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Canadian Intellectual Property Office
An agency of Industry Canada

CA 2370110 A1 2001/01/04

(21) 2 370 110

# (12) DEMANDE DE BREVET CANADIEN
# CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2000/06/19
(87) Date publication PCT/PCT Publication Date: 2001/01/04
(85) Entrée phase nationale/National Entry: 2001/11/29
(86) N° demande PCT/PCT Application No.: CA 2000/000734
(87) N° publication PCT/PCT Publication No.: 2001/000921
(30) Priorités/Priorities: 1999/06/28 (60/140,850) US; 1999/06/28 (2,275,738) CA

(51) Cl.Int.$^7$/Int.Cl.$^7$ D06N 7/00, E04C 5/07

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(54) Titre : STRUCTURE MULTICOUCHE A BASE DE CIMENT
(54) Title: MULTILAYER CEMENTITIOUS STRUCTURE

(57) Abrégé/Abstract:
The multilayer structure disclosed comprises an upper layer and a lower layer both made of a cementitious matrix. An intermediate layer made of a non-woven fibrous material and filled with a non-cementitious filling material is sandwiched between the upper layer and lower layer. The structure may advantageously comprise a plurality of intermediate layers included in a cementitious matrix. Among other things, adding a product inside the fibrous layer may reduce the weight of the structure and avoid contact between the different cement layers, thereby providing numerous advantages.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 January 2001 (04.01.2001)

PCT

(10) International Publication Number
WO 01/00921 A1

(51) International Patent Classification[7]: D06N 7/00, E04C 5/07

(21) International Application Number: PCT/CA00/00734

(22) International Filing Date: 19 June 2000 (19.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2,275,738 28 June 1999 (28.06.1999) CA
60/140,850 28 June 1999 (28.06.1999) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**
— *With international search report.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

WO 01/00921 A1

(54) Title: MULTILAYER CEMENTITIOUS STRUCTURE

(57) Abstract: The multilayer structure disclosed comprises an upper layer and a lower layer both made of a cementitious matrix. An intermediate layer made of a non-woven fibrous material and filled with a non-cementitious filling material is sandwiched between the upper layer and lower layer. The structure may advantageously comprise a plurality of intermediate layers included in a cementitious matrix. Among other things, adding a product inside the fibrous layer may reduce the weight of the structure and avoid contact between the different cement layers, thereby providing numerous advantages.

# MULTILAYER CEMENTITIOUS STRUCTURE

## FIELD OF THE INVENTION

The present invention relates generally to the field of fibre reinforced cementitious matrices, and more particularly, to cementitious structures reinforced with non-woven fibrous membranes. This invention may also be used in the form of construction panels, pipes and poles, bridge decks, road foundations, concrete repairs and many others.

## BACKGROUND

The technology consisting of providing some ductility to a cementitious matrix, by adding ductile fibres, has been known for quite some time. Over the years, three main methods have been developed to include the fibres. According to the first of those methods, discontinuous fibres are added to the cementitious matrix during mixing. These fibres take random orientations along the three main directions when the matrix hardens. The second reinforcing method consists of pouring cementitious matrix on fibres preferably aligned along the loading direction. A third method was also developed, and constitutes in essence a compromise between the first two. This method consists of soaking fibres randomly aligned in the three directions with a cementitious matrix. These fibres may be in the form of discrete fibres packed inside a mould or in the form of a non-woven fibre layer comprising fibres randomly aligned along the three directions.

Each of these methods has advantages and drawbacks. With the first method, a greater ductility may be obtained, since the fibres can be pulled out of the matrix before they break, but a large part of these fibres are also badly used because they have a wrong orientation with respect to the loading direction. Also, adding fibres during the mixing may entail some drawbacks (the main one being a loss of workability) and the dosing of the cementitious mix must be done with care. In addition, using fibres aligned along preferred directions, such as in the shape of a mesh or threads, increases the resistance by taking the load after a break in the cementitious matrices. However, since the fibres cannot be pulled out of the matrix, they break when stretched. This lowers the ductility of these structures, which are consequently relatively fragile. The third method has generally the same advantages and drawbacks as adding fibres to the mix, with the exception that the mix is not affected, inasmuch as its viscosity has to be low enough to allow it to infiltrate the pores of the fibre layer.

These three methods have been intensely studied in both the industry and academic research facilities and certain precise variants of fibre-reinforced cementitous structures have been patented. Among these, there is Currie et al. (U.S. 4,578,301) which describes a structure composed of a piling of mesh fabric inside a cementitious matrix. Also know in the art, there is Shupack (U.S. 4,617,219) which describes a structure composed of a non-woven layer made of fibres, for the most part continuous and randomly aligned along the three directions, soaked on all its depth with fresh cementitious matrix. Shupack also discloses a structure composed of a plurality of such layers divided or not by layers of cementitious matrix. Finally, Nicholls (U.S. 4,778,718) suggests a structure composed of non-woven fabric layers similar to those proposed by Shupack, soaked with cementitious matrix and provided with an organic film continuous on at least one of its faces. In the last case, the cement is added in a dried state inside the fabric layer and water is sprayed thereon afterwards to obtain a hard matrix after drying.

Other examples of prior art cementitious structures are given in the following documents: 3,984,989; 4,021,258; 4,088,808; 4,158,082; 4,203,788; 4,228,208; 4,247,979; 4,281,952; 4,298,413; 4,303,722; 4,378,405; 4,420,295; 4,420,525; 4,434,119; 4,450,022; 4,488,917; 4,504,335; Re 31,921; Re 32,037; Re 32,038; 4,706,430; 4,793,892;

4,816,091; 4,819,395; 4,885,880; 5,030,502; 5,221,386; 5,350,554; 5,356,446; 5,445,473; 5,449,543; 5,472,297; 5,513,925; 5,539,163; and 5,650,220; DE 2,821,490A; EP-A-0,387,968; and DE 1,759,133

## SUMMARY OF THE INVENTION

An object of the present invention is to propose an improved cement-based multilayer structure.

Another object is to propose a multilayer structure which has superior soundproofing and thermal qualities, and a good resistance to tension and to impact.

In accordance with the present invention, these objects are achieved with a multilayer structure comprising a plurality of fabric layers made of a porous nonwoven fibrous material sandwiched between layers of a cementitious matrix, characterized in that each of the fabric layers is filled with a nonhardening and non-cementitious filling material.

A person skilled in the art will understand that a cementitious matrix is a cement-based mixture including a cementitious material such as a cement powder and a fluid such as water. It may also comprise adjuvant, granulates etc., as apparent to any person skilled in the art.

The filling material and the cementitious matrix may advantageously comprise more than one type of filling material and cementitious matrix respectively. More than one type of fibrous reinforcement may also be used.

The present invention also proposes a method of making the multilayer structure as defined hereinabove. This method is characterized in that it comprises the steps of:

a) providing a mat of non-woven fibrous material;

b) filling the mat with a non-cementitious and nonhardening material; and

c) covering the mat of step b), after it has been filled with the non-cementitious and nonhardening material, with a cementitious composition.

As can be appreciated, the invention consists mainly of a cement-based multi-layer structure involving a double inclusion process. The first inclusion consists of soaking a fabric layer made of non-woven fibres with a filling material (organic or not) so as to fill the internal pores of the fabric layer. The second step consists of including the fabric layers inside a cementitious matrix. Any number of alternate fabrics and cement layers can then be pressed one against the other to obtain a structure of any desired thickness. The resulting structure differs from previous cementitious structures by the introduction of a third component inside the pores of the fabric layer, itself included in the cementitious matrices. Previously known structures generally involved a two-component system comprising a cementitious matrix reinforced by more or less randomly aligned fibres. In the present case, the non-woven layer acts as a support for a third product which gives the whole structure interesting properties. The cementitious matrix itself is reinforced by the fabric layers in a bi-dimensional manner, since the fibre-matrix interfaces are located on the outer faces of the non-woven fabric layers. Using the internal space of the fabric layer as a support for a product other than a cementitious matrix allows for a lot more possibilities than with a two-component fibre-cement system.

Including a product inside the pores of the non-woven fabric layer results directly in a separation of the cementitious matrix and the fabric layers. With this process, superior soundproofing and thermal qualities may be obtained since waves of all types are dissipated by repeated passages at the interface of two different medias in an heterogeneous structure. With an appropriate filling material, the heterogeneous structure also has better resistance to impacts, by dissipating energy inside the fabric layers. The soaking process of the fabric layers also allows distinct layers to resist to tension (through the fibres of the fabric layers) and to compression (through the cementitious matrices), which offers the possibility of either a very high flexibility, a strong resistance to bending or a compromise between both, depending on the composition of each layer. With this process, zones acting in tension and in compression can specifically be reinforced by varying the thickness and/or the composition of the cementitious and fibrous layers. Finally, filling the pores of the fabric layers with a lightweight product, can significantly reduce the weight of the whole structure with respect to a conventional concrete structure. Using light fibres and cementitious matrix can further reduce the weight of the whole structure.

Cementitious structures shaped as panels according to a preferred embodiment of the present invention, can be designed to have properties close to those of plywood. As with wood, these panels can be sawed, screwed through, nailed through, pierced or grounded. In addition, in spite of being cement-based, these panels can be pierced close to their edges or corners without breaking up, because of their high fibre content. They are also advantageous in that they are more durable than wood and can be bent further before breaking. This material, which constitutes a compromise between wood and concrete, may therefore be used in various manners in the field of construction. In a preferred embodiment, a non-woven needle-punched fabric layer can be used, which allows a pattern to be set all the way through to the surface of the panel, giving it a non-slipping textured finish. The resulting textured surface further increases the grip of glue or adhesives thereto, making these panels excellent supports for acrylic coatings or ceramic tiles.

The infinity of possible combinations of the three phases (cement, fibres and filling material) makes the structure according to the present invention extremely versatile, allowing it to be embodied in a variety of manners. Among the possible embodiments, in addition to panels, are the manufacture of posts, pipes, bridge decks, repair of existing concrete works, and many others. It should be noted that the thickness of the structure, and therefore its rigidity, may be varied according to the numbers and thickness of superposed layers. In this manner, a plurality of different applications may be generated from a single cement-fibre-filling material combination.

The structure in accordance with the present invention may be manufactured relatively easily through a continuous process. In the case of panels, for example, this process implies winding the fabric layer filled with filling material and covered with the cementitious matrices around a cylinder, and then unwinding it. This process allows to continuously make panels of any desired thickness.

As can be appreciated, the filling of a non-woven fabric layer with a filling material leads to superior characteristics on many levels and allows to apply the resulting cementitious structure to a wider field than with previous technologies. In addition, using non-woven fabric layers in the context of superposed layers, as it is the case for some preferred embodiments of the invention, instead of purely tri-dimensional structures, improves the mechanical behaviour and increases the proportion of fibres aligned in the right direction. The structure suggested here may be used in one embodiment in construction panels having a mechanical behaviour similar to that of plywood. These panels show good flexural and impact resistance in addition to a superior durability. Depending on the properties of the filling material, the non-woven fibrous material and the cementitious matrix, the panels can be used, for example, as floor elements, fireguards, soundproofing elements, thermal insulators, coverings for walls and roofs, impact protecting elements... The material may also be used in the manufacturing of posts, pipes, bridge decks, concrete repairs, etc.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic cross-sectional side view of a non-woven fabric layer filled with filling material. A legend of the composition is given on the left side of the figure.

Figure 2 is a schematic cross-sectional side view of a first preferred embodiment of the invention showing the inclusion of the non-woven fabric layer filled with filling material inside the cementitious matrices. A legend of the composition is given on the left side of the figure.

Figure 3 is a schematic representation of forces acting inside the structure of the present invention.

Figure 4 illustrates the continuous manufacturing process of panels according to an embodiment of the present invention.

# DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Referring to figure 1, a non-woven fibre layer (2) filled with a filling material (4) and used as a component of a multilayer structure according to a preferred embodiment of the invention is illustrated. The tri-dimensional structure of the fibrous membrane (2) allows it to act as a sponge and traps within its pores a certain amount of filling material (4). It should be noted that the fibrous layer (2) does not have to be saturated to effectively separate the cement layers, the filling of at least a layer portion is sufficient.

Figure 2 shows the inclusion of the non-woven fibrous layer (2) of figure 1 inside a cementitious matrix. This figure shows the multi-layer structure (10) of the present invention which comprises layers (6) of a cementitious matrix and intermediate layers (2) made of a non-woven fibrous material sandwiched between the layers of cementitious matrix. A non-cementitious filling material (4) is filling at least one layer portion of the intermediate layer (2). In the preferred embodiment illustrated, it is filling the entire thickness of the non-woven fibrous material (2).

It should be noted that the cementitious layers (6) are separated by the filled fibre layers (2) and are not in contact. It should also be noted that in another embodiment of the invention, as for example in figure 3, the structure may advantageously have many more layers of filled non-woven fibrous material sandwiched between layers of cementitious composition.

As mentioned above, a novel aspect of the present invention is the introduction of a third component in a fibre-reinforced cementitious matrix. The introduction of this component inside the matrix is realised through a double inclusion process. The filling material (4) is first included inside the pores of a fabric layer of non-woven fibres (2), and this layer is then itself included inside a cementitious matrix (6). The structure (10) so produced is heterogeneous and is made from at least one layer of fibres (2) covered with a cementitious composition (6). Among other things, adding a product inside the fibrous layer (2) reduces the weight of the structure (10) and avoids contact between the different cement layers (6), thereby providing the advantages described hereinafter.

The fibrous layer (2) used in the present invention is of the non-woven type. These layers (2) are composed of a tangle of fibres oriented more or less randomly along all directions, giving the fabric layers (2) a relatively high porosity. Providing a fabric layer (2) having such a high porosity and a large thickness with respect to the diameter of the individual fibres allows the layer (2) to store an important quantity of filling material (4), like a sponge.

Of course, the reinforcing effect in the direction of the thickness, while always present, decreases when the thickness of the fabric layer (2) is decreased, since the fibres in a thin layer tend to orient themselves in a plane. The longitudinal and transversal resistance properties determine for the most part the flexural resistance of the structure (10). Since the filling material (4) is not necessarily hardening, the fabric layers (2) often have to support all the tensile stresses applied to the structure (10) after the failure of the cementitious matrices (6). The resistance of the fabric layer (2) is determined by a plurality of factors, such as the nature of the fibres, their amount per volume unit inside the fabric, their mobility with respect to each other, their length, etc.

Using needle-punched non-woven fabric layers also allows a pattern to be set all the way through to the surface of the panel, giving it a non-slipping textured finish. The resulting textured surface further increases the grip of glue or adhesives thereto, making these panels excellent supports for acrylic coatings or ceramic tiles.

The fibres may be of various types: glass, carbon, steel, polymers, ceramic, asbestos and others. Certain materials, such as glass or polyester, are unstable in an alkaline medium. In this case, the fibres may be treated by a protective coat, which then may act as the filling material of the fabric layer.

The fibre density of the fabric layers (2) inside a structure (10) may also be variable. Usually, increasing the fibre density results in a decrease in the fibres' mobility with respect to each other. When the fibres are in a larger amount, the probability of a tighter tangle is increased. The length of the fibres also influences their mobility. Long fibres are theoretically less mobile when they are well tangled together. Longer fibres are however harder to tangle together. In addition, using shorter fibres allows a higher density to be reached. Of course, the degree of mobility of the fibres has a direct influence on the stress-strain behaviour of the fabric layer, and therefore, on the behaviour of the entire structure. The thickness of the non-woven fabric layer (2) affects the properties of the structure (10) in two different manners. First, a thick fibre layer (2) can lead to the formation of low-compressive strength zones due to the reduction of the space occupied by the cementitious matrices (6) for a given total thickness of the structure. On the other hand, a fibre layer (2) too thick can favour the formation of weak shear zones inside the fabric layer (2) itself.

To obtain the desired properties of the cementitious structure (6) (tensile strength, compression strength, flexibility, porosity), the properties of the fibre layer (2) must be taken into account when designing a structure (10) according to the invention. The required properties may therefore be indicated to the manufacturer, who can then produce customized fabric layers satisfying the specified performance criteria.

The filling material (4) used to fill the fabric layer (2) can be of any appropriate type, organic or not. The product has to sufficiently occupy the pores of the fabric layer (2) to avoid contact between the cement layers (6) on either sides of the fibre-filling material inclusion. Depending on its nature, the product may serve a variety of purposes and the following examples should in no way be considered restrictive. The filling material (4) may be used, for example, to reduce the weight of the cementitious structure with respect to conventional concrete. The weight can further be reduced by using light fibres and cement. The filling material (4) may also be used as a fireproof component in the case where the fibre layer itself is flammable. Another potential use of the filling material (4) would be to serve as a protective coating for fibres that are unstable in an alkaline medium such as glass or polyester fibres.

The filling material (4) can, if desired, have hardening properties so that the fabric layer (2) may be included in a rigid matrix. This can improve the tensile strength of the fabric layer (2) and even give it a certain compressive strength. The rigidity of the filling material (4) however has an influence on the bending capacity of the structure. If the movement of the individual fibres inside the fabric layer (2) is overly restrained, the bending capacity is reduced and even if it is more resistant to tension, the structure (10) becomes fragile. Finally, it should be mentioned that in the case of a fabric layer (2) having a good compressive strength, this fabric layer (2) could contribute to a reduction of both shrinkage and swelling by acting like a diaphragm.

The filling material (4) should occupy a given portion of the internal space of the non-woven fibrous layer (2). A product in the liquid state should have a viscosity allowing it to soak through the pores of the fabric layer. If the chosen filling material (4) is an emulsion, the particles must be small enough to penetrate inside the pores of the fibrous layer. It is not essential that the filling material (4) fill all the pores of the fabric layer (2), but it should be sufficiently present to prevent contact between the cement layers on the opposite faces of the fibre-filling material inclusion. If the product is chosen for its mechanical or insulating properties, as much of it as possible should preferably be included inside the fabric layer (2).

The filling material (4) allows to effectively separate the cement layers (6) from one another. This increases the resistance to impacts by providing zones softer than the cementitious matrices (6), which contributes to dissipate energy. These softer zones can also increase both the thermal insulation and soundproofing capacity of the structure. The filling material (4) can be chosen specifically with this goal in mind. Another advantage in separating the cementitious matrices (6) and fibrous layers (2) is the distinction between layers resisting to tension (through the fibres of the fabric layers) and to compression (through the cementitious matrices). This offers the possibility of either a very high flexibility, a strong resistance to bending or a compromise between both, depending on the composition of each layer. With this process, zones acting in tension and in compression can specifically be reinforced by varying the thickness and/or the composition of the cementitious and fibrous layers.

The filling material (4) can be inserted in the fabric layer (2) by soaking or spraying. If a soluble product is used, it should be dried or made gel so that a sufficient proportion of the material stays in place inside the fabric layer (2) during the inclusion inside the cementitious matrices (6).

The filling material (4) may preferably be a polymer, natural or synthetic, selected from the group consisting of acrylics, epoxies, varnishes, paints, latexes, rubbers, thermosetting resins, plastics, and vinyls.

The filling material may also include a flame-retardant powder emulsion.

The matrix (6) wherein the non-woven fibrous layer (2) is included may be made from various cementitious compositions, depending on the desired properties. In addition to cement and water, the composition may include, among other things, admixtures of various types (superplasticizer, setting accelerator, water-reducer, colloidal agent, etc.), light-weight or conventional aggregates (in the form of sand or powder), micro-fibres and various additives, binding or not (silica fumes, fly ash, blast furnace slags, glass micro-spheres, polymers, etc). The water/cement ratio by weight, usually known as an indication of the resistance of the hardened concrete, may also be varied to adjust the resistance of the mix to the desired value. For a more flexible structure, the water/cement ratio may be high, whereas for a more resistant and rigid structure, this ratio may be smaller. Generally, the water-cement ratio must be around 0,55 or lower to obtain sufficient strength, although this condition does not necessarily apply for certain special types of compositions.

The freedom allowed in choosing the cementitious composition makes it possible to make many variants of the structure. Ultra-light, ultra-resistant, ultra-flexible, fast setting, or other variants, may all be developed by varying the cementitious composition.

When the structure (10) is pressed in order to laminate the different layers (2,6) in a parallel manner, the porosity of the cementitious matrices (6) becomes greatly reduced. This phenomenon results in cementitious matrices with a low permeability that are extremely durable when faced with a multitude of deteriorating factors (freezing and thawing, scaling, alcali-silica reaction, chemical attacks). In fact, the reduced porosity of the matrix (6) makes the movements of deleterious substances as well as ice formation practically impossible or at least extremely difficult.

Taking into account all possible combinations of the various types of non-woven fibre layers (2), filling material (4) and of cementitious compositions (6), an almost infinite number of variants of the structure according to the present invention can be manufactured. In addition, inside a single structure (10), materials of different types can be used for making different layers. For example, it is possible to include different filling products (4) at different levels inside the structure (10), or varying the cementitious composition (6) from one layer to the next. The type of fibre could also be varied from one layer to the next throughout the structure. The common feature of all the possible variants is that they all form a double-inclusion multi-layered structure (10) where the cementitious layers (6) are separated from each other by fibrous layers (2) filled with a filling product (4).

The structure (10) may also comprise one or more mesh layer(s) having a high elastic modulus so as to increase the rigidity and/or the resistance.

Figure 3 schematizes the forces acting inside a structure (10) according to the present invention when a constant bending moment is applied thereto, as illustrated in figure 3. It should be noted that for the present illustrative purposes, the neutral axis (3) was set through the centre of the structure (10), as shown in figure 3b. The cementitious layers (6) essentially resist to compressive stresses (C), whereas the fibrous layers (2) essentially resist to tensile stresses (T), as schematized in figure 3b). In some cases, such as when the fibrous layers (2) are filled with a hardening material, the fibrous layers (2) may also offer some compressive strength. In the same manner, for high-performance cementitious matrices, the cementitious matrices (6) may show a non-negligible tensile strength.

When under a bending moment, the cementitious layers (6) in the upper region of the structure are compressed, as shown in figure 3b), whereas the fibrous layers (2) of the lower region are strained. The shear stresses are mostly absorbed within the various layers and the interfaces (figure 3c). It is important for the layers to be as thin as possible to avoid the formation of weak shear zones. If layers of either type are too thick, cracks may develop inside those layers. If, for some reason, thick fibrous layers are used, the fibres should be resistant and well set together to avoid separation of the fibres inside the fabric layer. It is also possible to choose a filling material, which helps to tighten the fibres together so that it will absorb a portion of the shear stresses. In the case of thick cementitious layers (6), the matrix should be strong enough to resist to the shear stresses efficiently.

Since the proposed structure (10) is shaped as a laminated multi-layered structure, it is preferable for the cement layers (6) and fibrous layers (2) to be well connected together so as not to generate weak shear zones. The impregnation of the fibrous layer (2) should therefore preferably generate a strong link at the fibre layer-matrix interface. This is essentially a physical link, since the hardened matrix (6) is physically hooked to the multiple surface irregularities of the fibrous layer (2) and to the fibres projecting from said surface. For this reason, it is preferable that the filling material do not overly spill out of the fibrous layer, especially in the case of hydrophobe products, so that the hooking surface is not too smooth, which would be damaging to the fibre-cement bonding.

Three main phases can be distinguished during bending tests carried out on the structure. At first, the cementitious matrices (6) do not crack and the elastic modulus is very high, since it is determined only by the cement matrix. If it is possible for the fibrous layer (2) to stretch freely, an intermediate zone is then observed where the cementitious matrices (6) are cracked in different places. This zone is characterized by the appearance of cracks getting closer and closer to each other inside the matrix (6). This phenomenon is caused by straining phases of the matrix (6) until the straining limit is reached, followed by phases of cracking, stress relaxation and straining anew. During this period, the elastic modulus is determined by both the matrix (6) and the fibrous layer (2). Finally, still considering that the fibrous layer (2) can stretch freely, a zone is reached where the matrix (6) is so cracked that it cannot offer any more resistance and only the fibrous layers (2) are resisting to tensile stresses.

The elastic modulus of the structure (10) is then mostly determined by the elastic modulus of the fibrous layers (2). It should be noted that this type of behaviour cannot be observed in circumstances where the fibrous layers cannot stretch freely, the structure then being susceptible to breaking, once the most strained of the fibrous layers yields to traction.

Figure 4 illustrates a manufacturing process of a preferred embodiment of the invention where the structure is shaped as a panel (38), with a fluid cementitious composition. The ingredients of the cementitious composition (6) are first introduced into a mixer (20) and are then poured into a soaking pool (22), where the mortar is moved around by means of pumps (24) to avoid separation. The fibrous layers (2) are fed in from rollers (26). The fibrous layer (2) is wound on a motorized cylinder (28) after having successively been through an impregnation pool (30), where the filling material (4) is introduced, a drying zone (32), where the filling material (4) is dried in, and the soaking pool (22), where it is covered with the cementitious composition (6). During the winding of the resulting structure (34) on the motorised cylinder (28), the different layers are pressed together by a second roller (36). The resulting thickness is determined by the height of the winding roller (28) with respect to the pressing roller (36). When the desired number of layers is reached, the feeding of the fibrous layer (2) is cut , the trailing end is then cut and fixed on the winding cylinder (28). The panel (38) is then cut off directly on the cylinder (28) and the latter is brought to the end of a preparation table (40) provided with a plate (42) designed to receive the panel (38). The structure is then unwound, the plate is taken away inside a curing chamber (45) and a new plate is brought. The final cut of the panel is done once hardened on a cutting bench designed for this purpose.

It should be noted that figure 4 illustrates one preferred version of the method according to the invention and that other versions exist. The essential is that the method comprises a step where the non-woven fibrous material is filled with a filling material.

WHAT IS CLAIMED IS:

1. A multilayer structure comprising :

a plurality of fabric layers made of a porous nonwoven fibrous material sandwiched between layers of a cementitious matrix, characterized in that each of the fabric layers is filled with a nonhardening and non-cementitious filling material.

2. A multilayer structure according to claim 1, characterized in that the nonwoven fibrous material (2) comprises more than one type of non-woven fibrous material.

3. A multilayer structure according to any one of claims 1 and 2, characterized in that the filling material (4) comprises more than one type of filling material.

4. A multilayer structure according to any one of claims 1 to 3, characterized in that the layers of cementitious matrix (6) comprises more than one type of cementitious matrices.

5. A multilayer structure according to any one of claims 1 to 4, characterized in that the filling material (4) is a polymer.

6. A multilayer structure according to any one of claims 1 to 5, characterized in that the filling material (4) is at least one polymer selected from the group consisting of acrylics and rubbers.

7. A multilayer structure according to any one of claims 1 to 6, characterized in that the filing material further includes a flame-retardant powder emulsion.

8. A multilayer structure according to any one of claims 1 to 7, characterized in that the non-woven fibrous material (2) is a needle-punched non-woven fibrous material.

9. A multilayer structure according to any one of claims 1 to 8, characterized in that the non-woven fibrous material (2) comprises fibres selected from among the group consisting of glass fibres, carbon fibres, steel fibres, polymeric fibres, ceramic fibres and asbestos fibres.

10. A method of making a multilayer structure as defined in any one of claims 1 to 9, characterized in that it comprises the steps of:

a) providing a mat of non woven fibrous material (2);
b) filling the mat with a non-cementitious and nonhardening material (4); and
c) covering the mat of step b), after it has been filled with the non-cementitious and nonhardening material, with a cementitious composition (6).

11. A method according to claim 10, characterized in that, in step a), the mat is provided as a roll of non-woven fibrous material.

12. A method according to claim 11, characterized in that step b) comprises the step of:
unwinding the mat of non-woven fibrous material (2) and soaking it in a pool (30) of fluid filling material (4).

13. A method according to claim 12, characterized in that step c) comprises the step of:
soaking the mat obtained in step b) in a pool (22) of a fluid cementitious composition (6).

14. A method according to claim 13, characterized in that it further comprises the steps of:
d) winding the mat obtained in step c) on a winding roller (28) to form a roll of a desired number of layers of filled non-woven fibrous material (2) covered with the cementitious composition (6);
e) cutting a trailing end of the filled non-woven material (34) and fixing it on the roll formed in step d); and
f) cutting of the roll and unwinding it to obtain a multilayer panel.

15. A method according to claim 13, characterized in that step d) comprises a step of adjusting the thickness of the roll formed by pressing it with a pressing roller (36) mounted close to the winding roller (28).

16. A method according to claim 14, characterized in that, in step f), the roll is unwinded on a plate (42).

17. Use of a multilayer structure as defined in anyone of claims 1 to 9 as a construction panel, a pipe, a post, a bridge deck or a repair of existing concrete works.

18. Use according to claim 17, characterized in that the construction panel is selected from among the group consisting of a floor panel, a fireguard panel, a soundproofing panel, a thermal insulator panel, a covering panel for walls and roofs and an impact protecting panel.

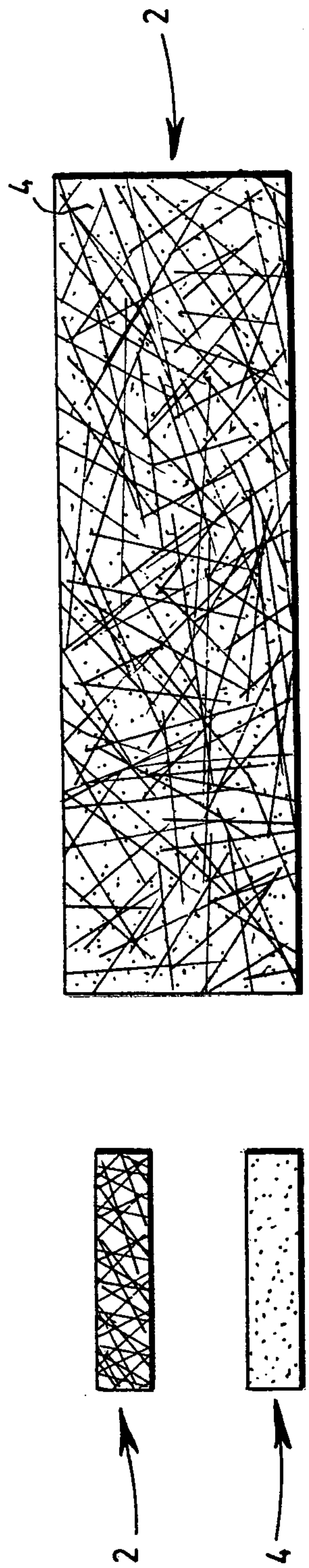


FIG. 1

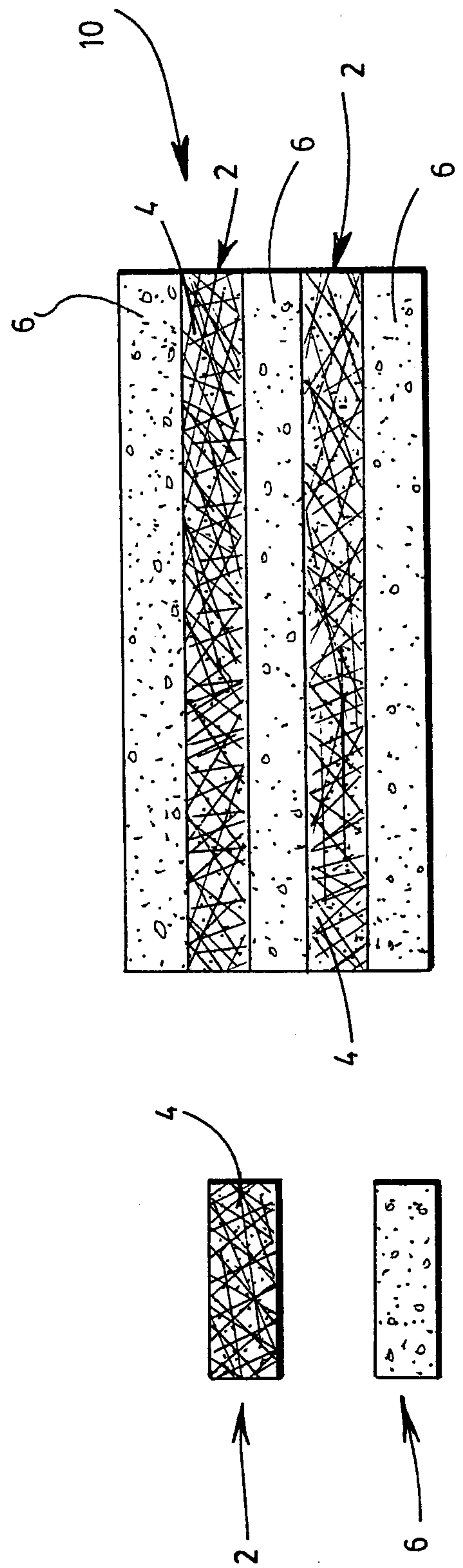


FIG. 2

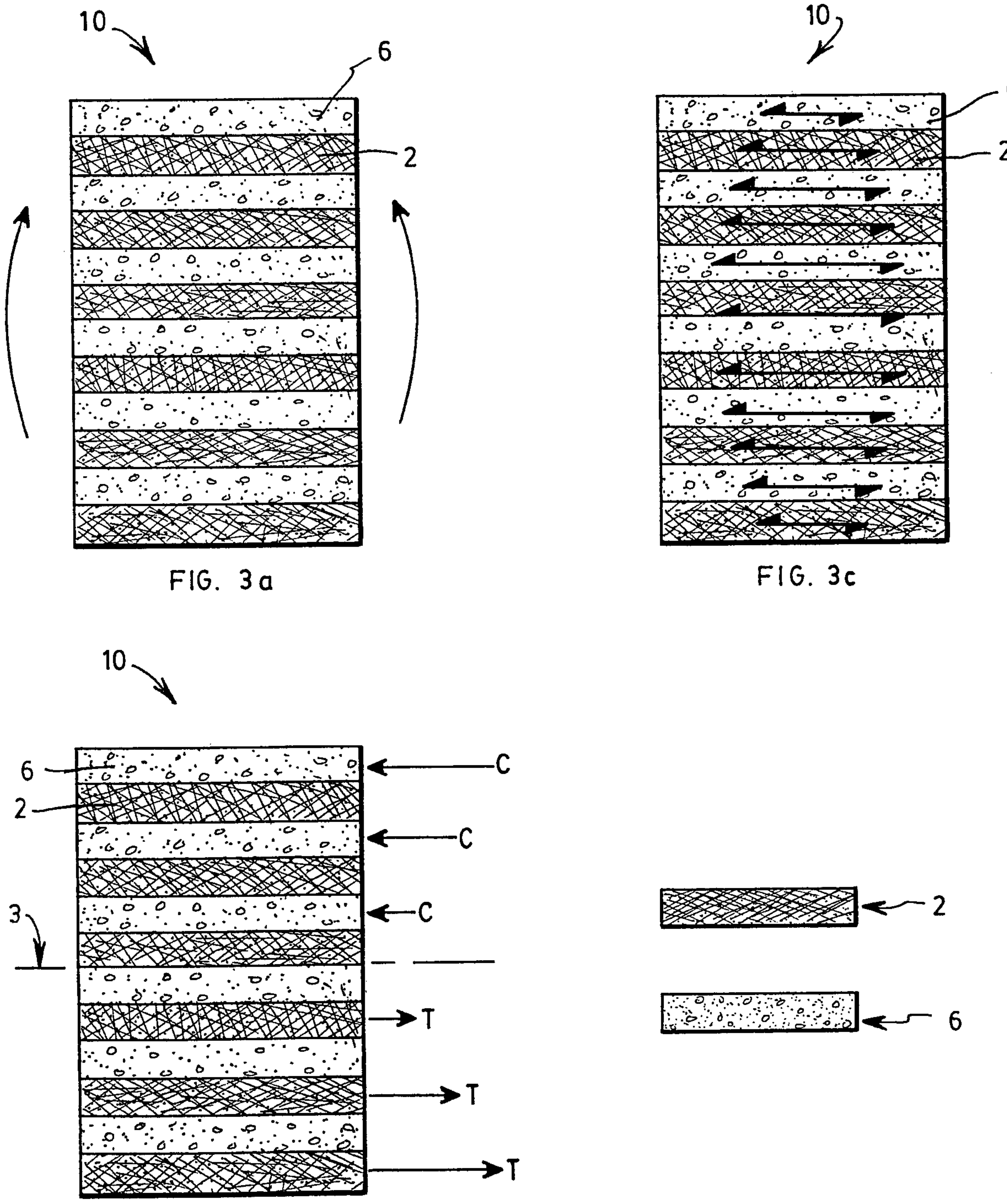


FIG. 3

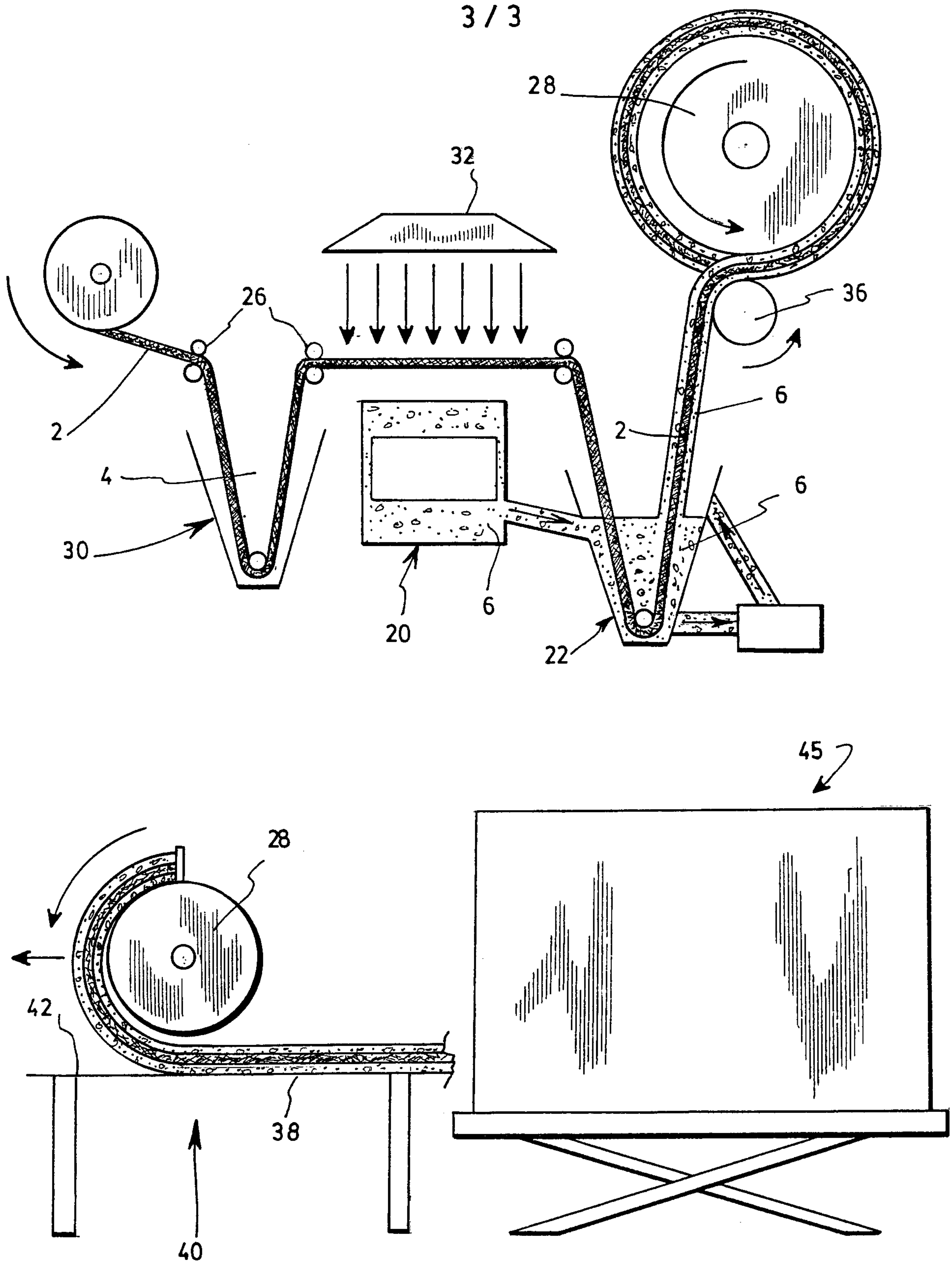


FIG. 4