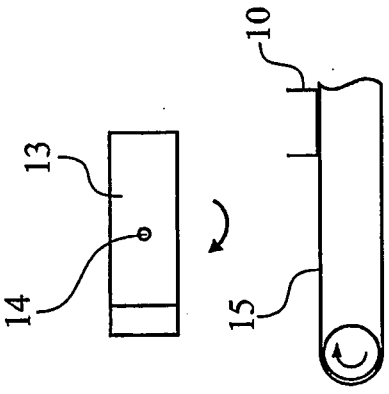


Fig. 9e

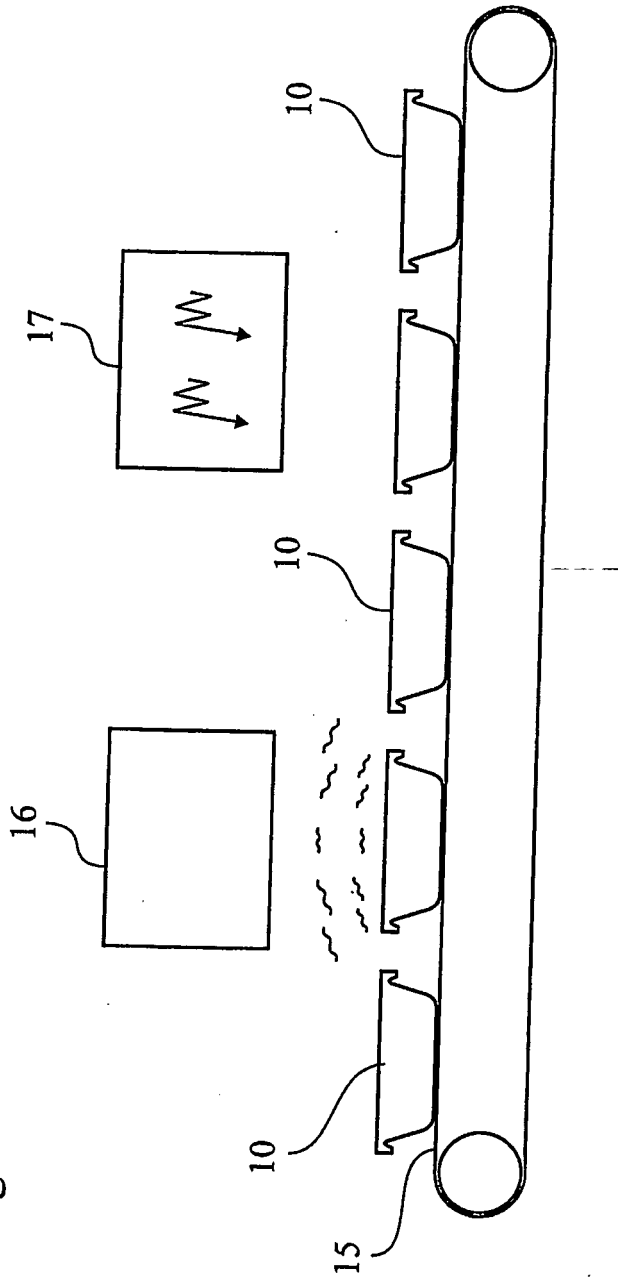


Fig. 10

Fig. 11

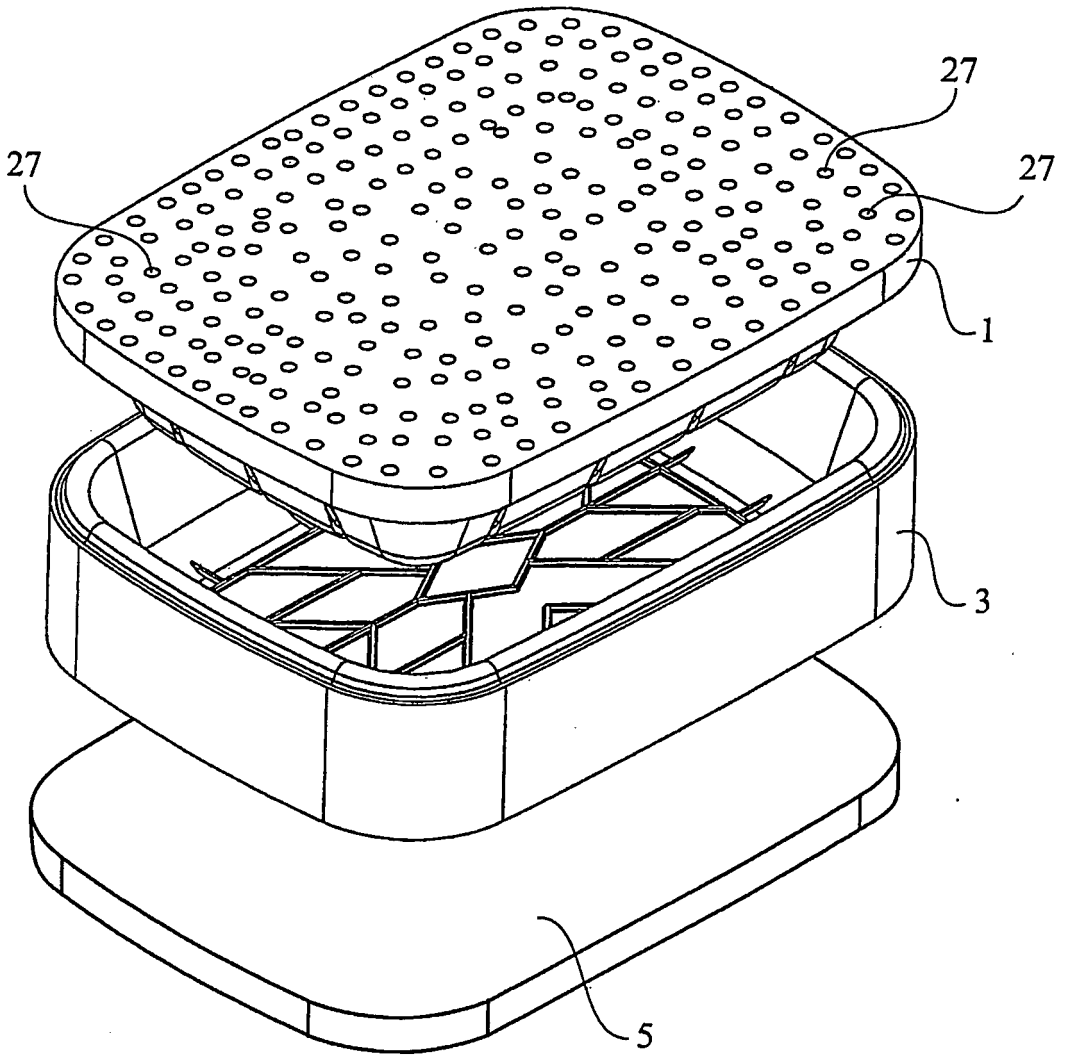
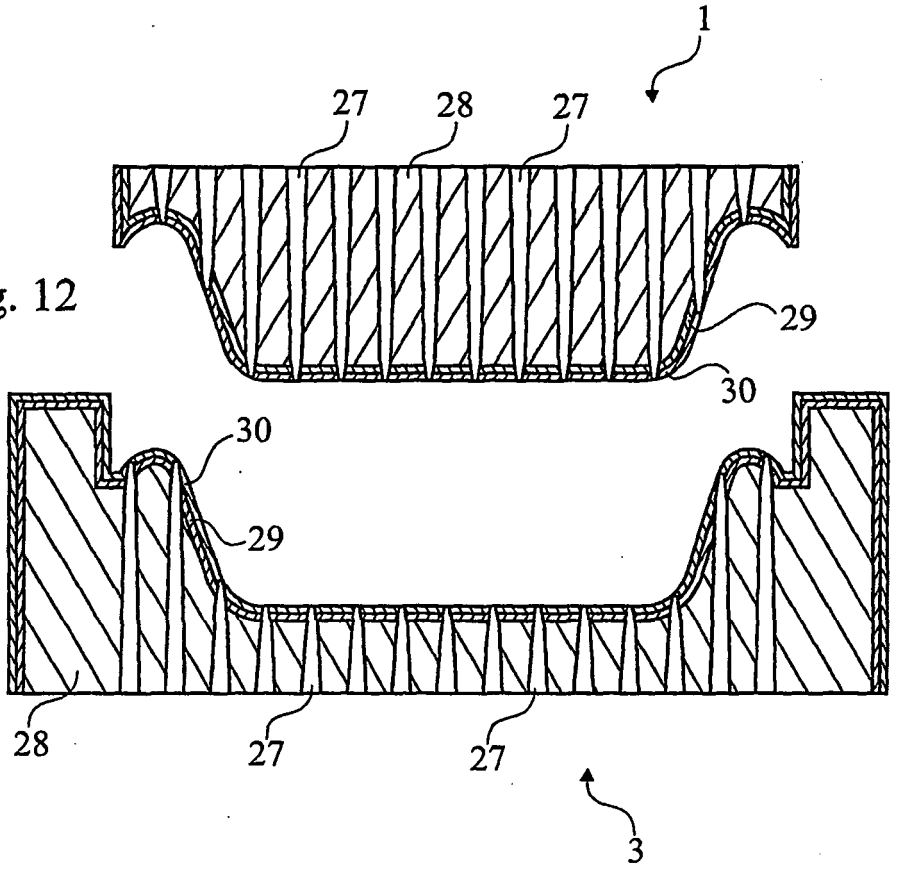


Fig. 12



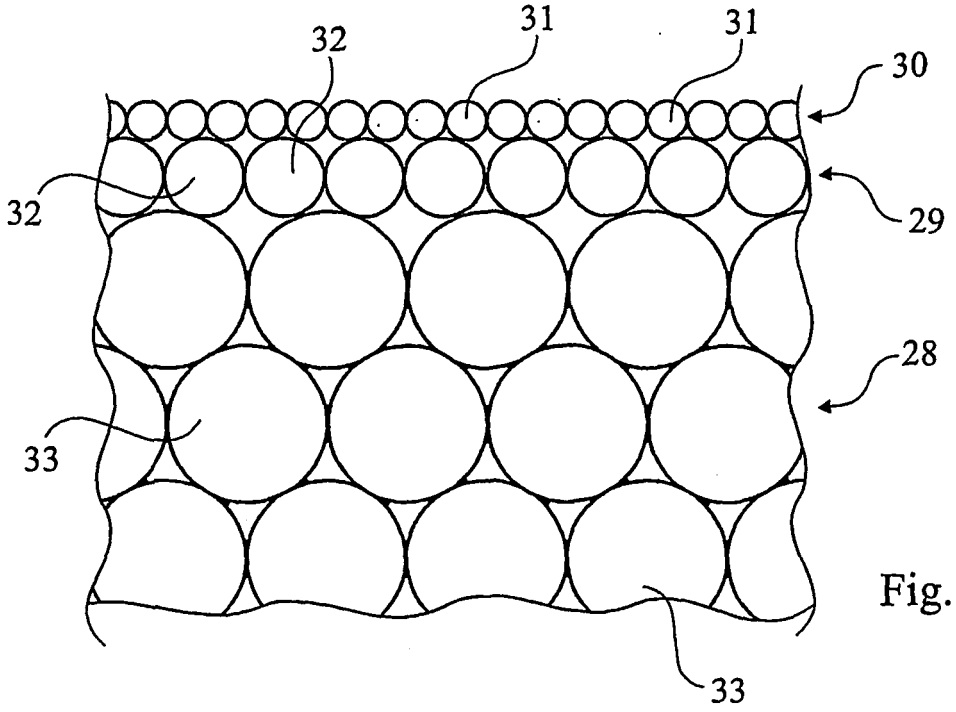


Fig. 13

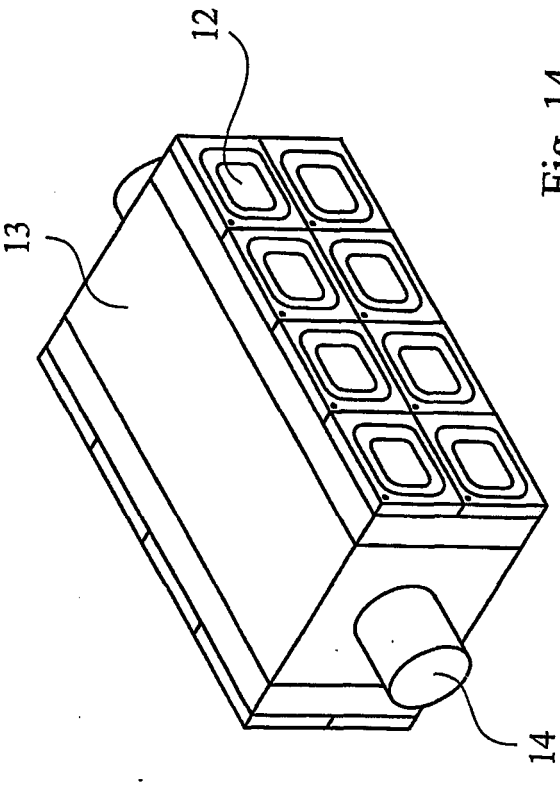


Fig. 14

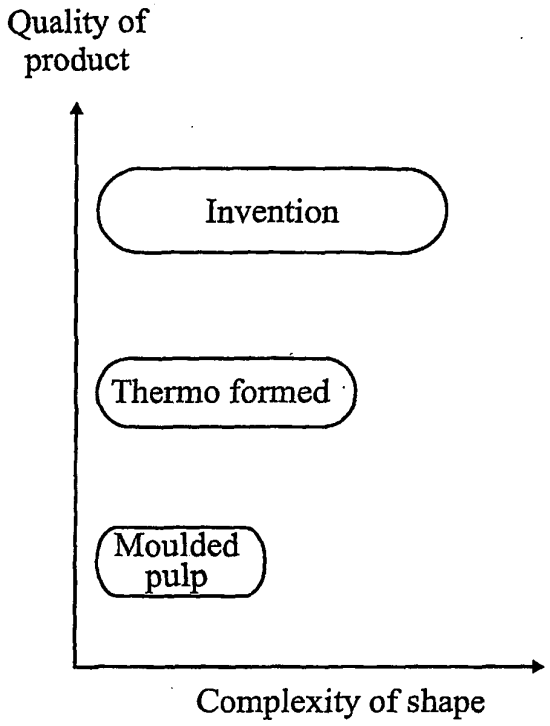


Fig. 15a

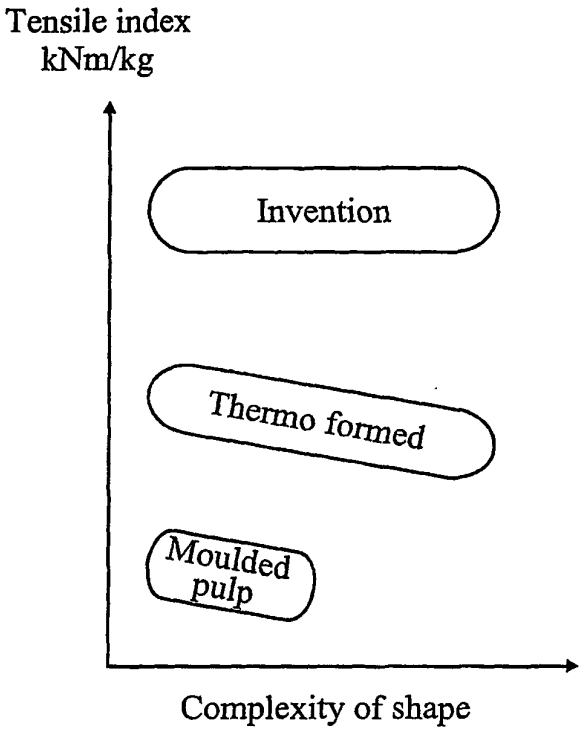


Fig. 15b

	Moulded Pulp	**Thermo formed** (prior art)	**Invention**
Grammage g/m2	200	200	200
Roughness (sideA/sideB) According to bendtsen ISO 8791-2	More then 5000/4000	900/1800	900/900
tensile index kNm/kg Iso1924-2.	26	55	82
Density kg/m3	220	580	800
Tear index	5	9	14
air resistance sek by gurley method iso 5636-5	24	52	90

Fig. 15c

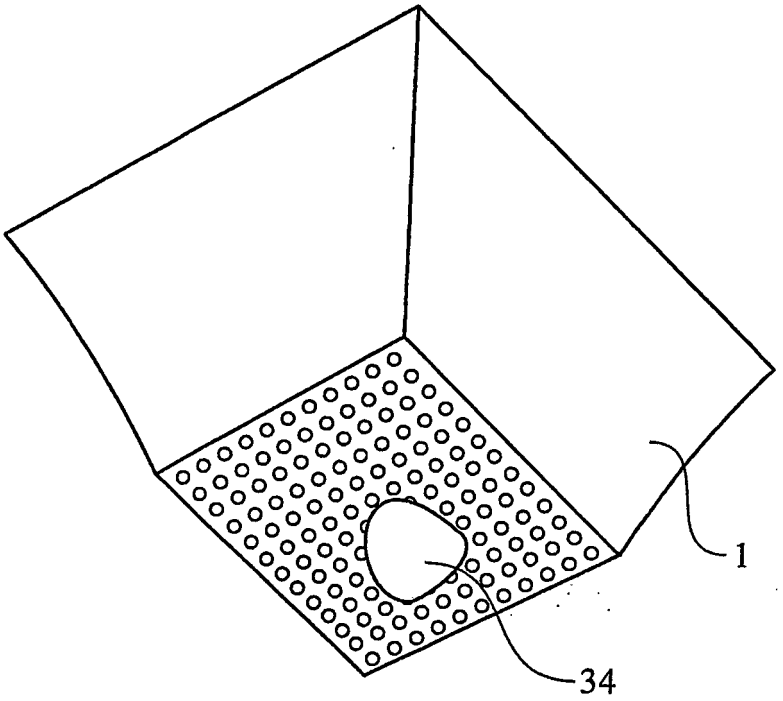


Fig. 16

REFERENCES CITED IN THE DESCRIPTION

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