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(54) **MINERAL FIBRE BATTS AND THEIR PRODUCTION**

GLASFASERMATTEN UND IHRE HERSTELLUNG

MATELAS DE FIBRES MINERALES ET LEUR PRODUCTION

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- **PATENT ABSTRACTS OF JAPAN vol. 1997, no. 10, 31 October 1997 (1997-10-31) & JP 09 158100 A (DAIKEN TRADE &IND CO LTD), 17 June 1997 (1997-06-17)**

EP 1 456 444 B2

Description

[0001] This invention relates to mineral fibre batts of the type which are conventionally known as "dual density" batts. These are bonded mineral fibre products comprising an upper layer intermeshed with a lower layer having a lower density than the upper layer, each layer being a bonded non-woven mineral fibre network.

[0002] The usual way of making dual density products is by providing a continuous mineral fibre web which contains binder, separating this web depthwise into upper and lower sub-webs, subjecting the upper sub-web to thickness compression so as to increase density, rejoining the sub-webs to form an uncured batt and then curing the binder to form the cured batt. The upper sub-web thus provides the higher density upper layer intermeshed with the lower density lower layer.

[0003] Typical disclosures of conventional dual density processes are given in, for instance, WO88/00265 and US-A-4,917,750. In each instance the web which is separated into sub-webs is a web as formed initially on a conveyor. As shown in WO88/00265, the web may be formed by cross lapping. As shown in both of those specifications the web is passed under some rollers as it approaches a device for separating the web into upper and lower sub-webs.

[0004] If no lengthwise compression is applied to the web before the separation, the fibres in the web will be substantially oriented parallel to the conveyor, because this is the predominant orientation during normal fibre lay-down processes. However in EP-A-1,111,113 the web is subjected to longitudinal compression before it is separated with the result that the fibres no longer have an orientation substantially parallel to the conveyor but instead have an orientation which has either a macro vertical component (so as to give significant visible pleats as shown in Figure 2 of EP-A-1,111,113) or a micro configuration (in which the vertical reconfiguration of the fibres has occurred but is not so visible to the naked eye, for instance as described in Figure 12 of EP-A-0,889,981).

[0005] In all these processes the lower web is subjected to little or no treatment between the positions where the upper web is separated from it and then rejoined on to it. This means that the ultimate performance of the totality of the product is dictated predominantly by the effect of the thickness compression on the upper layer and the structure of the web just before separation of the web into upper and lower sub-webs and by the effect of any post-treatment after the sub-webs are rejoined.

[0006] The thickness compression results in some length extension of the upper web. However as mentioned in EP-A-1,111,113 it is also possible to subject the upper web to longitudinal compression to compensate for the elongation of the upper web.

[0007] Unpublished research by us has demonstrated that the upper layer and the lower layer serve different but interrelated functions in providing the overall properties of the dual density batt, and that the properties of each layer are influenced significantly by the macro and micro' fibre arrangements within each layer in the final batt. Since the initial fibre orientation of the upper sub-web and the lower sub-web is the same this restricts the ability to obtain optimum properties. Thus a fibre arrangement in the initial web which is optimum for the lower layer may not be optimum for the upper layer, and vice versa.

[0008] Another disadvantage with this type of system is that if advantage is to be taken of longitudinal compression of the starting web, as in EP-A-1,111,113, the overall apparatus is very lengthy because of the length associated with longitudinal compression of the thick initial web followed by the dual density separation, thickness compression and rejoining.

[0009] A process is described in WO94/16162 in which upper and lower sub-webs are derived by separating an initial web and are subjected to independent treatments before they are rejoined. Thus in Figure 1 one sub-web is subjected to pleating by longitudinal compression, optionally followed by thickness compression or length compression, while the other sub-web is subjected to cross lapping and then length compression and then thickness compression and/or more length compression. This process does allow for independent configuration of the two sub-webs and the attainment of a dual density product, but suffers from the inherent disadvantage that the major processing steps conducted separately on the two sub-webs necessitate extremely complex and lengthy apparatus.

[0010] Simpler processes, in which the lower sub-web has the same fibre configuration as the initial web, are also shown in WO94/16162 but these suffer from the traditional disadvantage that the properties of the primary web may not be optimum for both the upper and lower sub webs.

[0011] We have now found that it is possible to make a very simple modification of a conventional dual density process so as to obtain an improved combination of product quality and apparatus simplicity. In particular we can obtain product quality at least as good as and often better than is obtainable by the elongated production line of EP-A-1,111,113 but using an apparatus production line which can be significantly shorter. In particular, we find that it is possible to achieve a unique fibre orientation by this process as a result of which improved properties, per unit weight of product, are obtainable, especially when compared to the product quality obtained by simple processes such as in WO88/00265 and US 4,917,950.

[0012] The invention broadly provides a continuous method of forming a bonded mineral fibre batt comprising an upper layer intermeshed with a lower layer having a lower density than the upper layer in which each layer is a bonded non-woven fibre network, wherein the method comprises providing a continuous mineral fibre web which contains binder, separating the web depthwise into upper and lower sub-webs, subjecting the sub-webs separately to lengthwise compression, and subjecting the upper sub-web to thickness compression before, during or after longitudinal' compression and optionally subjecting the lower sub-web to thickness compression generally before the lengthwise compression, whereby the upper layer of the batt has higher density than the lower layer, and then rejoining the sub-webs to form an uncured batt wherein the upper sub-web provides the upper layer of the batt, and curing the binder. Optionally either or both sub-webs may also be subjected to lengthwise stretching.

[0013] The upper sub-web is subjected to a very much greater thickness compression than the lower sub-web to give the required higher density (and indeed it is not absolutely essential for the lower layer to be subjected to any thickness compression), and some or all of the thickness compression on the upper sub-web is usually after longitudinal compression. As a result, the effect of the lengthwise compression on the two layers leads to very different fibre orientations in the two sub-layers even though the lengthwise compressions nominally may be substantially the same.

[0014] The two sub-webs are subjected to the same lengthwise compression, and they have substantially the same speed of travel when they are separated and when they rejoin. Minor differences in speed just before they rejoin can be tolerated provided that any resultant tension in other or both sub-webs when they are rejoined is so low that there is no distortion or delamination of the batt. Either or both may be subjected to lengthwise stretching.

[0015] Preferably the path lengths of the two sub-webs are not significantly different. For instance if the path length of' the sub-webs are different, the path length of the longer (usually the upper) sub-web is usually not more than 50%, preferably not more than 30% and most preferably not more than 15% longer than the path length of the lower sub-web, between the separating and rejoining points.

[0016] In some embodiments there may be benefit in having a significant vertical component in the fibre orientation at the time of separation of the web into the upper and lower sub-webs, as a result of longitudinal compression of the total web prior to separation. Best results, however, are obtained when the web which is separated has its fibres substantially oriented parallel to the surface of the web. By this we mean that the fibres in the web have the traditional essentially horizontal configuration which is typical for mineral fibres collected by an air-laying process, without any deliberate longitudinal compression or other vertical rearrangement of the fibres. Naturally the lay-down is not wholly horizontal, but the predominant orientation is clearly visible to the naked eye as being essentially parallel to the surface of the web.

[0017] The web at this stage may be a web formed by direct collection of mineral fibres by air-laying to the desired thickness or it may be a web formed by laying several such primary webs on one another or, more usually, by cross lapping a primary web to form a web of the desired thickness, optionally followed by mild thickness compression.

[0018] The web is then separated depthwise into upper and lower sub-webs in conventional manner by a knife or other splitting device which is usually arranged substantially horizontally at a desired spacing above a conveyor on which the web is carried continuously. The positioning of the separating device is chosen to provide the appropriate relative thicknesses of the upper and lower webs. The thickness of the upper sub-web, at the time of separation, is usually from 10 to 90% of the thickness of the total web. Usually it is at least 20% and often at least 30% of the total thickness, because the upper web is usually subjected to very high thickness compression and requires adequate thickness after this. Generally the upper sub-web is not more than about 70% or, at the most, about 80% of the total web thickness because usually it is required that the lower layer has sufficient thickness and structural content to impart significant properties to the final product.

[0019] Throughout this specification we are using the terms "upper" sub-web and layer and "lower" sub-web and layer in their conventional usage wherein conventionally a dual density batt is considered as having the higher density layer on its topmost surface. However the invention does, of course, include batts which are used the other way up and production processes in which the higher thickness compression is applied to the sub-web which is beneath the other sub-web, although in practice this is less preferred.

[0020] Also, it should be understood that although the' invention is described wholly in terms of upper and lower layers and upper and lower sub-webs the invention also extends to processes in which there are one or more other layers and corresponding sub-webs in the final product, wherein these other sub-webs may be subjected to the same or different thickness and/or lengthwise compressions as the upper sub-web and/or the lower sub-web. In particular there may be a higher density layer above the upper layer, for instance as described in WO00/73600.

[0021] Because, in the preferred process, the web which is separated into upper and lower webs has the initial fibre lay-down orientation (substantially parallel to the web surface), optionally with some thickness compression, the apparatus required for carrying out the process does not have to include preliminary lengthwise compression apparatus, for instance as described in EP-A-1,111,113. Instead, the entire apparatus can be confined within approximately the space occupied solely by the thickness compression stages for the upper sub-web shown in that specification or, for instance, in US 4,917,750 or. WO88/00265.

[0022] The upper sub-web, and optionally also the lower sub-web, is subjected to thickness compression between the separating and rejoining stages. The extent of thickness compression can be indicated by the percentage reduction in thickness. It is possible to perform the process without any thickness compression of the lower sub-web but generally it is subjected to a thickness compression of at least 5% (i.e., so that its thickness after the thickness compression is not more than 95% of its thickness when initially separated from the upper sub-web) and is usually at least 10%. Usually the thickness compression of the lower layer is not more than 60%, and preferably not more than 50%.

[0023] Preferably the actual thickness compression of the lower sub-web is equivalent to about 0.5 to 2 times, most preferably about 0.7 to 1.5 times the thickness of the upper sub-web at the time when it rejoins the lower sub-web. Typically therefore the extent to which the lower sub-web is subjected to thickness compression is such that its thickness is reduced by the thickness of the upper sub-web at the time of rejoining, so that the uncured batt formed by rejoining the sub-webs has the same, or substantially the same, thickness as the thickness of the lower sub-web when it was initially separated from the upper sub-web.

[0024] The thickness compression of the upper sub-web is always large, in order that this sub-web provides the required high density upper layer. Generally the overall thickness compression of the upper sub-web when it rejoins the lower sub-web is above 50%, preferably above 70% and most preferably above 85% (so that the final thickness of the upper sub-web is less than 15% of its thickness when initially separated from the lower sub-web. Usually, the overall thickness compression is less than 97%, and most preferably less than 95% of the initial thickness.

[0025] The thickness compression of the lower sub-web (when this is applied) is preferably conducted, and usually completed, before the longitudinal compression of the lower sub-web. Preferably, however, significant thickness compression is applied to the upper sub-web after it is subjected to some or all of the longitudinal compression to which it is to be subjected. Thus normally the upper sub-web is subjected to at least half, usually at least three quarters and preferably substantially all of its longitudinal compression and is then subjected to significant thickness compression.

[0026] The thickness compression which is applied.after the longitudinal compression may be the only thickness compression which is applied to the upper sub-web but usually the upper sub-web is also subjected to thickness compression before the longitudinal compression. Thus typically the upper sub-web is subjected to moderate thickness compression between separation and the longitudinal compression, for instance being reduced in thickness to from 90% to 30% of its original thickness, is then subjected to most or all of its longitudinal compression, and is then subjected to subsequent thickness compression which reduces the thickness of the sub-web to less than 50%, and usually less than 30%, of the thickness of the sub-web after the preceding thickness compression.

[0027] It seems that applying significant thickness compression to the upper sub-web after applying significant longitudinal compression is particularly beneficial to the final configuration and properties of the upper layer. The process can usually be optimised by subjecting the upper layer to substantially all the longitudinal compression before subjecting it to the final half or three quarters, or more, of the total thickness compression.

[0028] Although suitable thickness compression in the prior art is often achieved merely by the use of pairs of rollers, the unusual stresses created on the upper sub-web by the preferred process of the invention are such that the thickness compression after the longitudinal compression is preferably achieved by passage of the upper sub-web between converging endless surfaces. These may be converging conveyors, or a conveyor and a plate which converge.

[0029] The lengthwise compression in each of the upper and lower webs should be at least 1.2:1 and preferably at least 1.5:1 (i.e., the speed of the web leaving the lengthwise compression is not more than two thirds of the speed of the web entering the lengthwise compression stage). It is generally not more than 5:1 and often not more than 3:1.

[0030] Each longitudinal compression can be achieved in conventional manner by passing the relevant sub-web from one set of conveying surfaces (which may be belts or rollers) to a second set which are travelling slower. For instance the upper sub-web may be passed from a series of rollers or belts travelling at one speed to the converging passage between two conveyors which are travelling at a slower speed (so as to cause lengthwise compression followed by thickness compression). The lengthwise compression of the lower sub-web can be achieved by passage from rollers or converging belts that provide thickness compression to a set of rollers or belts which are moving slower and which are parallel to one another so that they do not provide thickness compression.

[0031] Although there is uncured binder in the upper and lower sub-webs, and this may be sufficient to achieve adequate integrity of the final batt, it is generally preferred to apply additional binder at the interface between the upper and lower sub-webs where they are rejoined, so as to promote the integrity of the final batt. The uncured batt is formed by pressing the upper and lower webs together with sufficient pressure to achieve intermeshing and integrity but preferably insufficient to cause thickness compression, because additional thickness compression at this stage is unnecessary, and indeed is generally undesirable since it may impair the pronounced' vertical fibre orientation which is'preferably achieved in the lower layer.

[0032] The batt is then passed through a curing oven in order to cure the total binder in conventional manner.

[0033] The invention not only includes the process but also includes the novel apparatus comprising the means for separating the web into sub-webs, subjecting each sub-web independently to treatments selected from lengthwise compression and thickness compression and rejoining the sub-webs, and wherein preferably the apparatus' is supplied with web direct from a fibre lay-down process or direct from a cross-lapping process.

[0034] The invention also includes the mineral fibre batts made by the process and batts having the structural characteristics of these. The preferred batts have an upper layer having a density of 100 to 300kg/m^3, often around 120 to 250kg/m^3. They have a lower layer which has a density which is usually not more than 80% but usually more than 30% of the density of the upper layer, often around 40 to 70% of the density of the upper layer. It is usually 50 to 150kg/m^2. Usually the upper and lower layers in the final product have a thickness of 30 to 300mm. The lower layer is usually 25 to 275mm thick and is usually at least 75mm thick. Generally it is at least 50%, and often 75 to 95%, of the combined thickness of the upper and lower layers.

[0035] The mineral fibres may be any suitable mineral fibres such as glass, rock, stone or slag. The invention is of particular value when applied to mineral fibres obtained by centrifugal fiberisation, and in particular by fiberisation of a rock, stone or slag melt by a cascade centrifugal spinner.

[0036] We find that it is possible, by the invention, to provide a lower layer which has a unique structure relative to the'structure of lower layers provided in other dual density processes and that this provides excellent support for the upper layer with the result that the overall properties of the combination of the high density upper layer and the unique lower layer provide a product having exceptional properties. This is discussed in more detail below.

[0037] The Figures 1 and 2 of the accompanying drawings are each a diagrammatic side view of apparatus according to the invention in use in the process of the invention.

[0038] In Figure 1, a web 1 is supplied direct from a cross lapping system which, in turn, is supplied direct from the collector of a collecting chamber from a conventional cascade spinner for rock fibres. Accordingly the overall and predominant orientation of the fibres in the web 1 is substantially parallel to the upper and lower surfaces of the web. The web 1 may have been vertically compressed and has a thickness TW and the rollers 2 and 3, and all the associated components with those, are set at a spacing corresponding to TW. The web 1 enters the apparatus at speed VW.

[0039] A separating knife 4 separates the web depthwise into an upper web 5 having a thickness TU1 and a lower web 6 having a thickness TL1. As shown, TU1 and TL1 are approximately the same, but they can be different. Lower web 6 passes between converging belts 7 and 8 driven by roller train 9 in the direction of travel of the web, as a result of which the belts 7 and 8 cause thickness compression of the lower web 6. As the lower web emerges from the converging belts at the position 10 it has a thickness TL2 which, as shown, is about three quarters of TL1.

[0040] The web then passes through upper and lower roller trains 11 and then through upper and lower roller trains 12. Within each of the roller trains, all the rollers rotate at the same speed to carry the web forward. Longitudinal compression is achieved by roller train 12 rotating slower than the rollers 9 and thus the belts 7 and 8. If roller train 11 rotates at the same speed as roller train 12 then longitudinal compression will be applied at position 10. If roller train 11 rotates at the same speed as roller train 9 then longitudinal compression will be applied at position 13. Often roller train 12 rotates slower than roller train 11 which rotates slower than roller train 9, in which event longitudinal compression is applied both at positions 10 and 13. The objective is that the speed of travel as the lower web 6 passes through guide rolls 14 should be the speed VB of the final batt as it enters the curing oven 15, with the ratio VW:VB generally being at least 1.5:1.

[0041] The upper web 5 is carried between a conveyor belt 16 and its supporting rollers 17 and a converging belt 18 and guide rolls 19. As a result of this the thickness of the upper web 5 is reduced from TU1 to TU2. TU2 may be, for instance, one third of TU1.

[0042] Conveyors 16 and 18 and rollers 19 all travel at the same speed and the upper web 5 travels from them to between converging belts 20 and 21 driven, respectively, by roller trains 22 and 23. Rollers trains 22 and 23 all rotate at the same speed, and at a-speed less than the roller trains 17 and 19. As a result, longitudinal compression is applied at position 24. The extent of this longitudinal compression is such that the speed of the upper web when it emerges from between the converging belts 20 and 21 is sufficiently close to VB that there will be no unacceptable distortions of the upper or lower layers when they are rejoined at 26 to form batt 29. Thus any stretching or compressing of either or both sub-webs, due to tension in either or both when they are rejoined, should be so low that there is no distortion or delamination of the batt 29.

[0043] The converging belts 20 and 21 apply substantial thickness compression to the upper web whereby the upper sub-web 5, when it emerges from between the converging belts, has an ultimate thickness (after any relaxation which occurs) of TU3, where TU3 is usually well below half of TU2 and typically below one fifth of TU1.

[0044] The upper sub-web may then slide over a supporting plate 25 as it travels down to the position 26 at which it rejoins the lower web. Binder is' sprayed between the webs as they are rejoined, from applicator 27.

[0045] As is apparent, it is preferred that substantially all the lengthwise and thickness compression steps conducted on the sub-webs are conducted between planar surfaces.

[0046] The rollers 28 apply enough pressure to press the upper and lower webs together to form an intermeshed batt 29 but' insufficient pressure to cause any significant thickness compression of it. The uncured batt

29 then passes into the curing oven 15 and is then cured and subjected to conventional post treatments, such as cutting into slabs of the desired size.

[0047] In Figure 2, the rolls 19 are arranged as separate sets 19a and 19b each of which is covered by a band and is driven. The roller train 17 has been divided into two sets, one set covered by conveyor 16a and the other set covered by conveyor 16b. Bands 16, 18 and 19a operate together at the same speed, and bands 16b and 19b operate together at the same speed, which can be lower. Lengthwise compression therefore can occur at both 40 and 24.

[0048] In one typical process of the invention, the ratio of the speeds of the belts 7:rolls 11:rolls 12: rolls 14 and 28 is 3:3:0.9:1 giving length compression at 13 and stretching between 12 and 14. In a second typical process, the ratio is 3:2:0.9:1, giving length compression at 10 and 13 and stretching between 12 and 14. This results in the lower layer being more relaxed, with less risk of the product distorting out of a planar configuration. Accordingly it can be desirable to subject the lower web to a plurality of length compressions.

[0049] As examples of the invention, products A, B and C were made using apparatus described above wherein the operating conditions were as follows:

Value	Product A	Product B	Product C
TW	110mm	380mm	360mm
TL1	65mm	330mm	225mm
TL2	60mm	185mm	185mm
TU1	45mm	50mm	135mm
TU2	6mm	6mm	10mm
TU3	12mm	15mm	30mm
TB	60mm	200mm .	215mm
VW	32m/min	6.9m/min	6.3m/min
VB	16m/min	2.3m/min	2.1m/min

[0050] We have established that the orientation of the fibres in the lower layer is unique and that the attainment of this unique orientation results in the lower layer giving better support to the top layer of a dual density product and that the product has improved penetration resistance and performance than is achieved when the lower layer does not have this orientation, when all other conditions are the same. Thus, as a result of obtaining the unique orientation it is possible to obtain equivalent results with a lower fibre' amount and/or better results with the same fibre amount, when the upper layer is unchanged. Similarly, it is possible to obtain better results when using the -same upper layer or equivalent results with an inferior upper layer.

[0051] The novel fibre orientation obtainable by the methods of the invention is also obtainable by other methods, and thus is another aspect of the invention.

[0052] In particular, in this product aspect of the invention we provide a dual density layer wherein the lower, lower density, layer is definable by its Kappa and Tau values in one or more cross sections, wherein these values are obtained by scanning examination of parts of each respective cross section through the thickness of the layer and Fast Fourier Transformation of the data.

[0053] In particular, in this product aspect of the invention we provide a dual density layer wherein the lower, lower density, layer is definable by its Kappa and Tau values in one or more cross sections, wherein these values are obtained by measuring parts of each respective cross section through the thickness of the layer in a flatbed scanner like Hewlett Packard ScanJet 6100C. The product to be examined is placed on the scanner so that it fits on top of the scanner with the shortest distance perpendicular to the scanning direction, see drawing.

[0054] For the set-up of the scanner use was made of the scanner-software Desk Scan II with the following settings: Sharp B, and W. Photo, Resolution 120x120dpi, and automatic adjustment of brightness and contrast. The scanned image (110mm x 270mm) was divided into a number of local windows in a pattern comprising 8 rows each with 33 windows of equal size (32x32pixels) in which the dominant fibre orientation was estimated using Fast Fourier Transformation.

[0055] As is known, a two-dimensional pattern, for instance of parallel stripes, can be expressed, by Fast Fourier Transformation, as a small number of dots and a complex two-dimensional pattern, such as a cross section of a mineral fibre network can be expressed by Fast Fourier Transformation as a large number of dots. These dots will be arranged in a pattern, which may be circular but more usually is elliptical.

[0056] The Tau value for the cross section is defined as the geometric mean of the ratio of the length of the ellipse to the width for each of the 33 local windows and thus a high value indicates a local well organised pattern (high consistency locally) and a lower value near 1 indicates that the pattern locally cannot be defined. The Kappa value is an indication of the statistical distribution of the different angles at which the ellipse is arranged locally for different parts of the overall structure, which is being examined. A high Kappa value indicates a narrow statistical distribution of angles whilst a low Kappa value indicates a broad distribution.

[0057] A description of the principles of the Tau and Kappa values for cross sections through the thickness of mineral fibre networks is described in "S.Dyrbol, Heat Transfer in Rockwool Modelling and Method of Measurement" Dept. of building and Energy, Technical University of Denmark and Rockwool International A/S. Ph.D-thesis, 1998. Reference should be made to that article for a description of how to examine a cross section and how to conduct a Fast Fourier Transformation on the result of the examination and calculate the Tau and Kappa values for the cross section. Other relevant publications are Russ., "Computer-Assisted Microscopy. The Measurement and Analysis of Images". Plenum Press, New York, 1990; Larsen and Hansen, "Orientation Analysis of Insulation Materials, A feasibility Studie for Rockwool International A/S". Department of Mathematical Modelling, Technical University of Denmark, 1997. IMM-TR-2001-03; and Ersboll and Conradsen "Analysis of directional data for Rockwool A/S", Department of Mathematical Modelling, Technical University of Denmark, 1998. IMM-TR-2001-04.

[0058] In every instance it is necessary to determine the Tau and Kappa values by taking the mean value of at least 5 separate determinations each consisting of 3 cross sections.

[0059] In novel mineral fibre batts of the invention there is an, upper layer having a density of 100 to 300kg/m^3 intermeshed with a lower layer having a lower density than the upper layer wherein each layer is formed of a bonded non-woven mineral fibre network the fibre orientation of which is definable by the Tau and Kappa values derived from Fourier Transformation of scanned images of thickness cross sections of the layers wherein T_x and K_x are the Tau and Kappa values determined on the thickness cross section of the layers in the lengthwise production direction X of the batt, and T_y and K_y are the Tau and Kappa values determined on the thickness cross section of the layers in direction Y which is perpendicular to the production direction X.

[0060] We have found that in the lower layers of conventional dual density products K_x is always less than K_y and that K_x is below 2, for instance 0.7 to 1.4. In the invention we find that improved performance from the lower layer is' achieved when K_x is greater than K_y, with the ratio K_x:K_y preferably being at least 1.3:1 and often at least 2:1, for instance up to 5:1.

[0061] Conventional products have K_x below about 1.5, but in the invention K_x is preferably at least 2.5 and most preferably at least 3.

[0062] We find that in conventional products T_x is always less than T_y but in the invention T_x is preferably above T_y. In particular, it is preferred that the ratio T_x:T_y is at least 1.2:1 and usually at least 1.5:1 and is often as much as 3:1 or more.

[0063] We find that T_x of the lower layer in conventional products normally has a value of 2.6 or less but in the invention T_x is preferably above 3, and most preferably above 3.5. For instance it may be up to 7 or more.

[0064] As an example, a conventional commercial product from a competitor was determined to have a lower layer in which K_x = 0.7, K_y = 2.9, T_x = 2.4 and T_y = 3.8. In contrast, a product made by the method described above had K_x 3.8, K_y 1.2, T_x 4.2 and T_y 2.6.

[0065] The upper layer of the commercial product had Kappa and Tau values in each direction substantially the same as the Kappa and Tau values of the upper layer of the product made by the present process, but the point load resistance of the products made by the present process was very much greater than the point load resistance of the commercial product. Although there was some difference in density and surface weight per unit area, the difference in point load resistance could not be explained by this and so, instead, can be attributed almost entirely to the benefits of the novel fibre orientation in the lower layer.

[0066] We believe that the unique Tau and Kappa values obtainable in the invention are due predominantly to the significant lengthwise compression applied to the lower layer independently of the upper layer, in combination with the relatively horizontal orientation of the fibres prior to splitting. Accordingly, if Kappa and Tau values or ratios not within the preferred ranges are obtained in any particular process, it is possible to achieve the desired results by'varying the extent of longitudinal compression of the lower sub-web, the extent of the combination of this with thickness compression of the lower sub-web, and the extent to which the fibres in the web before splitting are substantially horizontally arranged and the extent to which they are arranged predominantly in the Y direction, i.e., transverse to the lengthwise production direction X.

[0067] The lengthwise production direction X can usually be determined by observing the pattern impressed on the upper and lower surfaces of the batt by the curing oven, when cured in conventional manner.

[0068] Best results are achieved when the lower layer has the fibre orientation described above.and the upper layer has the fibre orientation described in PCT application ..... reference. PRL04361WO claiming priority from European application 01310773.5 filed even date herewith.

[0069] The invention may be utilised for production of roof boards, facade boards or similar boards produced from bonded mineral fibres when a certain point load resistance is required. They may be used generally for thermal insulation, fire proofing, fire protection, sound proofing, sound protection, and as horticultural growth medium.

Claims

1. A continuous method of forming a bonded mineral fibre batt (29) comprising an upper layer intermeshed with a lower layer having a lower density than the upper layer and in which each layer is a bonded non-woven mineral fibre network, the method comprising providing a continuous mineral fibre web (1) which contains binder,
   separating the web depthwise into upper and lower sub-webs (5, 6),
   subjecting each sub-web (5, 6) independently to treatments selected from lengthwise compression, lengthwise stretching, and thickness compression,
   rejoining the sub-webs (5, 6) whereby the upper sub-web provides the upper layer of the batt (29), and
   curing the binder,
   characterised in that both sub-webs (5, 6) are subjected to the same lengthwise compression and the upper sub-web is subjected to thickness compres-

sion before, during or after the lengthwise compression, and optionally the lower sub-web (6), is subjected to thickness compression, such that the upper layer of the batt (29) has higher density than the lower layer;
and in which the web (1) is a web made by collecting fibres by an air-laying process to form a primary web and then either;

(a) laying several such primary webs on one another or;
(b) cross lapping the primary web

without longitudinal compression prior to separating the web (1) into the upper and lower sub-webs (5, 6).

2. A method according to claim 1 in which, after the longitudinal compression of the lower sub-web (6), the lower sub-web (6) and the batt (29) are transported to a position at which the batt is cured without the lower sub-web or the batt being subjected to thickness compression.

3. A method according to claim 1 or claim 2 in which the upper sub-web (5) is subjected to at least half of its total longitudinal compression (24) and is then subjected to subsequent thickness compression (20, 21) which reduces its thickness (TU3) to less than half of the thickness (TU2) immediately prior to the said longitudinal compression.

4. A method according to claim 3 in which the upper sub-web is subjected to thickness compression to reduce its initial thickness (TU1) to provide a thickness (TU2) which is less than half the initial thickness (TU1) and is then subjected to longitudinal compression and is then subjected to thickness compression to provide a thickness (TU3) which is less than half its thickness immediately prior to the longitudinal compression (TU2).

5. A method according to claim 3 or claim 4 in which thickness compression of the upper web (5) after the longitudinal compression is effected by passage between converging planar surfaces (20, 21).

6. A method according to any of claims 1 to 5 in which the lengthwise compression of each of the sub-webs (5, 6) is between 1.5:1 and 5:1.

7. A method according to any of claims 1 to 6 in which binder is applied (27) between the upper and lower sub-webs (5, 6) as they are rejoined (26).

8. A method according to any of claims 1 to 7 in which the batt (29) has an upper layer having a density of 100 to 300kg/m^3 intermeshed with a lower layer having a density of less than 80% of the upper layer.

9. A method according to any of claims 1 to 8 in which the sub-webs have the same path lengths or path lengths which differ by not more than a ratio of 1.5:1.

10. A method according to any of claims 1 to 9 in which the product is a product according to claim 1.

11. Apparatus comprising means (2, 3) for continuously supplying a mineral web (1) to a separating device (4) whereby the web (1) is separated depthwise into upper and lower sub-webs (5, 6),
means for subjecting each sub-web (5, 6) independently to treatments selected from lengthwise compression (16, 18, 19; 20, 21; 9; 11; 12) and thickness compression (16, 18; 20, 21; 7, 8),
means (28) for rejoining the sub-webs (5, 6) and a curing oven (15) for curing the binder,
characterised in that the means (16, 18; 20, 21) for thickness compressing the upper sub-web (5) and any means (7, 8) for thickness compressing the lower sub-web (6) are such that the upper sub-web and the upper layer of the batt will have higher density than the lower sub-web and lower layer, and
there are means (16, 18, 19; 20, 21) for applying lengthwise compression to the upper sub-web (5) and these are means (9, 11, 12) for applying lengthwise compression to the lower sub-web (6), and
the means for supplying the web (1) to the separating device (4) comprise means for collecting fibres by an air-laying process to form a primary web, means for either

(a) laying several such primary webs on one another or
(b) cross-lapping the primary web,

and for supplying the layered or cross-lapped web to the separating device (4) without longitudinal compression of the layered or cross-lapped web, wherein the means for applying lengthwise compression to the upper and lower sub-webs each provide the same lengthwise compression.

Patentansprüche

1. Kontinuierliches Verfahren zur Herstellung eines gebundenen Mineralfaservlieses (29), umfassend eine obere Schicht, die mit einer unteren Schicht vermascht ist, welche eine geringere Dichte hat und in welchem jede Schicht ein gebundenes Mineralfaservlies-Netzwerk ist, wobei das Verfahren umfasst:

Bereitstellen einer kontinuierlichen Mineralfaserbahn (1), welche Bindemittel enthält,
Auftrennen der Bahn in der Tiefe in obere und untere Teilbahnen (5, 6),
Unterwerfen jeder Teilbahn (5, 6) auf unabhän-

gige Weise Behandlungen ausgewählt aus Längskompression, Längsdehnung und Dickenkompression,

Wiederverbinden der Teilbahnen (5, 6), wodurch die obere Teilbahn die obere Schicht des Vlieses (29) bereitstellt, und Härten des Bindemittels,

dadurch gekennzeichnet, dass beide Teilbahnen (5, 6) der gleichen Längskompression unterworfen werden und die obere Teilbahn vor, während oder nach der Längskompression der Dickenkompression unterworfen wird und wahlweise die untere Teilbahn (6) der Dickenkompression unterrworfen wird derart, dass die obere Schicht des Vlieses (29) eine höhere Dichte als die untere Schicht hat;

und in welchem die Bahn (1) eine Bahn ist, hergestellt durch Sammeln von Fasern durch einen Luftlegevorgang, um eine Primärbahn zu erzeugen und dann entweder;

(a) Übereinanderlegen mehrerer solcher Primärbahnen oder;

(b) Zickzackstapeln der Primärbahn,

ohne Längskompression vor dem Auftrennen der Bahn (1) in die oberen und unteren Teilbahnen (5, 6).

2. Verfahren gemäß Anspruch 1, bei welchem nach der Längskompression der unteren Teilbahn (6), die untere Teilbahn (6) und das Vlies (29) zu einer Position transportiert werden, an welcher das Vlies ohne die untere Teilbahn gehärtet wird oder das Vlies der Dickenkompression unterworfen wird.

3. Verfahren gemäß Anspruch 1 oder Anspruch 2, bei welchem die obere Teilbahn (5) mindestens der Hälfte ihrer gesamten Längskompression (24) unterworfen wird und dann einer nachfolgenden Dickenkompression (20, 21) unterworfen wird, welche ihre Dicke (TU3) auf weniger als die Hälfte der Dicke (TU2) unmittelbar vor der Längskompression verringert.

4. Verfahren gemäß Anspruch 3, bei welchem die obere Teilbahn der Dickenkompression unterworfen wird, um ihre anfängliche Dicke (TU1) zu verringern, um eine Dicke (TU2) bereitzustellen, welche geringer als die Hälfte der anfänglichen Dicke (TU1) ist, und dann der Längskompression unterworfen wird und dann der Dickenkompression unterworfen wird, um eine Dicke (TU3) bereitzustellen, welche geringer als die Hälfte ihrer Dicke unmittelbar vor der Längskompression (TU2) ist.

5. Verfahren nach Anspruch 3 oder Anspruch 4, bei welchem die Dickenkompression der oberen Bahn (5) nach der Längskompression durch Hindurchgehen zwischen konvergierenden ebenen Oberflächen (20, 21) durchgeführt wird.

6. Verfahren gemäß irgendeinem der Ansprüche 1 bis 5, bei welchem die Längskompression von jeder der Teilbahnen (5, 6) zwischen 1,5:1 und 5:1 beträgt.

7. Verfahren nach irgendeinem der Ansprüche 1 bis 6, bei welchem Bindemittel zwischen die oberen und unteren Teilbahnen (5, 6) aufgebracht (27) wird, wenn diese wieder verbunden (26) werden.

8. Verfahren gemäß irgendeinem der Ansprüche 1 bis 7, bei welchem das Vlies (29) eine obere Schicht mit einer Dichte von 100 bis 300 kg/m^3 aufweist, welche mit einer unteren Schicht vermascht ist, die eine Dichte von weniger als 80% der oberen Schicht aufweist.

9. Verfahren gemäß irgendeinem der Ansprüche 1 bis 8, bei welchem die Teilbahnen die gleichen Weglängen oder Weglängen haben, die sich um nicht mehr als um ein Verhältnis von 1,5:1 unterscheiden.

10. Verfahren nach irgendeinem der Ansprüche 1 bis 9, bei welchem das Produkt ein Produkt gemäß Anspruch 1 ist.

11. Vorrichtung umfassend Mittel (2, 3) zum kontinuierlichen Zuführen einer Mineralfaserbahn (1) zu einer Trennvorrichtung (4), durch welche die Bahn (1) in der Tiefe zu oberen und unteren Teilbahnen (5, 6) aufgetrennt wird,

Mittel zum Unterwerfen jeder Teilbahn (5, 6) auf unabhängige Weise Behandlungen ausgewählt aus Längskompression (16, 18, 19; 20, 21; 9; 11; 12) und Dickenkompression (16, 18; 20, 21; 7, 8),

Mittel (28) zum Wiederverbinden der Teilbahnen (5, 6) und einen Härtungsofen (15) zum Härten des Bindemittels, **dadurch gekennzeichnet, dass** die Mittel (16, 18; 20, 21) zur Dickenkompression der oberen Teilbahn (5) und irgendwelche Mittel (7, 8) zur Dickenkompression der unteren Teilbahn (6) solche sind, dass die obere Teilbahn und die obere Schicht des Vlieses eine höhere Dichte haben als die untere Teilbahn und die untere Schicht, und

Mittel (16, 18, 19; 20, 21) vorhanden sind zum Aufbringen von Längskompression auf die obere Teilbahn (5) und Mittel (9, 11, 12) zum Aufbringen von Längskompression auf die untere Teilbahn (6) vorhanden sind, und

die Mittel zum Zuführen der Bahn (1) zu der Trennvorrichtung (4) Mittel zum Sammeln von Fasern durch einen Luftlegevorgang umfassen, um eine Primärbahn zu erzeugen, und zwar Mittel zum entweder

(a) Übereinanderlegen mehrerer solcher Pri-

märbahnen oder
(b) Zickzackstapeln der Primärbahn,

und zum Zuführen der geschichteten oder zickzack-gestapelten Bahn zu der Trennvorrichtung (4) ohne Längskompression der geschichteten oder zick-zack-gestapelten Bahn, wobei die Mittel zum Aufbringen der Längskompression auf die obere und die untere Terilbahn jeweils die gleiche Längskompression bereitstellen.

Revendications

1. Procédé pour former en continu une nappe de fibres minérales collées (29) comprenant une couche supérieure entremêlée avec une couche inférieure ayant une densité inférieure à la couche supérieure et dans lequel chaque couche est un réseau de fibres non tissées collées, le procédé comprenant

de fournir un voile continu (1) de fibres minérales qui contient un liant,
de séparer le voile dans le sens de la profondeur en un voile partiel inférieur et un voile partiel supérieur (5, 6),
de soumettre chaque voile partiel (5, 6) indépendamment à des traitements choisis parmi la compression en longueur, l'étirage en longueur, et la compression en épaisseur,
de réunir les voiles partiels (5, 6) de telle façon que le voile partiel supérieur constitue la couche supérieure de la nappe (29), et de faire durcir le liant,
caractérisé en ce que les deux voiles partiels (5, 6) sont soumis à la même compression en longueur et le voile supérieur est soumis à une compression en épaisseur avant, pendant ou après la compression en longueur, et en option le voile partiel inférieur (6) est soumis à une compression en épaisseur, de telle sorte que la couche supérieure de la nappe (29) possède une densité supérieure à celle de la couche inférieure ;
et dans lequel le voile (1) est un voile réalisé en rassemblant des fibres par un processus de dépose à l'air pour former un voile primaire et ensuite :

(a) ou bien on pose plusieurs voiles primaires de ce type les uns sur les autres ;
(b) ou bien on effectue une pose croisée du voile primaire

sans compression longitudinale avant de séparer le voile (1) en un voile partiel supérieur et un voile partiel inférieur (5, 6).

2. Procédé selon la revendication 1, dans lequel, après la compression longitudinale du voile partiel inférieur (6), le voile partiel inférieur (6) et la nappe (29) sont transportés à une position à laquelle la nappe est durcie sans que le voile partiel inférieur ou la nappe soit soumis à une compression en épaisseur.

3. Procédé selon la revendication 1 ou 2, dans lequel le voile partiel supérieur (5) est soumis à au moins la moitié de sa compression longitudinale totale (24), et est ensuite soumis à une compression en épaisseur ultérieure (20, 21) qui réduit son épaisseur (TU3) à moins de la moitié de l'épaisseur (TU2) immédiatement avant ladite compression longitudinale.

4. Procédé selon la revendication 3, dans lequel le voile partiel supérieur est soumis à une compression en épaisseur pour réduire son épaisseur initiale (TU1) pour produire une épaisseur (TU2) qui est inférieure à la moitié de l'épaisseur initiale (TU1), et est ensuite soumis à une compression longitudinale, puis est alors soumis à une compression en épaisseur pour donner une épaisseur (TU3) qui est inférieure à la moitié de son épaisseur immédiatement avant la compression longitudinale (TU2).

5. Procédé selon la revendication 3 ou 4, dans lequel la compression en épaisseur du voile supérieur (5) après la compression longitudinale est effectuée par un passage entre des surfaces planes convergentes (20, 21).

6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel la compression en longueur de chacun des voiles partiels (5, 6) est entre 1,5:1 et 5:1.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel un liant est appliqué (27) entre le voile partiel supérieur et le voile partiel inférieur (5, 6) lorsqu'ils sont réunis (26).

8. Procédé selon l'une quelconque des revendications 1 à 7, dans lequel la nappe (29) possède une couche supérieure ayant une densité de 100 à 300 kg/m^3 entremêlée avec une couche inférieure ayant une densité inférieure à 80 % de la couche supérieure.

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel les voiles partiels ont les mêmes longueurs de trajet, ou des longueurs de trajet qui diffèrent de quantités qui ne dépassent pas un rapport de 1,5:1.

10. Procédé selon l'une quelconque des revendications 1 à 9, dans lequel le produit est un produit selon la revendication 1.

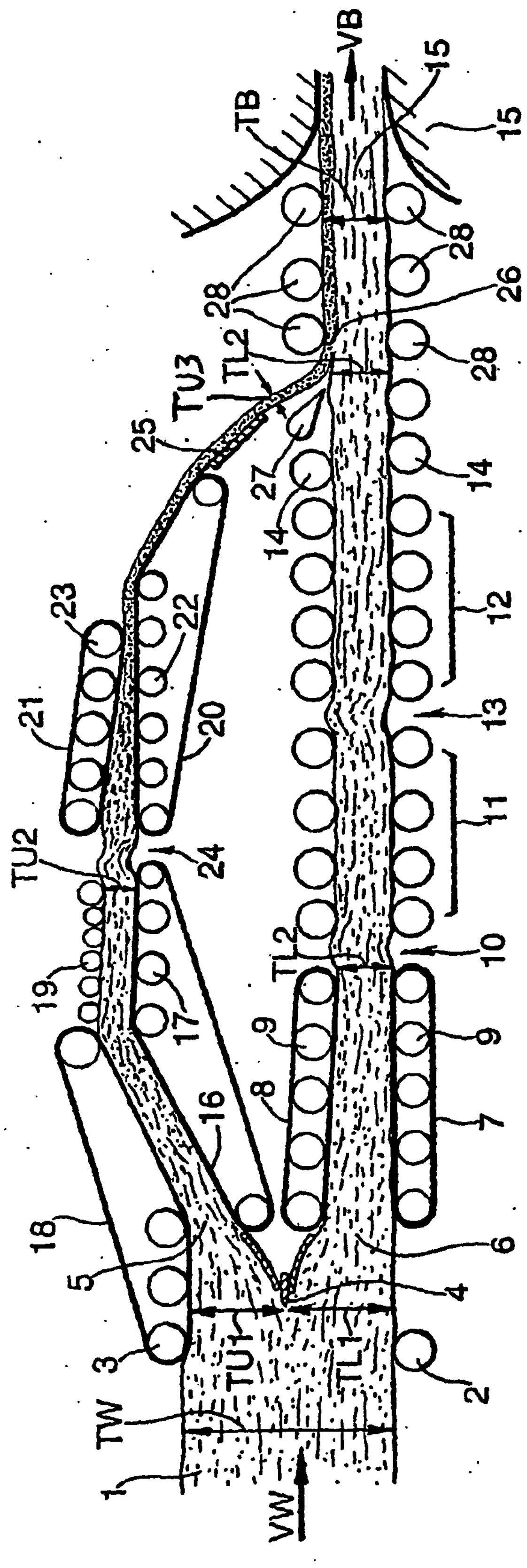
11. Appareil comprenant des moyens (2, 3) pour fournir en continu un voile minéral (1) à un dispositif de séparation (4) grâce auquel le voile (1) est séparé dans le sens de la profondeur en un voile partiel supérieur et un voile partiel inférieur (5, 6),

des moyens pour soumettre chaque voile partiel (5, 6) indépendamment à des traitements choisis parmi la compression longueur (16, 18, 19 ; 20, 21 ; 9 ; 11 ; 12) et la compression en épaisseur (16, 18 ; 20, 21 ; 7, 8),
des moyens (28) pour réunir les voiles partiels (5, 6), et
un four de prise (15) pour faire prendre le liant, **caractérisé en ce que** les moyens (16, 18 ; 20, 21) pour comprimer en épaisseur le voile partiel supérieur (5) et tous moyens (7, 8) pour comprimer en épaisseur le voile partiel inférieur (6) sont tels que le voile partiel supérieur et la couche supérieure de la nappe auront une densité supérieure au voile partiel inférieur et à la couche inférieure, et il est prévu des moyens (16, 18, 19 ; 20, 21) pour appliquer une compression en longueur au voile partiel supérieur (5), et il est prévu des moyens (9, 11, 12) pour appliquer une compression en longueur au voile partiel inférieur (6), et
les moyens pour fournir le voile (1) au dispositif de séparation (4) comprennent des moyens pour recueillir des fibres au moyen d'un procédé de dépose à l'air pour former un voile primaire, et des moyens

(a) ou bien pour déposer plusieurs voiles primaires de ce type les uns sur les autres,
(b) ou bien faire une pose croisée du voile primaire,

et pour alimenter le voile en couches ou le voile posé en croix vers le dispositif de séparation (4) sans compression longitudinale du voile en couches ou du voile posé en croix, dans lequel les moyens pour appliquer une compression en longueur au voile partiel supérieur et au voile partiel inférieur assurent chacun la même compression en longueur.

Fig.1.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TL2
TU3
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TU2
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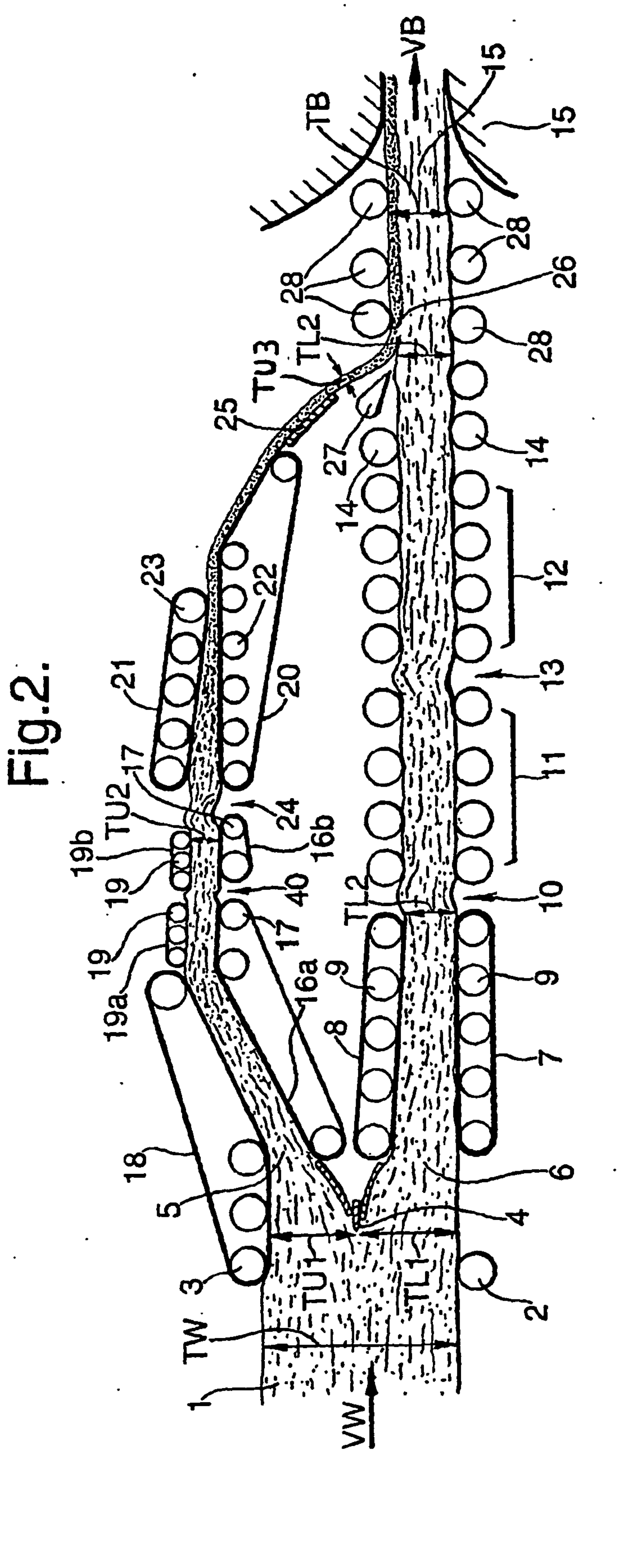
TL1
2
TW
1
VW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17
TU2
19b
19
16b
40
19a
16a
9
8
7
18
5
6
4
3
TU1
TL1
2
TW
1
VW

Fig.2.

REFERENCES CITED IN THE DESCRIPTION

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