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(54) Method and apparatus for manufacture of embossed fibre cement board and said embossed fibre cement board

(57) The method of manufacturing profiled fibre cement sheets includes the stages of preparing raw materials and preparing a mixture, forming and shaping the fibre cement sheets, cold pressing of the sheets, preliminary hardening of the sheets, follow-up hardening of the sheets and finishing the sheets. The equipment for manufacturing the profiled fibre cement sheet includes a device for forming and shaping the fibre cement sheets, a conveyor for preliminary hardening of the fibre cement sheets, a flow-through shelf for follow-up hardening of the fibre cement sheets, and a template painting system for finishing the fibre cement sheets. The stage of forming and shaping the fibre cement sheet utilises a seven-step device including a slurry bath 1, a mixer 2 added to the slurry bath, oil sprayers 11 and a formwork which comprises a shell 4, a vacuum chamber 5 located inside the shell 4, a covering sieve 6 which covers the outside of the work surface of the formwork, water removal channels 7 between the covering sieve 6 and the vacuum chamber 5, a vacuum pipe 8, fastening eyes 9 of the formwork, and a counterpart 10 of the formwork. The profiled fibre cement sheet has a thickness in range 1.5 to 3 mm and a relief depth in range 10 to 120 mm and includes an imitation pattern 33, an imitation edge 34, an imitation vertical joint 35, an imitation horizontal joint 36, and also a fastening opening 37, grooves 38 hindering lateral movement of water, grooves 39 ensuring proper positioning of fibre cement sheets to each other or an overhang 40.

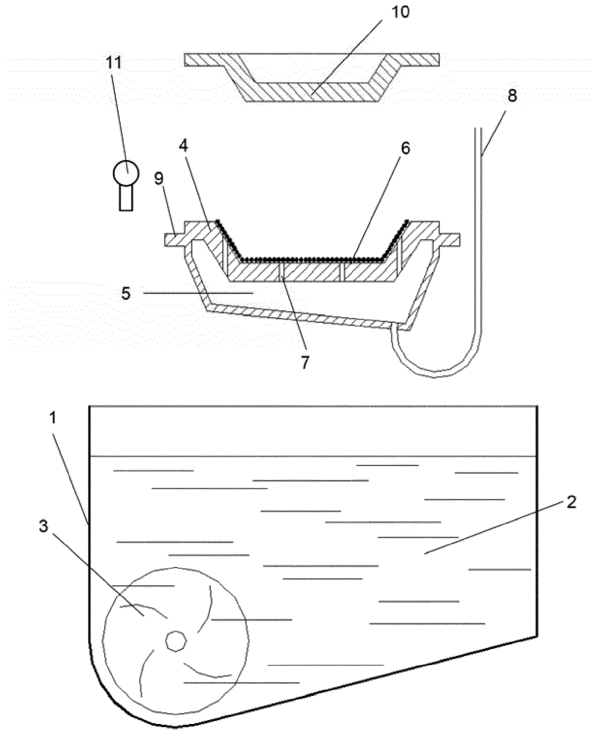

FIG 2

EP 2 687 346 A1

Description

FIELD OF TECHNOLOGY

[0001] This invention belongs to the field of manufacturing fibre cement sheets, particularly the field of manufacturing lightweight façade decorations and roof sheets with various shapes and imitation patterns.

PRIOR ART

[0002] Fibre cement sheet is a widely used building material. It is mainly utilised for roof covering (for example as wave-profiled sheets and as shingles) and façade covering (for example as printed imitation of wood, stone and bricks); fire-resistant fibre cement sheets are also made. The well-know solutions have a sheet thickness of 5 to 6 mm for roof covering and mainly 6 to 12 mm for façade covering (up to 20 mm as imitation of bricks or natural stone). Fibre cement is also used for manufacturing garden furniture. Fibre cement sheets have proven to be a very durable building material.

[0003] The industrial technology for manufacturing fibre cement sheets was proposed by Austrian inventor L. Hatschek in the beginning of the 20^{th} century. The product was called eternit thanks to its durability (*éternité - eternity in French*). Asbestos was used as the reinforcement fibre. The technology invented by Hatschek is still the most widespread method for manufacturing fibre cement sheets.

[0004] In 1970s, awareness about the health hazard posed by asbestos started to appear. In the end of 1980s, Europe gradually stopped using asbestos in manufacturing of fibre cement sheets. Asbestos has now been substituted by cellulose and PVA (polyvinyl alcohol) or PAN (polyacrylonitrile) fibre. Cellulose acts as a technological fibre and the synthetic fibres provide the end product with strength and durability. Since 01 January 2005, all Member States of the European Union prohibit the use of asbestos and any products containing it. On the other hand, several other countries are still producing asbestos-containing fibre cement products today.

[0005] The well-known process of manufacturing fibre cement sheets consists of the stages of preparing the raw materials, forming the sheets, drying the sheets and if necessary then finishing the sheets. In modern fibre cement sheets the raw material preparation stage utilises mainly cellulose instead of asbestos. The exact constitution of the mixture depends largely on the drying method. There are air-dried and autoclave-hardened fibre cement sheets. Cellulose is soaked in water and then fibrillated (after which it separates into fibres); thereafter it is directed into the cellulose slurry pool. For air-dried fibre cement sheet, the cellulose is mixed with durable synthetic fibres, e.g. PVA (polyvinyl alcohol) or PAN (polyacrylonitrile), depending on the required physical properties of the finished product. Cellulose acts as a technological fibre and the synthetic fibres provide the end product with strength and durability. When manufacturing autoclave-hardened fibre cement sheets (where calcium silicate is formed), only cellulose is used.

[0006] The most commonly used binder material for manufacturing fibre cement sheets is Portland cement, supplemented by finely ground limestone (dust) or quartz sand. Lower-weight filler materials are used in some cases. For autoclave-hardening fibre cement sheets, 50% of the cement is substituted by finely ground quartz sand (with high silicone dioxide - SiO_2 - content). In air-hardening fibre cement sheets the quartz sand content may be up to 25%.

[0007] Ordinary quartz sand is finely ground in a special wet mill with rubber lining, resulting in sand slurry. Sand slurry is pumped into a slurry pool where mixers retain the slurry in a state of suspension. Depending on the required density of the mixture, a computer then calculates the water content already present in the slurry and configures the dosing equipment for automatic addition of the necessary additional water. The production water is utilised repeatedly in the technological process. The cellulose slurry is pumped onto scales and dosed as a primary component. The mixing order is as follows: the slurry is directed into the main mixer; then cement, additives and production water are added (the specific details of the procedure depend on the formula of the mixture and the quality of the raw materials); the mixing time is configured for an optimum mixture quality; recuperators add clean production water.

[0008] After mixing, the freshly made slurry is stored in a pool where it remains until it has to be added to the homogeniser for further use in the sheet forming machine. The homogeniser carefully mixes together the fresh slurry coming from the slurry pool, the reject material redirected from production, and the waste materials. Production water is added until attaining the required density of the mixture (the automation calculates the ratio of volume and mass of the mixture).

[0009] There are several different sheet-forming technologies used in the world; the most common of those are the *Hatschek method,* the *Flow-on method* and the *extruder method.* The goal of all technologies is to form the solid content of the slurry into a smooth solid element, removing the superfluous water (by pressing and vacuuming). After forming, the sheet retains its shape on the production line (doesn't flow apart) and it can be lifted with suction heads.

[0010] Freshly made sheets are cut to prescribed dimensions. Different cutting systems are required for manufacturing standard straight sheets, lining sheets, shingles or wave-profiled roofing sheets. Cutting of fresh sheets may be the final cutting or it may be preliminary cutting followed by hardening and second, i.e. final cutting.

[0011] Profiled surface of the sheets is formed directly by a forming roller (without additional pressing) or with a press roller. Wave-profiled sheets are pressed with a single press. Follow-up pressing increases the weather resistance of the sheets.

[0012] In the drying stage, the air-drying fibre cement sheets are stacked onto trolleys for preliminary hardening as a mixed stack, i.e. straight of wave-profiled steel sheets are placed between fibre cement sheets. Autoclave-hardening sheets are stacked without intermediate sheets. After the sheets have hardened somewhat (the duration of such preliminary hardening depends on the cement being used), the hydratation of cement makes the sheets sufficiently hard and the sheets are sent to full hardening in air (air-drying sheets) or in an autoclave (autoclave-hardening sheets).

[0013] After a preliminary hardening of 8-10 hours, the air-drying sheets are placed on wooden bases and left in air for 2-4 weeks of follow-up hardening (at room temperature). The autoclaving process (for autoclave-hardening sheets) begins with steaming and gradual increasing of pressure until 10-12 bar at the temperature of 180-190°C. Once attained, the pressure and the temperature are kept stable for a few hours, until calcium silicate hydrate forms and the sheets harden. In the end of the autoclaving cycle, the pressure decreases slowly to the atmospheric level.

[0014] Depending on the usage purpose of the fibre cement sheets, they may need final finishing. Fully hardened sheets are processed in machines which apply surface covering or paint cover to them or grind their surfaces and edges.

[0015] The methods known from the current level of technology allow manufacturing large quantities of high-quality fibre cement sheets (the production capacity of a production line is approximately 2 to 20 t/h). The thickness of the produced sheets is approximately 4 to 20 mm. The main existing forming technologies (*Hatschek, Flow-on,* etc.) result in straight sheets exiting the forming machine. Fresh (unhardened) straight sheets can be formed into profiles, but in a limited way. Sharper profiles can have up to 2 mm of depth. As a rule, only one side of the sheet can be profiled. Wave-profiles must have a gentle line. Pressing in sharper profiles would bend the fibre ends loose at the bending lines or would cause tears in the sheet. This in turn would deteriorate the looks and the strength of the sheets. Sheets manufactured with the *extruder* technology can have a deeper pattern on one side (approx. 10 mm), but only with higher sheet thickness (approximately 20 mm). Thus the technologies currently used in the world do not allow manufacturing fibre cement sheets with complex profiles.

[0016] In order to use façade decoration, certain physical requirements to the construction of the wall must be respected, in that the thermal insulation must be located on the exterior side of the wall. Façades are divided into ventilated and non-ventilated façades. Ventilated façades have an air gap between the thermal insulation and the façade covering; non-ventilated façades have no air gap. In case of non-ventilated façades it is recommended that the façade covering be made of a breathing material. This allows the effect where moisture entering the walls can dry off to outside. In ventilated façades the moisture can escape via the air gap and thus the breathing properties of the external cover material are not important.

[0017] It is technologically easier to build non-ventilated façades. On the other hand, the thermal insulation materials used (EPS, façade wool, etc.) have usually low mass per volume and thus limited load-bearing capacity and durability. Thus the façade covering installed onto thermal insulation must be lightweight. For those reasons it is currently not possible to use fibre cement sheets as façade covering for non-ventilated façades, although the breathing properties of the material would allow it.

[0018] There is a wide variety of different roof covering materials used in the world. One of the most common among those is roof tiles. They are good-looking, durable, don't make loud noise in rain and they are breathing. On the other hand, roof tiles are usually heavy (requiring large transport expenses and a carrier structure with high load-bearing capacity), and the tiles are small and thus require lots of time to install.

SUMMARY OF THE INVENTION

[0019] The purpose of this solution is to offer a method and equipment for manufacturing fibre cement sheets with any level of profile complexity, and to offer a profiled fibre cement sheet which could be used as a façade covering for non-ventilated façades. The sheet made with the method detailed in this invention is a shell with a uniform thickness, whereas in large-volume production the thickness would be in the range of 1.5 to 5 mm and the profile depth would be up to 100 mm having any level of profile sharpness. Production volumes would decrease when manufacturing the sheets with thickness over 5 mm.

[0020] Unlike the currently known solutions, the fibre cement sheet manufactured according to this method has less thickness and less weight when compared to fibre cement sheets manufactured with the currently known technologies and having the same physical properties.

[0021] The low weight and the unlimited profile options allow the fibre cement sheet manufactured with this method to be utilised in various areas of constructions where it has been impossible until now. For example, it is possible to manufacture sheets with various patterns and profiles, to be glued onto thermal insulation. The method also allows manufacturing sheets with all kinds of roof tile imitations or imitations of other stone materials, which is not possible with the currently known technologies.

[0022] This method allows manufacturing lightweight fibre cement sheets with various shapes (for example as façade decoration), to be glued directly to thermal insulation with glue mortar. Such sheets don't require any screws or other additional fixtures for installing. The various patterns of the fibre cement façade decorations can be e.g. imitation of bricks or natural stone, etc. The edges of the façade decoration sheets have overhang. The edge of the upper sheet is always on the edge of the lower sheet. Thus any water will always flow from the upper sheet to the lower sheet and this excludes any water seeping behind the decoration. The joints of sheets are not filled. This allows the sheets to have some thermal play without encountering mechanical stresses. Finishing materials for façade decoration sheets must be silicate paint and fine sand, as these are also breathing materials. When compared to the existing façade covering sheets, the fibre cement façade decoration made with this method is breathing, has lower cost price and is easier and faster to install.

[0023] This method allows manufacturing a roof sheet having all the good properties of usual roof tiles and none of their shortcomings. The roof sheet comprises a monolithic fibre cement sheet with a thickness of approximately 5 mm, looking like approximately 8 assembled roof tiles. Any kind of roof tiles can be imitated.

[0024] As this method widens the design opportunities of fibre cement sheets in a revolutionary extent, it is clear that the areas of application are not limited to the few examples given here.

[0025] The equipment for manufacturing profiled fibre cement sheet as detailed in this invention includes a device for forming and shaping the fibre cement sheet, a conveyor for preliminary hardening of the fibre cement sheet, a flow-through shelf for follow-up hardening of the fibre cement sheet, and a template painting system for finishing the fibre cement sheet.

DESCRIPTION OF THE DRAWINGS

[0026] This invention is explained in more detail with references to the drawings where:

The Figure 1 shows a flow diagram of the method detailed in this invention;
Figure 2 shows a schematic of the device to be utilised in the sheet forming and shaping stage of the method detailed in this invention;
Figure 3a shows form 3 of the device to be utilised in the sheet forming and shaping stage of the method detailed in this invention, as variant A with the formwork's work surface directed down;
Figure 3b shows form 3 of the device to be utilised in the sheet forming and shaping stage of the method detailed in this invention, as variant B with the formwork's work surface directed up;
Figures 4-1 to 4-7 show work steps 1 to 7 of forming and shaping the fibre cement sheet;
Figure 5 shows a schematic of the multi-storey conveyor used in the preliminary hardening stage of this method;
Figure 6 shows a schematic of the flow-through shelf utilised in the follow-up hardening stage;
Figure 7 shows template painting utilised for finishing of the fibre cement sheet manufactured method detailed in this invention;
Figure 8 shows the possible thickness and profile of fibre cement sheets manufactured according to the methods known from the current level of technology;
Figure 9 shows the possible thickness and profile of fibre cement sheets manufactured according to the method detailed in this invention;
Figure 10 shows an implementation example of a fibre cement sheet manufactured according to this method, i.e. a roof sheet;
Figure 11 shows an implementation example of a fibre cement sheet manufactured according to this method, i.e. a façade decoration.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The method of manufacturing profiled fibre cement sheets as detailed in this invention includes the stages of preparing raw materials, forming the fibre cement sheets, preliminary hardening of the sheets, follow-up hardening of the sheets and finishing the sheets.

[0028] In the stage of preparing raw materials for the fibre cement sheet manufactured with this method, a mixture is prepared which has a 2 to 40 (preferably 10 to 14) times less volume than the mixture prepared in the currently known process of manufacturing air-drying fibre cement sheets.

[0029] Cellulose is supplied to the factory as packages. After soaking in water, cellulose is separated into fibres and then directed into the cellulose slurry pool. Bleached and unbleached cellulose can be used. Cellulose is used for strengthening the fibre cement sheets, but it also acts as a technological fibre, facilitating the process of producing synthetic fibres. In the course of fibrillating, cellulose is separated into fibres and thus attains maximum strength.

[0030] Cellulose is mixed with durable synthetic fibres like PVA (polyvinyl alcohol) or PAN (polyacrylonitrile), depending on the required physical properties of the finished product. The synthetic fibres provide the end product with strength and durability. The cellulose slurry is pumped onto scales and dosed as a primary component.

Binder materials and additives

[0031] The binder material of the fibre cement sheets manufactured with this method is Portland cement and the main additive is finely ground limestone dust or finely ground quartz sand, supplied in tanker trucks or railcars and stored in outdoors silos. The silos should have the storage capacity satisfying the raw material need for 3-12 work days (this volume depends on the supply certainty of the components). The daily needed volume is directed into day silos located inside the production building where the materials attain room temperature. Cement and additives are dosed onto scales by separate screw dosers.

Mixing

[0032] All raw materials are weighed and dosed. The overall volume of water has an important role in the composition of the mixture. The system automatically regulates the water content in the mixture. Depending on the required density of the mixture, a computer then calculates the water content already present in the slurry and configures the dosing equipment for automatic addition of the necessary additional water. The production water is utilised repeatedly in the technological process.
[0033] The mixing order is as follows:

- the slurry is directed into the main mixer;
- cement, additives and production water are added (the specific details of the procedure depend on the formula of the mixture and the quality of the raw materials);
- mixing time is configured for an optimum mixture quality;
- recuperators add clean production water.

[0034] After mixing, the freshly made slurry is stored in a pool where it remains until it has to be added to the homogeniser. The homogeniser carefully mixes together the fresh slurry coming from the slurry pool, the reject material redirected from production, the waste materials and the production water, until attaining the required density of the mixture. From the homogeniser, the slurry is directed into the sheet forming machine.

Composition of the mixture

[0035] The mixture composition for the fibre cement sheet manufactured with this method is similar to the mixture composition used for manufacturing the sheets with the *Hatschek* technology known from the current level of technology.

Main components of the composition (kg per 1 tonne)

[0036]

Components	Kg per 1 tonne of mixture
cellulose 1)	30-70 (preferable close to kraft cellulose)
synthetic fibre	20 - 30
Portland cement 2)	640 - 730*
additives (finely ground limestone dust, etc.)	< 100
aluminium trihydrate	< 10
water (chemically crystallises in the product)	140 - 200
industrial water	200 - 300
1) up to 50% of the cellulose may be substituted by waste paper. 2) up to 25% of the Portland cement may be substituted by finely ground quartz sand.	

Requirements for Portland cement

[0037]

C3S	> 50%
C3A	7 - 10%
C2 (A, F)	< 10%
Na2O + K2O	<1%
Artificial stone density	3,200 - 4,500 kg/m3

<u>Requirements for synthetic fibre</u>

[0038] *PVA (polyvinyl alcohol) fibres,* fibre length 4 - 6 mm and fibre strength 27 - 54 km [ZST], or *PAN (polyacrylonitrile) fibres,* fibre length 4 - 6 mm and fibre strength 23 - 25 km [ZST].

[0039] The composition described above is one of the preferable variants. The exact composition of the mixture is determined according to the required parameters and intended purpose of the sheets. Depending on the product being manufactured, colouring agents can be added to the slurry; this results in the entire sheet being of single tone throughout its thickness.

[0040] Unlike the usual process of forming paper mass (cellulose), the stage of initial forming of fibre cement sheets manufactured with this method is performed together with cold pressing as this yields better results.

[0041] The equipment for manufacturing profiled fibre cement sheet as detailed in this invention includes a device for forming and shaping the fibre cement sheet (as shown in the following drawings: Figure 2, Figure 3a and Figure 3b and Figures 4-1 to 4-7), a conveyor for preliminary hardening of the fibre cement sheet (as shown in the following drawing: Figure 5), a flow-through shelf for follow-up hardening of the fibre cement sheet (as shown in the following drawing: Figure 6) and a template painting system for finishing the fibre cement sheet (as shown in the following drawing: Figure 7).

[0042] The equipment to be used in the stage of forming the fibre cement sheet includes a slurry bath 1 into which the slurry 2 is added, a mixer 3 added to the slurry bath 1, oil sprayers 11 and a moving formwork which comprises a shell 4, a vacuum chamber 5 located inside the shell 4, a covering sieve 6 which covers the outside of the work surface of the formwork (the covering sieve's mesh openings should preferably be sized approximately 0.5 mm), water removal channels 7 between the covering sieve 6 and the vacuum chamber 5, a vacuum pipe 8, fastening eyes 9 of the formwork, and a counterpart 10 of the formwork, whereas the formwork may be positioned in two ways (as shown in the following drawings: Figure 3a and Figure 3b).

[0043] In case of the formwork positioning variant A (as shown in the following drawing: Figure 3a), the work surface of the formwork is directed down. In case of the formwork positioning variant B (as shown in the following drawing: Figure 3b), the work surface of the formwork is directed up. In case of variant A, only the work surface of the formwork together with the covering sieve 6 is dipped into the slurry 2 in the course of the work cycle. In case of variant B, the entire formwork together with the vacuum chamber 5 is dipped into the slurry 2. In case of variant B, forming is possible both with and without vacuum, although it's preferable to use vacuum in order to quicken the work cycle. In case of variant A, the formwork can move up-down on a straight line or in a circle. In case of variant B, the formwork can move up-down on a straight line only.

[0044] The work steps of forming the sheet are shown in the following drawings: Figure 4-1 to 4-7:

Step 1: formwork is oiled

Step 2: formwork is dipped into the slurry

Step 3: the sheet is formed. In case of using the formwork with work surface directed down, i.e. variant A, the solid particles in the slurry 2 are vacuumed to the surface of the formwork until achieving the required layer thickness. Due to vacuuming, the solid particles are deposited to the surface of the covering sieve 6 and water is sucked out through the covering sieve 6. Water is sucked into the vacuum chamber via water removal channels in the surface of the formwork. From the vacuum chamber, water is directed via vacuum pipes into reuse in the process. The particles deposited on the mesh constitute the formed sheet 12.

In case of using the formwork with work surface directed up, i.e. variant B, after lifting up the formwork, the formwork is filled with the slurry 2 which seeps out under gravitation or due to vacuuming being used to quicken the process. As a result of the process, a layer of solid particles (the sheet) with the required thickness is deposited on the covering sieve 6 of the formwork.

Step 4: oiling the side of the fibre cement sheet 12.

Step 5: the counterpart 10 of the formwork moving against the formed sheet 12.

Step 6: initial pressing.

Step 7: counterpart 10 of the formwork moving away from the formwork, whereas the fibre cement sheet 12 remains attached to the counterpart 10 of the formwork. The side of the fibre cement sheet against the formwork is smoother and will be used as the front side of the fibre cement sheet. The side of the fibre cement sheet against the counterpart

10 of the formwork is more uneven and will be used as the back side of the fibre cement sheet. The mixer 3 is running throughout all steps, in order to retain a homogeneous consistence of the slurry 2.

[0045] After step 7, the sheets are directed into cold pressing. Cold pressing is a secondary pressing of the sheet with a force of 80-220 kg/cm^2. In the course of cold pressing, the remaining surplus water is removed from the sheet, the sheet attains a higher density (its thickness is reduced by up to 30% due to pressing), and as a result the sheet becomes more resistant to weather.

[0046] After the initial pressing, the side of the sheet that was against the covering sieve 6 displays the profile of the covering sieve 6; this is due to the fact that the surface of the initial formwork is covered by the covering sieve 6. Upon cold pressing, the pattern of the covering sieve 6 is lost. The initial pressing doesn't allow finer patterns (less than 5 mm) to be pressed into the sheet. Upon cold pressing, a fine pattern (starting from 1 mm) is pressed into the sheet without changing the main shape of the sheet. Cold pressing can be performed as a single pressing (1 sheet at a time) or as a package pressing (in a mixed stack of die-sheet-die-sheet etc.). Unlike with well-known methods, the cold pressing dies are made of highly abrasive-resistant polyurethane.

[0047] Dies made of the aforementioned material don't require oiling during the process and have a very long service life. Unlike with well-known methods, the dies utilised in package pressing have a two-sided profile. Cold pressing gives the sheet its final surface profile.

[0048] After cold pressing, the fibre cement sheets are directed into preliminary hardening. The preliminary hardening stage of the method detailed in this invention takes place at room temperature and lasts for at least 8 hours. Due to the chemical process taking place inside the fibre cement sheet, its temperature may rise up to the level of 80°C.

[0049] Due to the shape and surface profile of the fibre cement sheet, the non-hardened sheets cannot be stacked on top of each other. A reasonable solution is to have the preliminary hardening process take place on a conveyor where the fibre cement sheets are lying as a single layer.

[0050] Figure 5 shows the conveyor system to be used in the equipment detailed in this invention, in the stage of preliminary hardening of the fibre cement sheet; the drawing shows the movement of the fibre cement sheets. The conveyor system should preferably have multiple storeys and comprises elevators 13, trolleys 14, trolley pockets 15 attached to lifting cables 16 of the elevator 13, a pusher 17 and the guiding rails 18 of the trolleys. The elevator 13 directs the non-hardened fibre cement sheets 12 onto the trolleys 14 moving on the guiding rails 18 of the trolleys on the storeys of the conveyor system; at the end of the process, another elevator 13 directs the preliminary-hardened fibre cement sheets 19 off from the trolleys. As a result of the preliminary hardening, the fibre cement sheets attain sufficient strength to have them stacked on a pallet. The fibre cement sheets stacked onto a wooden pallet are directed into follow-up hardening.

[0051] In the follow-up hardening process, the equipment detailed in this invention utilises a flow-through shelf shown in Figure 6. The follow-up hardening stage of this method takes place at the preferable temperature of 10-20°C and lasts for 2 to 4 weeks. During the period of follow-up hardening, the fibre cement sheets are stacked onto pallets 21 which are stored in the flow-through shelf 22 using a loader 20. In the flow-through shelf 22, a ramp 23 runs through various subsequent storage places. The incline of the ramps 23 of the flow-through shelf 22 is approximately 4%. The pallets 21 have rollers and move under gravity to the right places by themselves. The rollers have special brakes preventing any acceleration when moving on the ramp and thus preventing damages to the goods. The flow-through shelf 22 should preferably operate according to the FIFO principle; the fibre cement sheets are well protected, the risk of damaging them is minimised and the efficiency of utilising the warehouse space is high.

[0052] The number of subsequent storage places on a ramp running through the flow-through shelf 22 should preferably be equal to the number of days that a sheet spends in follow-up hardening. In that case, the same number of pallets 21 are added to each ramp in each day and taken off each ramp at the other side of the flow-through shelf in each day. In that case, the pallets 21 being taken off have passed through the entire ramp in the number of days prescribed for follow-up hardening.

[0053] If using a slurry containing colouring agent and if the manufactured sheets are allowed to be single-colour, the fibre cement sheets manufactured according to this method are ready to be used after the follow-up hardening and need no follow-up finishing.

[0054] The fibre cement sheet finishing stage of the method detailed in this invention is performed additionally after the follow-up hardening, depending on the requirements and the design of the fibre cement sheet being manufactured. For finishing, the fibre cement sheets stacked onto pallets 21 must be unstacked again and directed to the finishing line. Finishing can mean painting with a single or multiple paint layers (applied by a roll or a spray), covering with various crushed materials and/or waxing the back side of the sheet. Template painting is used for finishing the façade decoration sheets described above.

[0055] Figure 7 shows a schematic of the template painting system of the equipment detailed in this invention. In the template painting system, the fibre cement sheets 24 to be painted move in a position where their side to be painted is directed down. The fibre cement sheets 24 to be painted are held hanging from the conveyor 28 with vacuum heads 26 of the hangers 27. When a fibre cement sheet 24 to be painted, moving on the conveyor 28, reaches a template 25, the fibre cement sheet 24 starts pushing the template 25 along; this ensures synchronous movement and precise positioning of the template 25 on the fibre cement sheet 24 to be painted. The template 25 has openings above the areas of the fibre cement sheet 24 which are to be painted. When the fibre cement sheet 24 and the template 25 reach above the painting box 29, the sprayer 30 activates. The paint sprayed onto the interior surfaces of the painting box 29 flows back to the bottom of the box and is reused. After passing the painting box, the template is separated from the painted fibre cement sheet and is directed back to reuse, passing under the painting box. Templates 25 have wheels 31 for moving along guide rails 32; templates 25 move under gravity towards under the painting box 29 via the guide rails 32 and are then lifted to above the painting box 29 again by way of an escalator (not shown in the drawing), whereas templates 25 are not connected to each other.

[0056] The templates 25 can be various, i.e. different areas of different fibre cement sheets can be painted. This method avoids repetition of the pattern. This is very important when imitating natural materials. Façade decoration sheets can be followed up by spraying fine sand onto them, which sticks to the fresh paint layer.

[0057] While the currently known methods allow manufacturing fibre cement sheets with a thickness (dimension a in Figure 8) of approximately 3 to 20 mm and a maximum profile depth (dimension b in Figure 8) of less than 10 mm, the method detailed in this invention allows manufacturing fibre cement sheets with lower thickness (dimension a in Figure 9) of 1.5 to 5 mm and a profile depth (dimension b in Figure 9) of up to 120 mm. Thus, unlike the currently known solutions, the profiled fibre cement sheet detailed in this invention has a thickness range of 1.5 to 3 mm and a profile depth range of 10 to 120 mm.

[0058] Figure 10 and Figure 11 show implementation examples of profiled fibre cement sheets manufactured according to the method detailed in this invention. The fibre cement sheets manufactured according to this method can have imitation patterns 33 (e.g. slates, bricks, roof tiles, etc.), imitation edges 34, imitation vertical joints 35, imitation horizontal joints 36. The implementation example of a fibre cement sheet shown in Figure 10 also has a fastening opening 37, grooves 38 hindering lateral movement of water, and grooves 39 ensuring proper positioning of fibre cement sheets to each other. The implementation example of a fibre cement sheet shown in Figure 11 also has an overhang 40.

[0059] The surface structure of the profiled fibre cement sheet manufactured according to this method allows imitating other façade materials which form structured surfaces. Unlike the currently known fibre cement sheets, the fibre cement sheets detailed in this invention allow making watertight smooth surfaces. Water removal is ensured via overhangs of edges of the fibre cement sheets, where each upper row of the sheets is placed onto the previous lower row of the sheets. In this case, the overhung edges are located lower, thus the covered surface can be smooth if wished. Such shape and placement of the fibre cement sheets precludes the wall structure becoming wet, and there will be no visible rests and removal works of glue or installation mixture used for attaching the fibre cement sheets to the underlying surface. Also, the fibre cement sheet detailed in this invention allows easier placement of the sheets on the underlying surface when compared to the currently known solutions, because the precise pressing and cutting of the fibre cement sheets in the production process and its profile pattern make it unnecessary to perform additional measurements in the course of the installation process. Thanks to the advantages over the currently known solutions, this fibre cement sheet provides extended architectural opportunities for outdoors and indoors use without the need for additional finishing or covering.

Claims

1. A method of manufacturing profiled fibre cement sheets, comprising the stages of preparing raw materials and preparing a mixture, forming and shaping the fibre cement sheets, cold pressing of the sheets, preliminary hardening of the sheets, follow-up hardening of the sheets and finishing the sheets, which is **characterized in that** the stage of forming and shaping the fibre cement sheets comprises the following work steps:

    - In the first step, the side of the formwork toward the covering sieve (6) is oiled;
    - In the second step, the formwork is dipped into the slurry (2);
    - In the third step, the fibre cement sheet (12) is formed;
    - In the fourth step, the side of the fibre cement sheet (12) toward the counterpart (10) of the formwork is oiled;
    - In the fifth step, the counterpart (10) of the formwork is moved against the formed fibre cement sheet (12);
    - In the sixth step, the initial pressing of the fibre cement sheet (12) is performed;
    - In the seventh step, the counterpart (10) of the formwork together with the fibre cement sheet (12) is moved away from the formwork.

2. The method according to claim 1, which is **characterized in that** the formwork is used in the position of its work surface directed down when forming the fibre cement sheet and the solid particles in the slurry (2) are vacuumed

to the side of the formwork toward the covering sieve (6).

3. The method according to claim 1, which is **characterized in that** the formwork is used in the position of its work surface directed up when forming the fibre cement sheet and the lifting of formwork after dipping results in the formwork being filled with the slurry (2) which is seeped out under gravity or vacuumed out.

4. The method according to claim 1, which is **characterized in that** after the seventh step, cold pressing with an engraved polyurethane die is used as follow-up pressing of the fibre cement sheet (12).

5. The method according to claim 1, which is **characterized in that** the preliminary hardening of the fibre cement sheets (12) takes place on a conveyor.

6. The method according to claim 1, which is **characterized in that** the follow-up hardening of the fibre cement sheets (19) takes place in a flow-through shelf.

7. The method according to claim 1, which is **characterized in that** the finishing of the fibre cement sheets (19) takes place as template painting.

8. An equipment for manufacturing profiled fibre cement sheets, comprising a device for forming and shaping the fibre cement sheets, a conveyor for preliminary hardening of the fibre cement sheets, a flow-through shelf for follow-up hardening of the fibre cement sheets, and a template painting system for finishing the fibre cement sheets.

9. The equipment according to claim 8, which is **characterized in that** the device for forming and shaping the fibre cement sheet comprises a slurry bath (1), a mixer (2) added to the slurry bath, oil sprayers (11) and a formwork comprising of a shell (4), a vacuum chamber (5) located in the shell (4), a covering sieve (6) which covers the outside of the work surface of the formwork, water removal channels (7) between the covering sieve (6) and the vacuum chamber (5), a vacuum pipe (8), fastening eyes (9) of the formwork, and a counterpart (10) of the formwork, whereas the formwork may be positioned in two ways.

10. The equipment according to claim 9, which is **characterized in that** the mesh openings of the covering sieve (6) of the formwork are sized approximately 0.5 mm.

11. The equipment according to claim 9, which is **characterized in that** the formwork is positioned with the work surface directed down.

12. The equipment according to claim 9, which is **characterized in that** the formwork is positioned with the work surface directed up.

13. A profiled fibre cement sheet with a thickness in range 1.5 to 3 mm and with a relief depth in range 10 to 120 mm including an imitation pattern (33), an imitation edge (34), an imitation vertical joint (35), an imitation horizontal joint (36).

14. The profiled fibre cement sheet according to claim 13, which is **characterized in that** it additionally has a fastening opening (37), grooves (38) hindering lateral movement of water and grooves (39) ensuring proper positioning of fibre cement sheets to each other.

15. The profiled fibre cement sheet according to claim 13, which is **characterized in that** it additionally has an overhang (40).

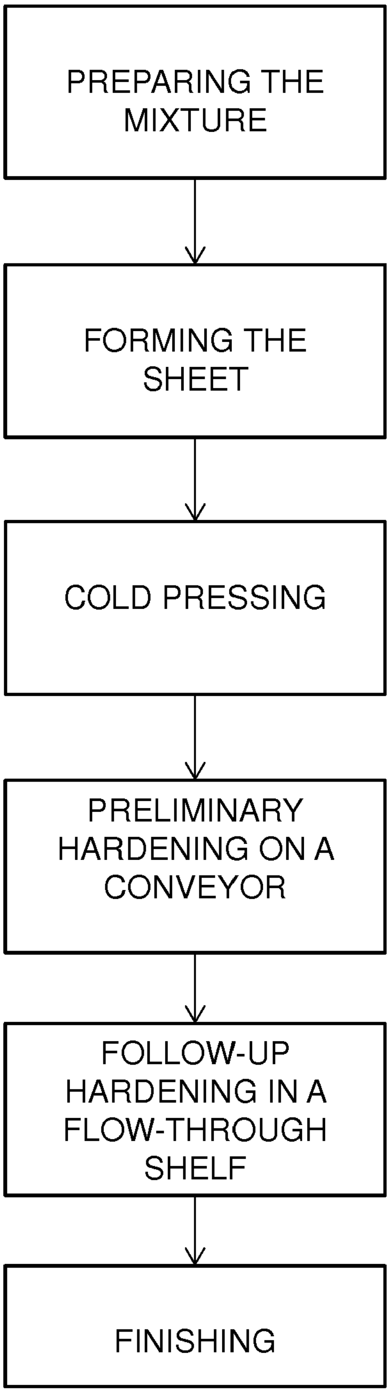
PREPARING THE MIXTURE
FORMING THE SHEET
COLD PRESSING
PRELIMINARY HARDENING ON A CONVEYOR
FOLLOW-UP HARDENING IN A FLOW-THROUGH SHELF
FINISHING

FIG 1

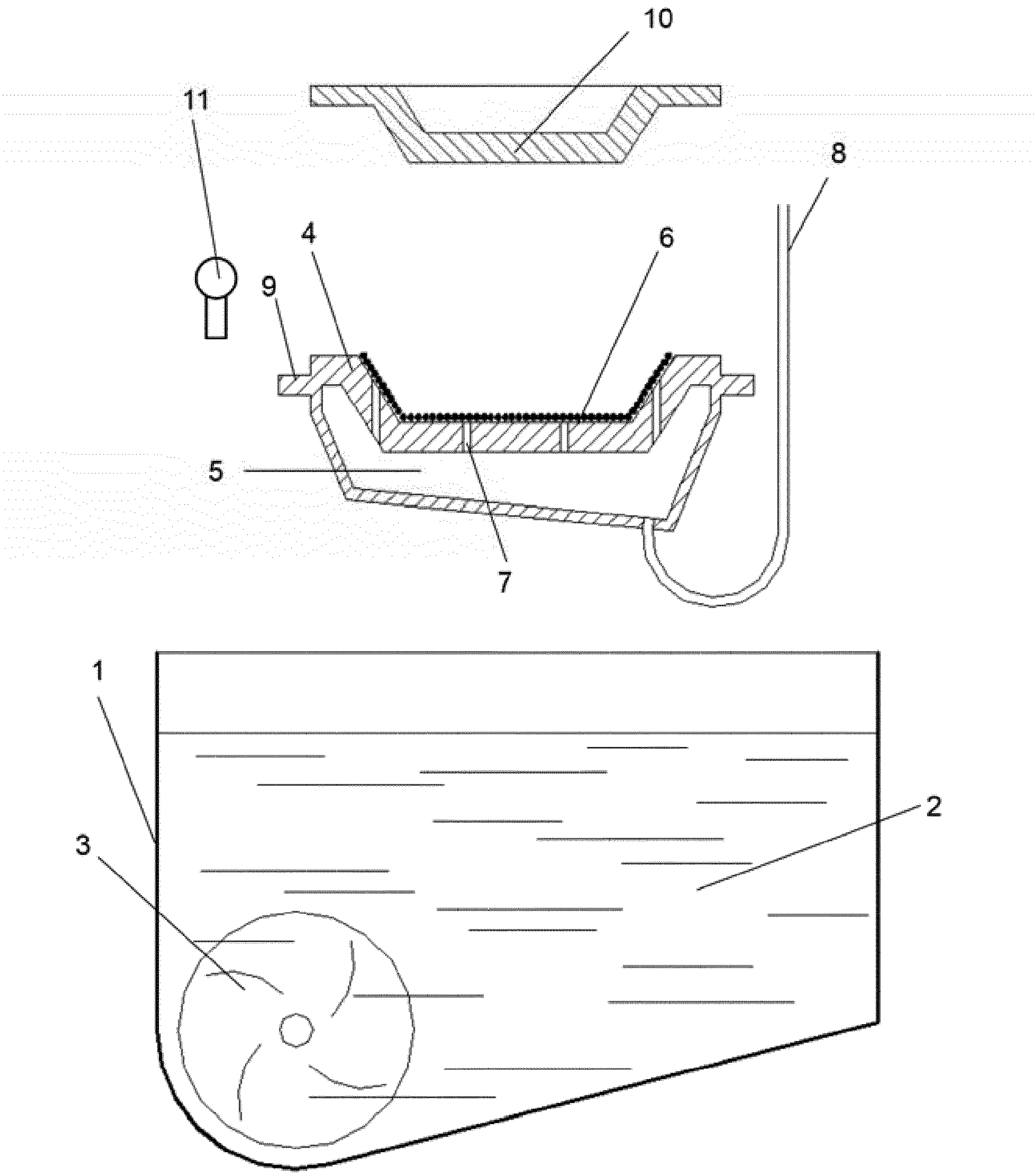

FIG 2

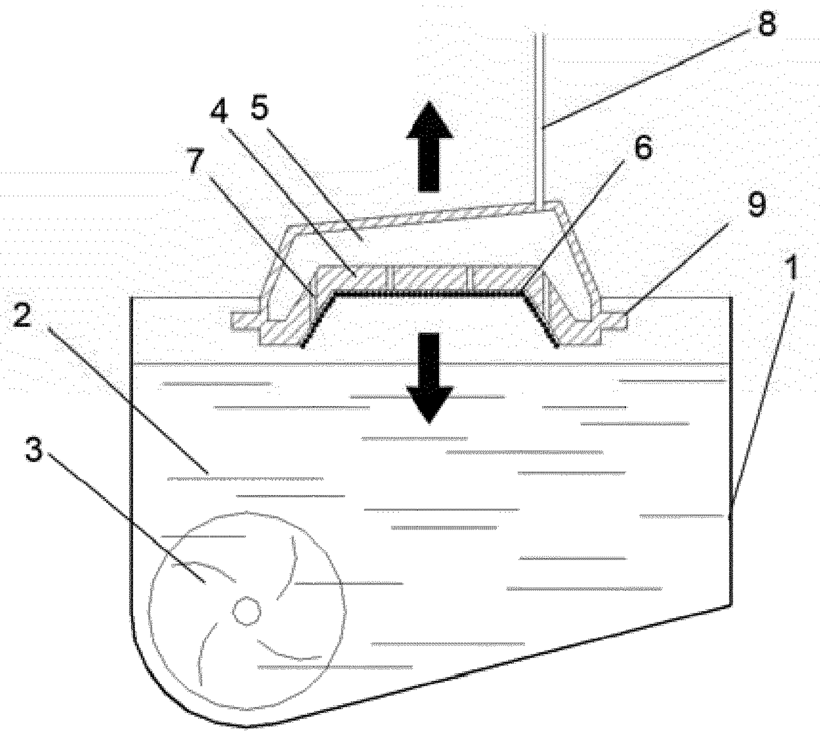

FIG 3a

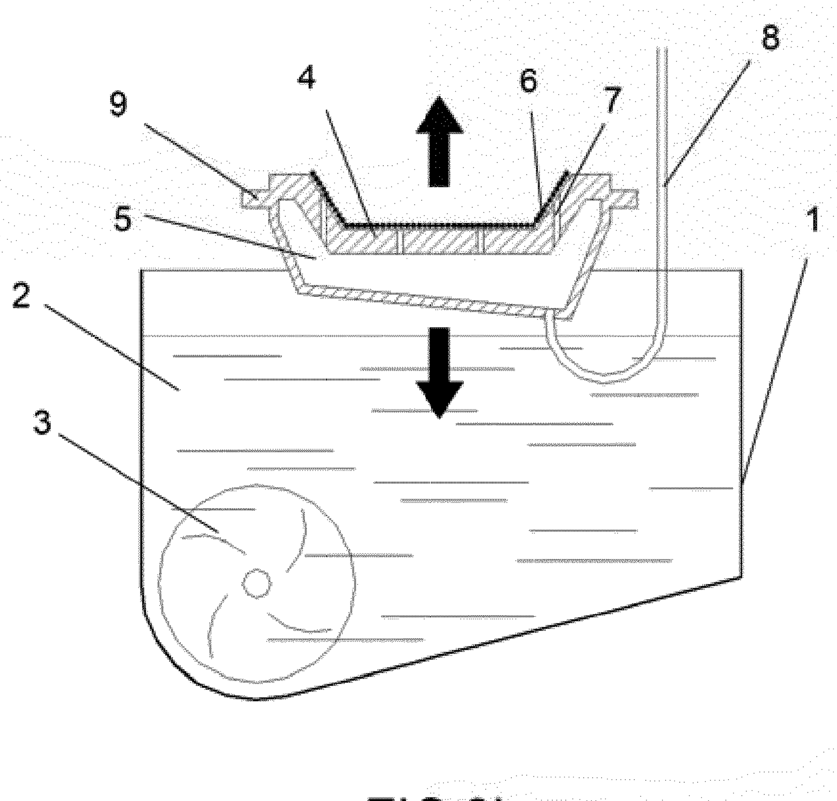

FIG 3b

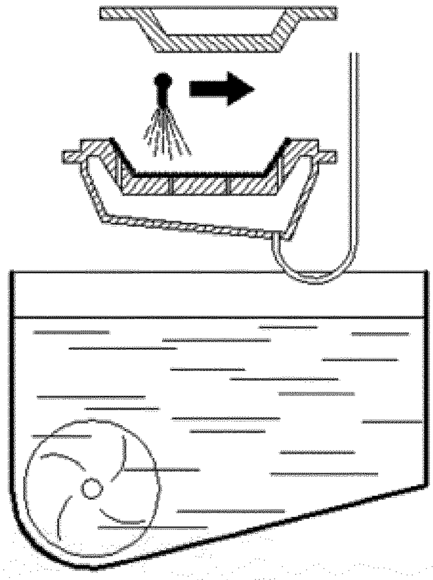

FIG 4-1

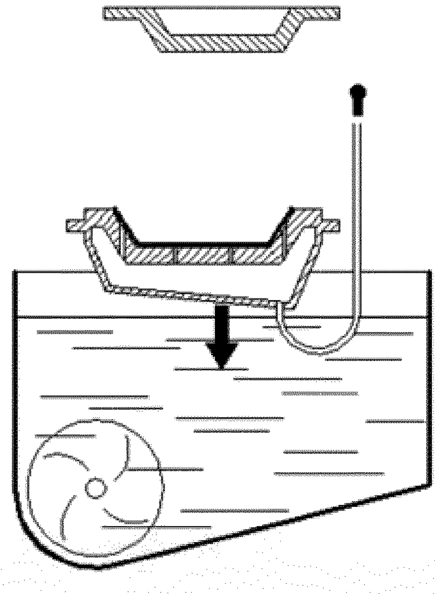

FIG 4-2

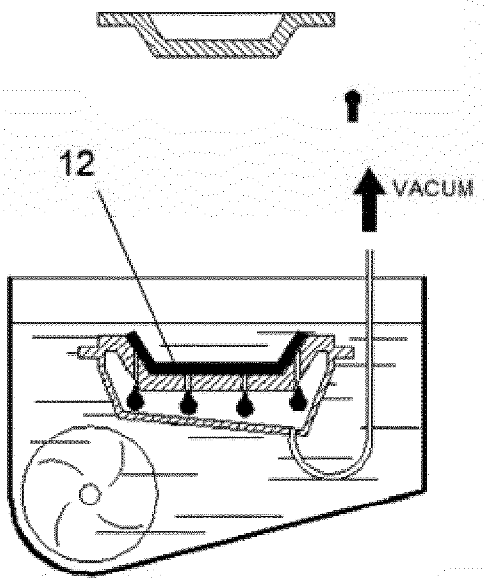

FIG 4-3

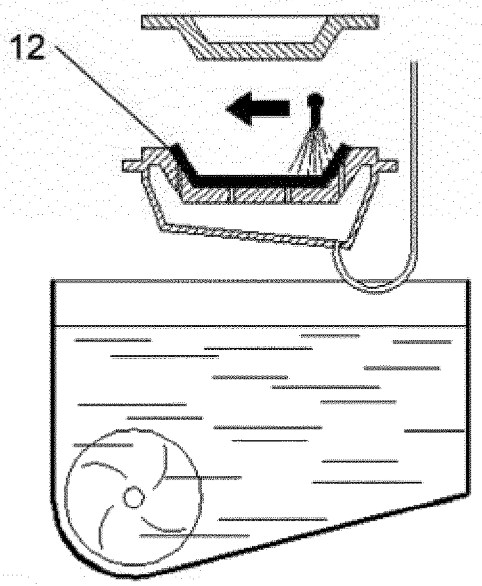

FIG 4-4

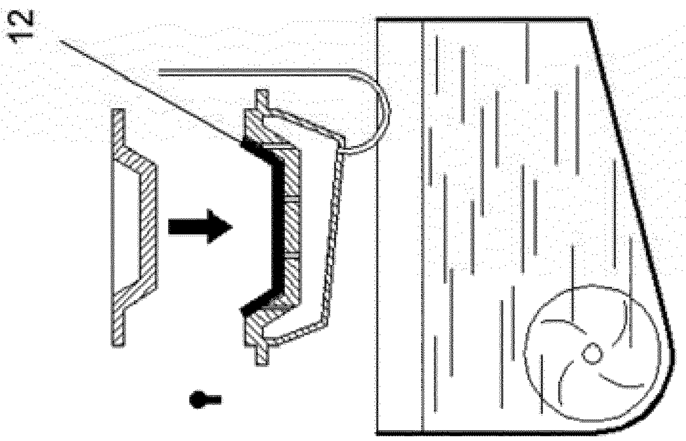

FIG 4-5

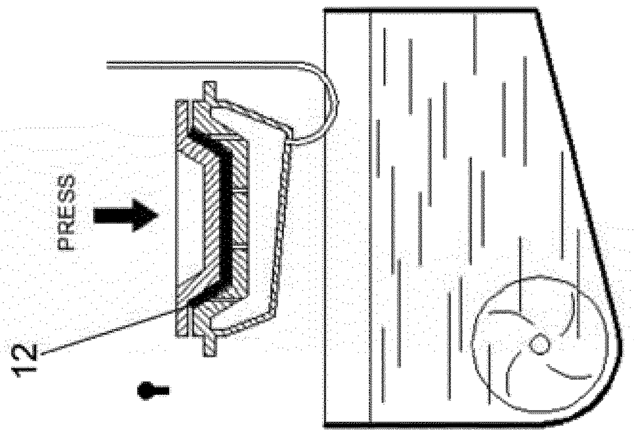

FIG 4-6

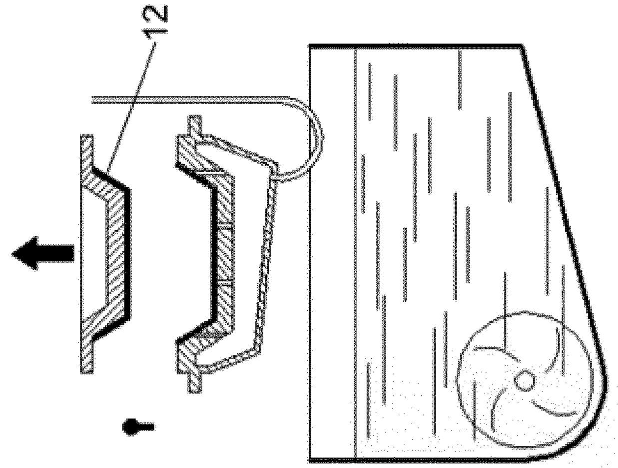

FIG 4-7

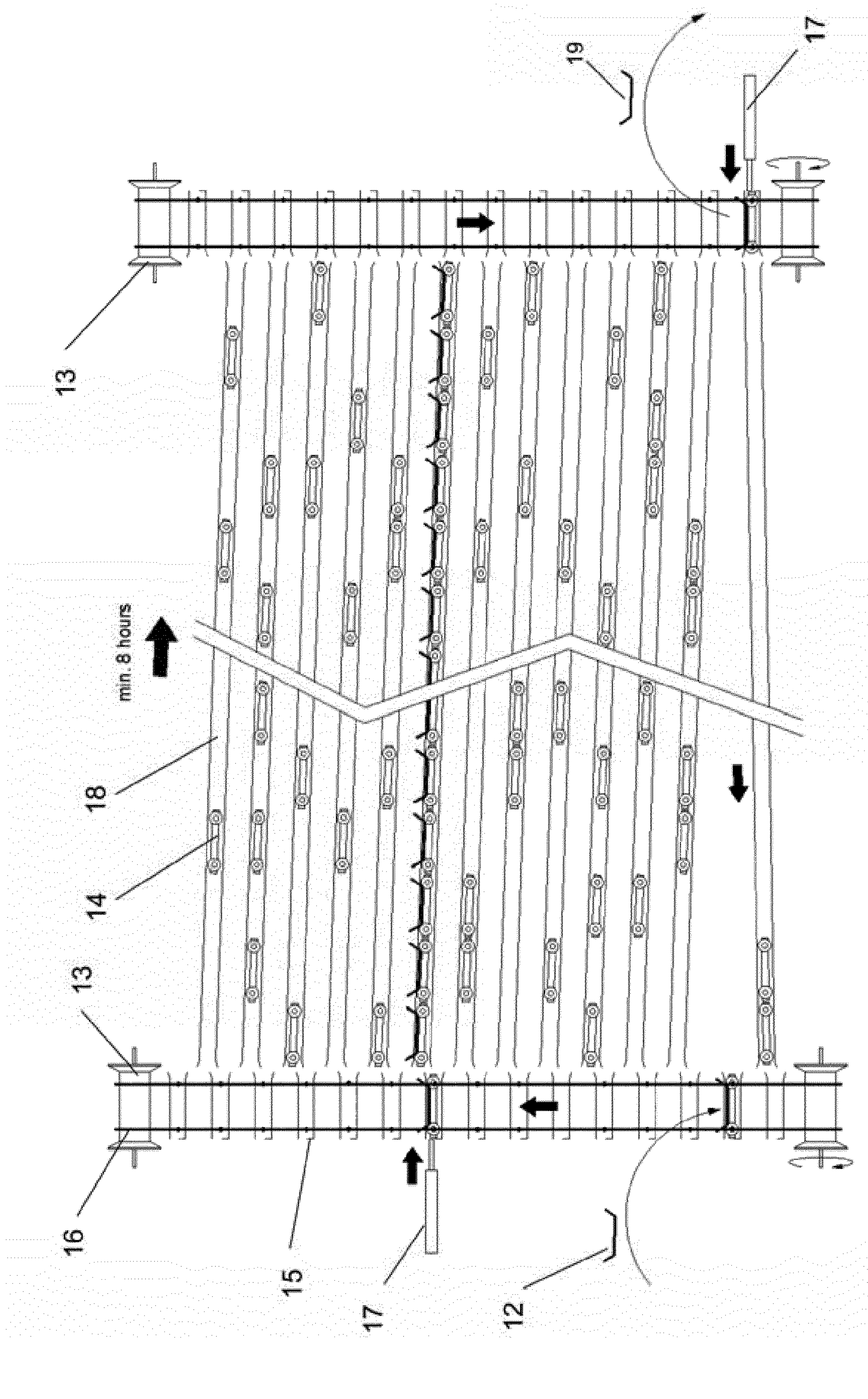

FIG 5

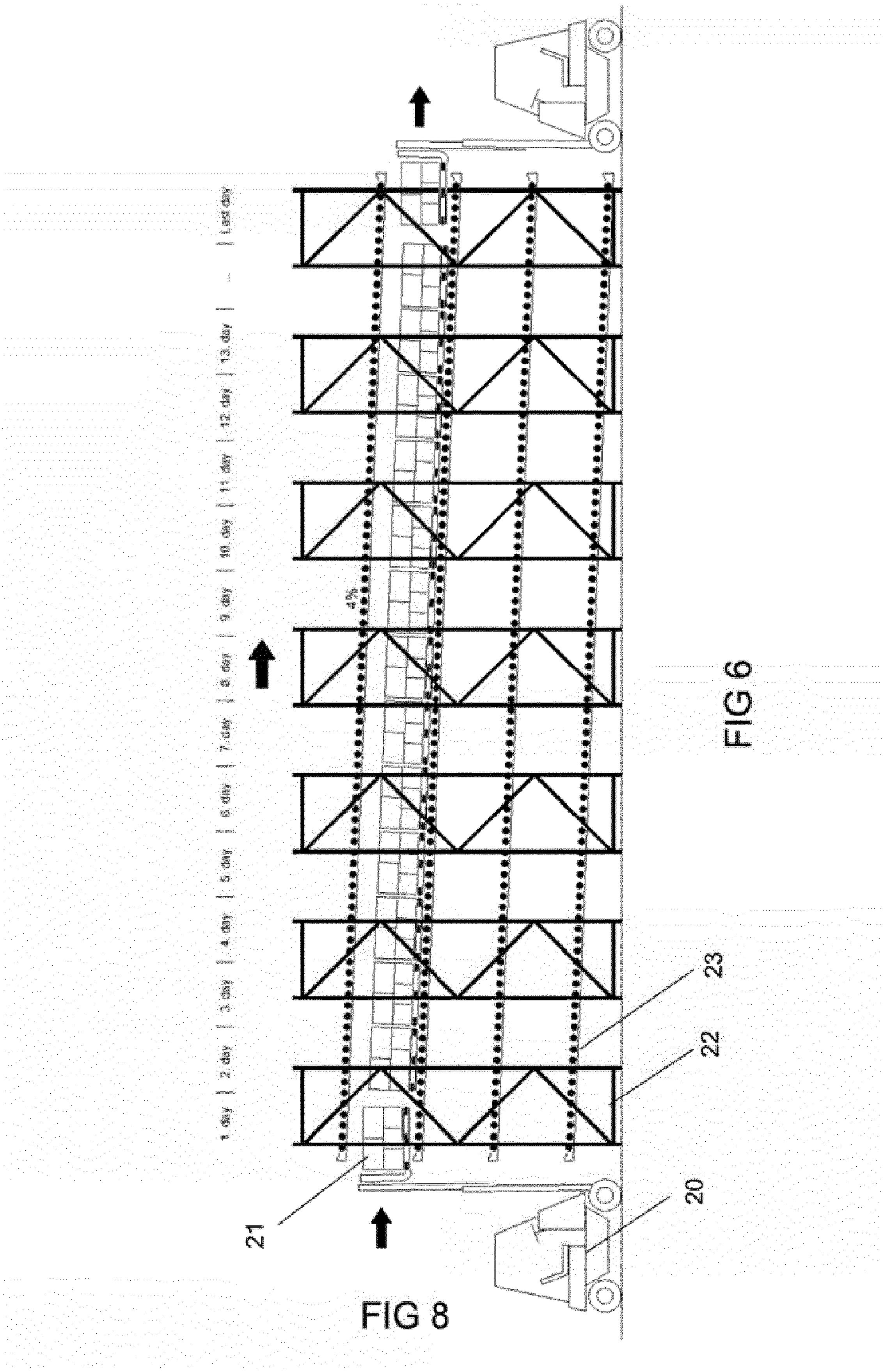
1. day
2. day
3. day
4. day
5. day
6. day
7. day
8. day
9. day
10. day
11. day
12. day
13. day
...
Last day
4%
20
21
22
23

FIG 6

FIG 8

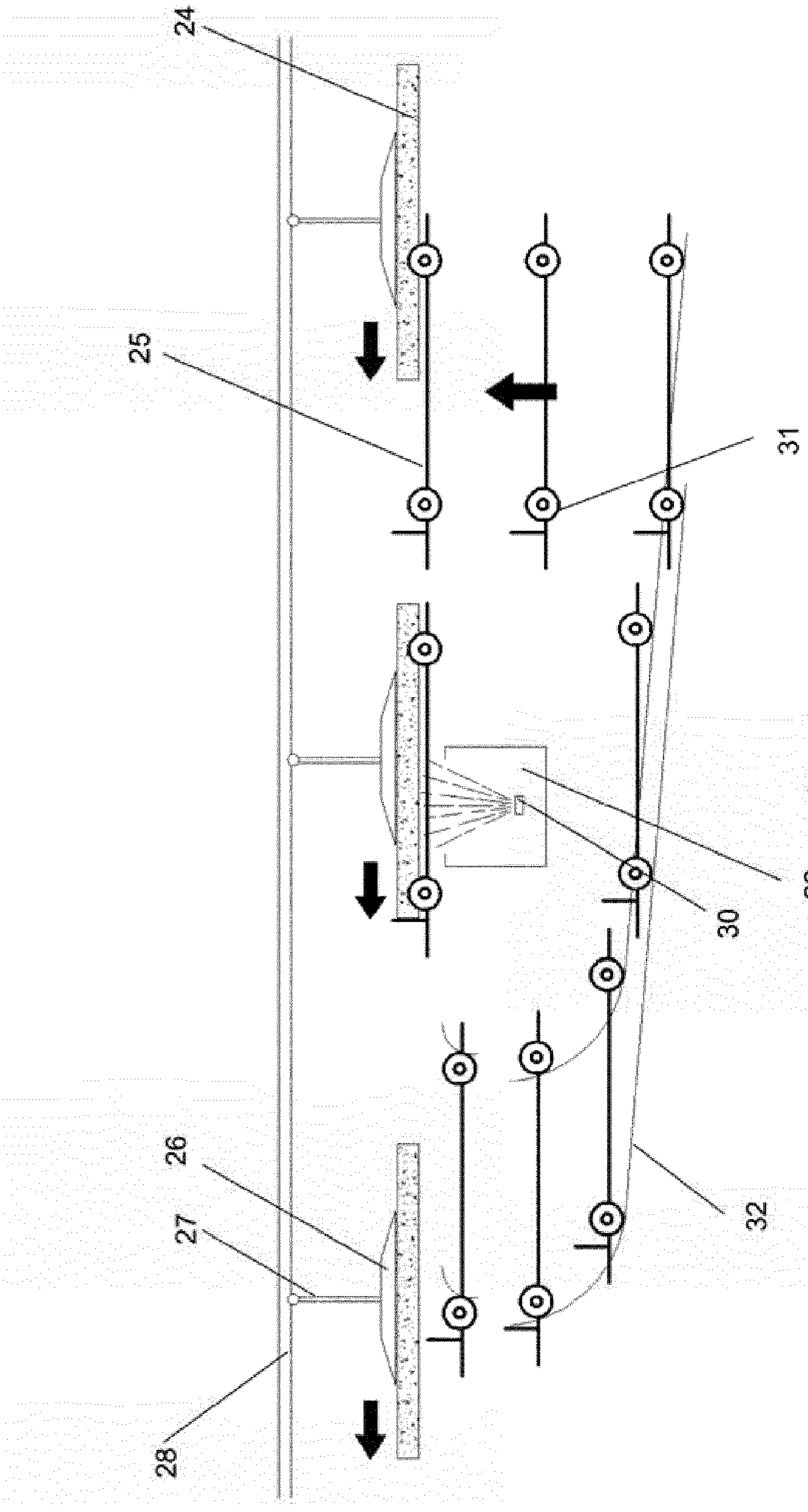

FIG 7

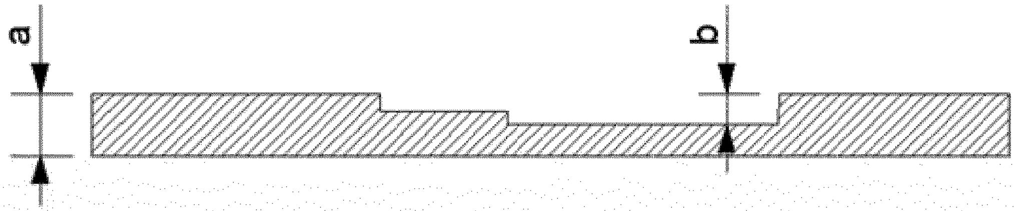

FIG 8

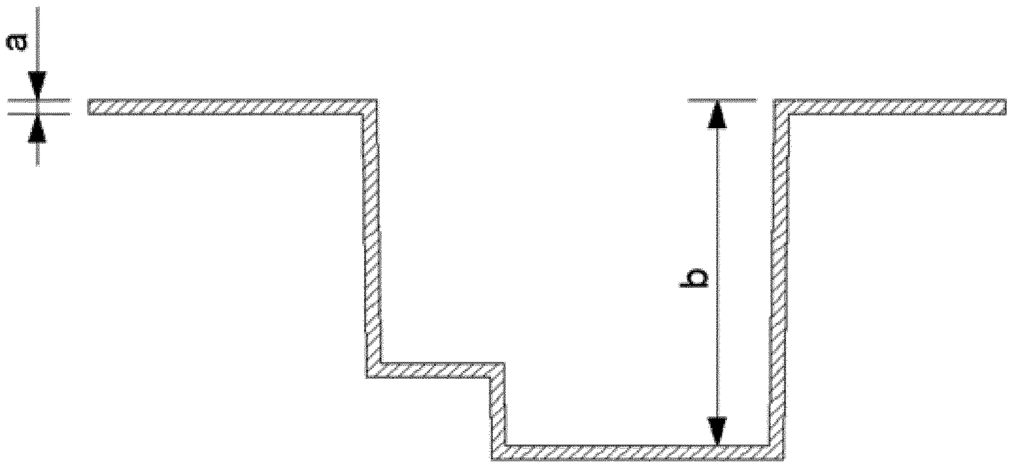

FIG 9

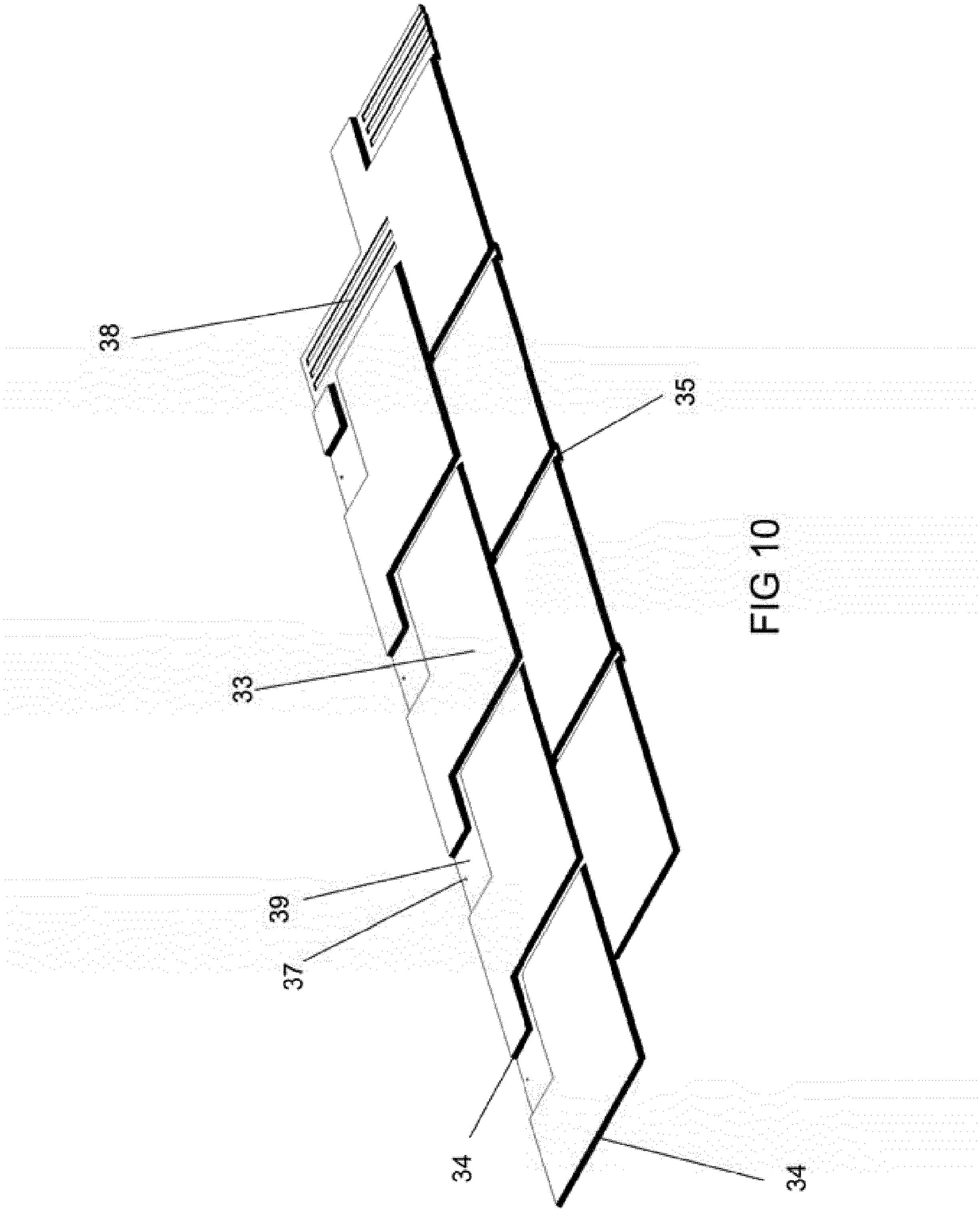

FIG 10

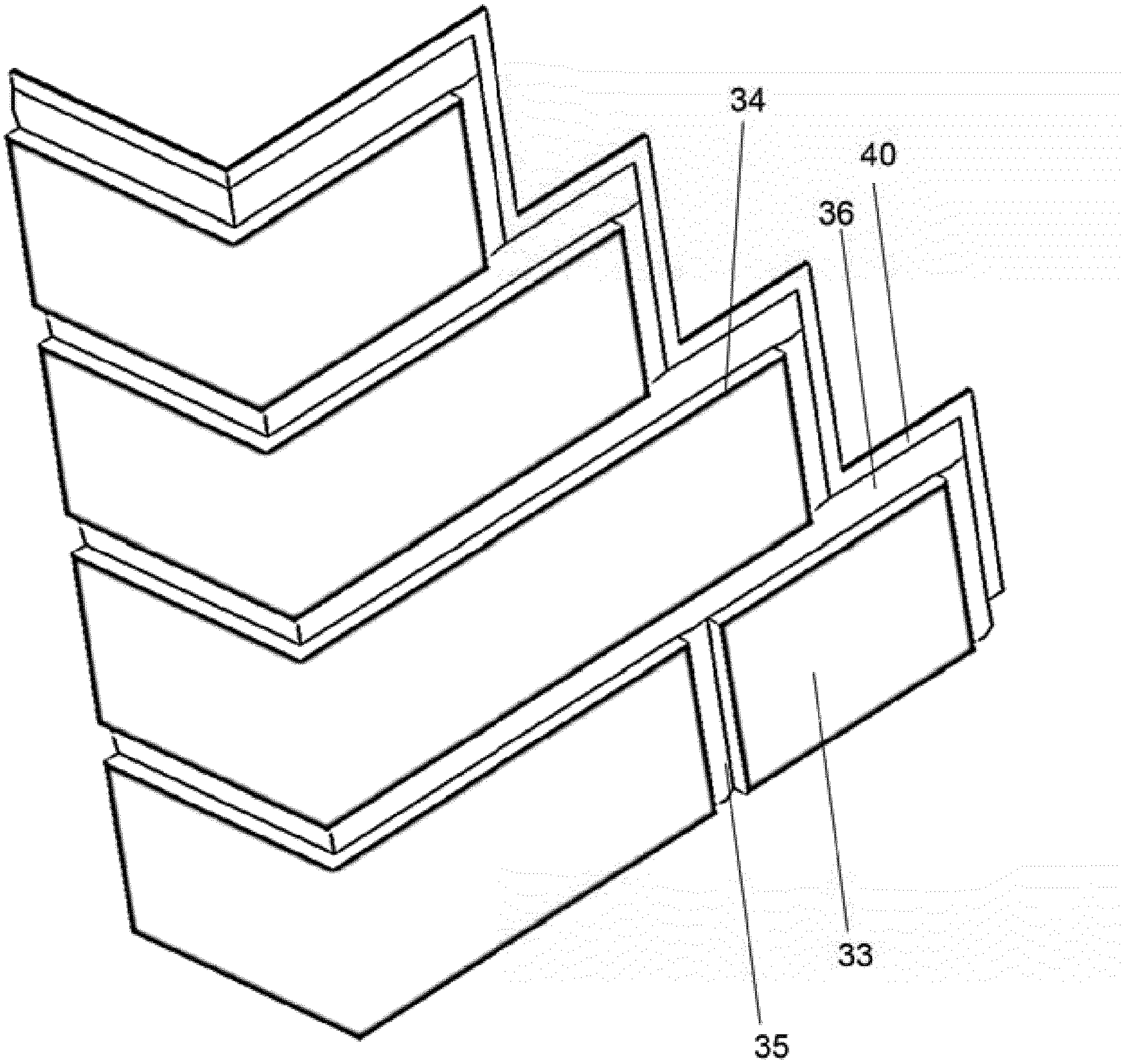

FIG 11

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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 7352

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	FR 2 201 647 A5 (EVERITUBE [FR]) 26 April 1974 (1974-04-26) * page 3, line 6 - page 4, line 33; claims; figures * -----	1,2,4-11	INV. B28B1/38 B28B1/52 B28B7/46
X	JP S54 106532 A (SEKISUI CHEMICAL CO LTD) 21 August 1979 (1979-08-21) * figures * -----	1,3,4,8, 9,12	
X	JP 2003 154510 A (MATSUSHITA ELECTRIC WORKS LTD) 27 May 2003 (2003-05-27) * abstract; figures * -----	1,2,4-11	

TECHNICAL FIELDS SEARCHED (IPC)

B28B

~~The present search report has been drawn up for all claims~~

1

Place of search	Date of completion of the search	Examiner
The Hague	13 August 2013	Orij, Jack

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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European Patent Office
Office européen des brevets

Application Number

EP 12 17 7352

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

- [ ] Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

- [ ] No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- [ ] All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

- [ ] As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

- [x] None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

  1-12

- [ ] The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 12 17 7352

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-12

   A method and equipment of manufacturing profiled fibre cement sheets

   ---

2. claims: 13-15

   A profiled fibre cement sheet

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 17 7352

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-08-2013

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
FR 2201647	A5	26-04-1974	NONE	
JP S54106532	A	21-08-1979	JP S61162 B2	07-01-1986
			JP S54106532 A	21-08-1979
JP 2003154510	A	27-05-2003	NONE	

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