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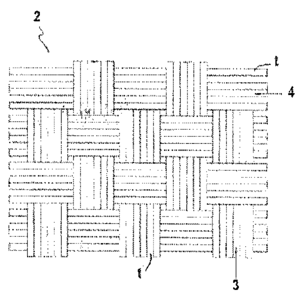
(54) **Titre : TISSU NOTAMMENT DE FILS DE CARBONE PRESENTANT UNE FAIBLE VARIABILITE D'EPAISSEUR COMBINEE A UNE GAMME SPECIFIQUE DE MASSE SURFACIQUE**

(54) **Title: FABRIC IN PARTICULAR MADE OF CARBON YARNS HAVING LOW THICKNESS VARIABILITY COMBINED WITH A SPECIFIC BASIS WEIGHT RANGE**



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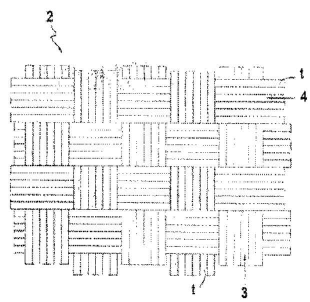

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(57) **Abrégé/Abstract:**

Fabric having warp and weft yarns where filaments in the yarns freely move relatively to each other. The basis weight of the fabric is related to the thickness standard deviation of a stack of three identical fabrics deposited on each other. For basis weights greater than or equal to 40 g/m^2 and less than 100 g/m^2, the thickness standard deviation is less than or equal to 35 µm. For basis weights greater than or equal to 100 g/m^2 and less than or equal to 160 g/m^2, the thickness standard deviation is less than or equal to 50 µm. For basis weights greater than 160 g/m^2 and less than or equal to 200 g/m^2, the thickness standard deviation is less than or equal to 60 µm. For basis weights greater than 200 g/m^2 and less than or equal to 400 g/m^2, the thickness standard deviation is less than or equal to 90 µm.

ABSTRACT OF THE DISCLOSURE

Fabric having warp and weft yarns where filaments in the yarns freely move relatively to each other. The basis weight of the fabric is related to the thickness standard deviation of a stack of three identical fabrics deposited on each other. For basis weights greater than or equal to 40 g/m^2 and less than 100 g/m^2, the thickness standard deviation is less than or equal to 35 µm. For basis weights greater than or equal to 100 g/m^2 and less than or equal to 160 g/m^2, the thickness standard deviation is less than or equal to 50 µm. For basis weights greater than 160 g/m^2 and less than or equal to 200 g/m^2, the thickness standard deviation is less than or equal to 60 µm. For basis weights greater than 200 g/m^2 and less than or equal to 400 g/m^2, the thickness standard deviation is less than or equal to 90 µm.

FABRIC IN PARTICULAR MADE OF CARBON YARNS HAVING LOW THICKNESS VARIABILITY COMBINED WITH A SPECIFIC BASIS WEIGHT RANGE

The present invention relates to the technical field of machines allowing homogenization of the thickness of fibrous sheets and/or spreading of such fibrous sheets, in order to obtain lower basis weights. In particular, the invention relates to a method and to a machine allowing homogenization of the thickness of such sheets, as well as to fabrics which may be obtained by applying such a method.

In the field of composite materials, the applicant was interested in proposing textile fabric sheets having a thickness as homogenous as possible, so as to obtain parts with controlled final mechanical properties. In the case of fabrics, conventionally consisting of an interlacing of warp yarns and of weft yarns, the latter is particularly difficult.

The reinforcements for a composite are exclusively used with addition of resin with different methods. The geometry of the final composite part therefore directly results from the thicknesses of the reinforcement used. It is then clear that the use of thinner reinforcements will provide lighter composite parts and also more performing since they have their fibres better oriented with less ripples. A fact which is less obvious but also true is that these reinforcements, being also used in a sometimes significant stack, it is necessary to reduce to a minimum their variations in thickness in order to make the geometry of the obtained composite part more reliable and robust. As the individual variabilities of the folds will gradually add up, a great variability in thickness of the reinforcement will inevitably cause a strong variability in thickness in the final part during the use of methods such as vacuum infusion.

Various documents are interested in spreading of fabrics, without however mentioning the impact which may have the spreading applied on the thickness and in particular on the thickness deviations which have the obtained spread textile sheets. Mention may be made of documents US

4,932,107, US 5,732,748, EP 670 921, WO2005/095689 and WO 94/12708. It is important to note that a tissue does not leave a weaving machine with homogenous thickness and openness factor on its width. Indeed, the actual principle of weaving induces a shrinkage phenomenon well known to one skilled in the art. This shrinkage is a reduction in the width of the warp sheet before and after weaving. It is due to the interlacing action of the warp and weft yarns. The latter cover a shorter final distance because of their ripples over and under the warp yarns. The result of this is a reduction in the width of the sheet upon leaving the comb of a weaving machine. As this shrinkage is related to the ripples of the weft yarns, it is not homogenous over the width of the fabric by the fact that the weft yarns are more free, close to the edges and less held by less numerous neighbouring warp yarns. As they are less blocked and more free, these edge of yarns therefore ripple more, the result of this is then a larger thickness and generally a larger openness factor. The thickness difference between the edges and the medium increases with the basis weight of the fabric.

It should also be noted that the over–thickness phenomenon of the edges is very locally enhanced by the use of generally thermoplastic selvage yarns used on the edges of the fabric for blocking the last warp yarns.

All the fabrics proposed in the prior art, which are spread out after their weaving, because of the applied spreading technique necessarily have significant thickness variation. In particular, in document US 4,932,107, no mention of any width of the fabric, of the average width of the warp and weft yarns after spreading and of homogeneity of the openness factor on the fabric. Now, all these elements determine the more or less homogenous thickness of the fabric obtained after spreading. If the examples proposed in this patent are considered, if a tension of 200g/cm is applied on a fabric with a width of 1.5m, the value of the tension on the roller will be 150x200=30,000 i.e. 30,000g. This value is sufficient for generating flexure of the rollers preventing the obtaining of a parallelism between the axes of the rollers and therefore a homogeneous pressure on the fabric, because of a higher pressure on the edges. There results a limitation of the width of the fabric to be processed in connection with the diameter of the rollers and of their length. In order to attempt to circumvent this difficulty, an increase in the diameter of the rollers may be contemplated for limiting flexure, but in this case, the inertia of the latter will then become significant and the energy required for obtaining the amplitude and the frequency will increase in proportion. Moreover, it may be noted that patent US 4,932,107 applied in its example 3B, 2 rollers with the diameter of 125 mm with a single upper vibrating roller with a diameter of 60 mm, which on the one hand does not give the possibility of obtaining satisfactory spreading and on the other hand homogenization of the thickness. In a more general way, all the techniques for spreading fabrics described in the prior art do not give the possibility of adapting to the initial differences in thickness which the fabric has and therefore do not give the possibility of obtaining satisfactory spreading and homogenization of the thickness.

There also exist fabrics made in two steps, the first step being the formation of sheets with low basis weight consolidated via a polymeric binder, and then producing the interlacing for forming a fabric. Such fabrics because of the preliminary consolidation of the sheets provide lesser possibilities in terms of deformability during their applications. Further, the polymeric binders used may not be compatible with the sheet of requirements under hygrothermal stress of the final composite part.

In a more general context, mention may be made of documents US 2007/066171 and US 2004/142618 which describe fabrics of reinforcing yarns, in dry form, without any data being provided on their thickness variation, which as indicated earlier is implicitly important, taking into account the available methods for making such fabrics.

In this context, the invention proposes to react to the problems mentioned above and encountered in the prior art and to provide a novel method and a novel machine giving the possibility of simply controlling the thickness of the obtained textile sheet following a spreading operation, so as to obtain a low thickness variability, and this even on large widths of sheet.

In this context, the invention describes a method for spreading a textile sheet including at least warp yarns, according to which:

- the sheet is caused to run between at least two rotary rollers, the axes of which extend parallel with each other and are substantially perpendicular to the running direction of the sheet,

- the sheet is passed under pressure between at least one pressure generator for the rollers driven into axial oscillation and opposed in phase.

According to the invention, a pressure generator for the rollers is produced with adjustable pressure values along said generator for spreading the sheet with low thickness variability.

Within the scope of the invention, it is also possible to ensure the application of a uniform pressure on the sheet so as to obtain a uniform thickness regardless of the width of the sheet. The rollers thus modulate the applied pressure between the centre and the ends of the sheet, by taking into account the different thicknesses of the sheet so as to apply a uniform pressure on the material along the pressure generator. Typically, the pressure applied at the centre of the sheet is greater than that applied on its edges so as to take into account the upper thickness of the sheet on its edges with respect to its central portion.

According to a preferred embodiment, one of the rollers is made to be flexible and the other one rigid and localized supports distributed along the axis of the roller are exerted on this flexible roller, substantially perpendicularly to its axis and with adjustable values for producing the generator with adjustable pressure values. The flexible roller may thus position itself automatically without any stress and thereby modulate the pressure applied on the sheet. In this case, preferably, the method *inter alia* consists of adjusting the position of the localized supports along the axis of the flexible roller and/or distributing the localized supports regularly along the axis of the flexible roller.

According to a preferred embodiment which may be combined with the previous one, the method *inter alia* consists of distributing the localized supports at most over the whole width of the textile sheet.

According to another preferred embodiment which may be combined with the previous ones, the method *inter alia* consists of causing the textile sheet to pass over the periphery of the flexible roller between two pressure generators with adjustable localized pressure values of both rigid rollers synchronously driven in rotation and in oscillation. In this case, preferably, the method consists of causing the textile sheet to pass between 1/6 and 1/3 of the periphery of the flexible roller. It is thus possible to do without the applied tension on the running textile sheet. Further, this facilitates obtaining an adjustable pressure on the textile sheet, all along both pressure generators, between the textile sheet and the rigid rollers, given that this method for the passing of the textile sheet which no longer covers the rollers, as in patent US 4,932,107, thus allows addition of a series of rigid supports to both rigid rollers thereby avoiding any flexure of the latter. On the other hand, this passing method also facilitates the positioning of the localized supports on the flexible roller.

According to another preferred embodiment which may be combined with the preceding ones, the method comprises the heating of the textile sheet during its passing between the pressure generator(s).

According to another preferred embodiment which may be combined with the previous ones, the method consists of bringing as a textile sheet, a fabric including warp yarns and weft yarns each consisting of a set of filaments which may freely move relatively to each other within said yarn, the spreading being produced on the warp yarns and on the weft yarns.

The present invention also describes a machine for spreading a textile fabric consisting of at least warp yarns, including:

- at least two rotary rollers, the axes of which extend parallel with each other and perpendicularly to a pressure generator, delimited between both rollers,
- a rotation motor–drive for at least one roller,
- and a system for driving the rollers in axial oscillation with phase opposition.

According to the invention, the machine includes a system for producing the pressure generator with adjustable pressure values distributed along said generator, for spreading the textile fabric with low thickness variability.

The machine, according to the invention, comprises either one, or even all the features below when they do not exclude one from the other:

- the system for producing the pressure generator includes from among rotary rollers, a flexible roller and a series of localized supports with adjustable pressure, distributed along the axis of the flexible roller and acting on the flexible roller supported by at least one rigid roller,

- the localized supports are equipped with a device for adjusting their position along the axis of the flexible roller,

- the localized supports exert their pressure on the flexible roller, via rolling members with axial displacement,

- the flexible roller delimits with two rigid rollers, the axes of which extend parallel with each other, two pressure generators with adjustable localized pressure values, both of these generators being separated between 1/6 and 1/3 of the periphery of the flexible roller,

- the rollers have a diameter comprised between 30 mm and 60 mm,

- the machine includes, for each rigid roller, a series of rigid supports each including a cradle attached to a chassis and having two supporting branches each equipped with a rolling member for a rigid roller, having a rotary movement and a translational movement along the axis of the rigid rollers,

- the system for driving the rollers into axial oscillation and in phase opposition includes a motor synchronously driving by means of a transmission, two camshafts shifted by 180°, one of which acts on one of the ends of the flexible roller and the other one acts on one of the ends of the rigid roller(s), the other end of the rollers being urged by an elastic system; this gives the possibility of ensuring perfect control of the amplitude and of the operation, in phase opposition between the flexible roller and both rigid rollers,

- the machine includes a system for lifting the flexible roller, the ends of which are provided with plates on which acts the elastic system and on the other one of which acts the camshaft,

- the machine includes a system for heating the textile sheet upon passing the textile sheet between the pressure generators.

Such a method and such a machine make it thus possible to access the fabrics, object of the invention.

Actually, the object of the invention is fabrics consisting of warp yarns and of weft yarns, having a low thickness variation, characterized by either one of the combinations of the following characteristics:

- a basis weight greater than or equal to 40g/m^2 and less than 100g/m^2 and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 35µm,

- a basis weight greater than or equal to 100g/m^2 and less than or equal to 160g/m^2 and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 50µm,

- a basis weight greater than 160g/m^2 and less than or equal to 200g/m^2 and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 60µm, or

- a basis weight greater than 200g/m^2 and less than or equal to 400g/m^2 and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 90µm.

In the fabrics according to the invention, the warp yarns and/or the weft yarns consist of a set of filaments, said filaments may freely move relatively to each other within a same yarn. This is why the fabrics according to the invention may be obtained by means of the method according to the invention. Unlike prior techniques, the method according to the invention provides access to such fabrics having such a combination of features.

Obtaining such fabrics with a width of at least 100cm, notably with a width from 100 to 200cm, is possible. The fabrics according to the invention may therefore have a great width and a very great length, for example approximately equivalent to the length of the available yarns, i.e. several hundred or thousands of meters.

The fabrics proposed within the scope of the invention, because of their lower thickness variability, will give composite parts with a better controlled geometry and will lead to a more robust global manufacturing method.

By thickness standard deviation, is meant the quadratic average of the deviations to the mean, i.e.:

$$\sqrt{\frac{1}{n}\sum_{i}(x_i - \bar{x})^2}$$

with:

n = number of values of measurements of the thickness of the stack of three identical fabrics and oriented in the same direction, i.e. the warp yarns on the one hand, and the weft yarns on the other hand are oriented in the same direction within the stack,

xi = a measurement value of the thickness of the stack of the three identical fabrics,

$\bar{x}$= arithmetic mean of the thickness measurements of the stack of three identical fabrics.

As the measured fabric unit folds become so thin, it appeared to be more representative to measure the thickness standard deviation on a stack of 3 folds.

Within the scope of the invention, the standard deviation may be obtained on a stack of three folds of a same fabric deposited on each other and oriented in the same direction and placed under a pressure of 972mbars +/- 3mbars, and notably from 25 one–off thickness measurements distributed over a surface of 305 x 305 mm, with for example one of the sides of the square which extends parallel to the warp yarns of the fabric. The method described in the examples may be used.

Advantageously, the fabrics defined within the scope of the invention consist of warp yarns identical with each other and weft yarns identical with each other, and preferably warp yarns and weft yarns which are all identical. In particular, the fabrics defined within the scope of the invention consist of, preferably by at least 99% by mass, or even exclusively consist of multi-filament reinforcement yarns, notably glass, carbon or aramide yarns, carbon yarns being preferred. As examples of fabrics according to the invention, mention may be made of those having an architecture of the web type otherwise called taffeta, twill, a basket weave, or satin.

In particular, the invention relates to:

- fabrics which have a basis weight greater than or equal to 40g/m^2 and less than 100g/m^2, a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 35µm and an average openness factor from 0 to 1%. Advantageously, such fabrics have a variability of openness factor from 0 to 1%. Within the scope of the invention, the obtained spreading gives the possibility of obtaining such fabrics with yarns, and in particular carbon yarns, having a titer from 200 to 3,500 Tex, and preferably from 200 to 800 Tex,

- fabrics which have a basis weight greater than or equal to 100g/m^2 and less than or equal to 160g/m^2, a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 50µm and an average openness factor from 0 to 0.5%. Advantageously, such fabrics have a variability of openness factor of at most 0.5%. Within the scope of the invention, the obtained spreading gives the possibility of obtaining such fabrics with yarns, and in particular carbon yarns, having a titer from 200 to 3,500 Tex, and preferably from 400 to 1,700 Tex,

- fabrics which have a basis weight greater than 160g/m^2 and less than or equal to 200 g/m^2, a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 60μm and an average openness factor from 0 to 0.5%. Advantageously, such fabrics have a variability of openness factor of at most 0.5%. Within the scope of the invention, the obtained spreading gives the possibility of obtaining such fabrics with yarns, and in particular carbon yarns, having a titer from 200 to 3,500 Tex, and preferably from 400 to 1,700 Tex,

- fabrics which have a basis weight greater than 200g/m^2 and less than or equal to 400g/m^2, a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 90μm and an average openness factor from 0 to 0.1%. Advantageously, such fabrics have an openness factor variability of at most 0.1%. Within the scope of the invention, the obtained spreading gives the possibility of obtaining such fabrics with yarns, and in particular carbon yarns, having a titer from 200 to 3,500 Tex and preferably from 800 to 1,700 Tex.

The openness factor may be defined as the ratio between the surface area not occupied by the material and the observed total surface area, the observation of which may be made from the top of the fabric with an illumination from below the latter. The openness factor (OF) is expressed in percentages. For example it may be measured according to the method described in the examples.

By openness factor variability, is meant the maximum difference in absolute value obtained between a measured openness factor and the average openness factor. The variability is therefore expressed in % like the openness factor.

The average openness factor may be obtained, for example from 60 openness factor measurements distributed over a surface of 305 x 915 mm of fabric. The distribution may, for example, be achieved, by distributing 1/3 of the openness factor measurements over a first third of the width of the fabric, 1/3 of the openness factor measurements on the second third of the fabric width corresponding to its central portion and 1/3 of the openness factor measurements on the third portion of the fabric width.

By average openness factor, is meant the arithmetic mean of the 60 measured openness factor (OF) values.

Mean openness factor = (OF1 + OF2 + OF3 + ... + OF60)/60

According to one aspect of the present invention, there is provided a fabric consisting of warp and weft yarns, comprising one of the combinations of following characteristics: a basis weight greater than or equal to 40 g/m² and less than 100 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 35 μm, a basis weight greater than or equal to 100 g/m² and less than or equal to 160 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 50 μm, a basis weight greater than 160 g/m² and less than or equal to 200 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 60 μm, or a basis weight greater than 200 g/m² and less than or equal to 400 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 90 μm, and wherein the warp yarns and/or the weft yarns consist of a set of filaments wherein the warp yarns and weft yarns are neither impregnated nor coated nor associated with any polymeric binder so that the filaments within each warp yarn and weft yarn are adapted to freely move relatively to the others within said yarn.

The detailed description which follows, with reference to the appended Figures allows the invention to be better understood.

Fig. 1 is a schematic front view of a spreading machine according to the invention.

Fig. 2 is a transverse sectional view of the spreading machine illustrated in **Fig. 1**.

Fig. 3 is a schematic front view of a spreading machine according to the invention, in the raised position of the flexible roller.

Figs. 4A and **4B** are planar views of an example of a fabric illustrated before and after spreading, respectively.

Fig. 5 is a view giving the possibility of schematically illustrating the spreading principle applied by the spreading machine according to the invention.

Figs. 1 to **3** schematically illustrate an exemplary embodiment of a spreading machine **1** according to the invention, adapted for spreading with a low thickness variability, a textile sheet **2** including at least warp yarns **3**. Conventionally, by textile sheet, is meant a sheet material consisting of yarns and by warp yarns, yarns extending along the running axis of the sheet on the machine. The textile sheets may be one–directional or fabrics. In the example illustrated in **Figs. 4A** and **4B,** the sheet **2** is a fabric including warp yarns **3** and weft yarns **4**, each warp **3** and weft **4** yarn consisting of a set of filaments **t.** According to a preferred embodiment, the spreading machine **1** according to the invention, is placed at the outlet of a weaving machine and at the inlet of a system for winding up the sheet. It may also be provided that the sheet to be spread out is from an unwinding system and which is not directly positioned in line with a weaving machine.

The spreading machine **1** includes at least one first **5** and one second **6** rotary rollers and in the illustrated example, a third rotary roller **7**. The rotary rollers **5**, **6** and **7** have axes **A** extending, parallel with each other, and perpendicularly to the running direction **f1** of the sheet **2** or perpendicularly to the warp yarns **3**. The first roller **5** and the second roller **6** delimit between them a first pressure generator **G1** for the sheet **2** passing between the first and second rollers **5**, **6**. Also, in the example illustrated in the drawings, the first roller **5** and the third roller **7** delimit between them a second pressure generator **G2** for the sheet **2** passing between the first and third rollers **5**, **7**. Of course, the length of the rollers is adapted to the width of the sheet **2** to be spread out, so as to have a greater length than the width of the sheet **2**. Typically, the length of the rollers is comprised between 1m and 2m.

According to an advantageous feature of the invention, the rollers **5**, **6** and **7** are positioned in such a way that both pressure generators **G1** and **G2** are separated between 1/6 and 1/3 of the periphery of the first roller **5**. In other words, the sheet **2** is in contact with the first roller **5** exclusively between 1/6 and 1/3 of its periphery.

According to a preferred alternative embodiment, the second **6** and third **7** rollers are positioned side by side in a horizontal plane, while the first roller **5** is positioned in the middle and above the second **6** and third **7** roller.

The spreading machine **1** according to the invention also includes a motor drive **10** for ensuring synchronous driving into rotation around their axes **A** and along a same direction of rotation, second **6** and third **7** rollers. In the illustrated example, the motor–drive **10** includes an electric motor **11** controlled for synchronously controlling the speed of rotation of the second **6** and third **7** rollers. The output shaft of the electric motor **11** cooperates with a transmission belt **12** which drives into rotation pulleys **13** supported by shafts **14** mounted so as to be axially secured to the first end of the second **6** and third **7** rollers.

In the illustrated example, the first roller **5** is not driven into rotation by the motor–drive **10**. The first roller **5** is driven into rotation by the running force of the sheet **2** and by the rollers **6**, **7**. Of course, it is possible to envision that the motor–drive **10** also drives into rotation the first roller **5**.

The spreading machine **1** according to the invention also includes a system **15** for driving the rollers **5**, **6** and **7** into axial oscillation each along its axis **A**. More specifically, the driving system **15** allows axial oscillation of the first roller **5** in phase opposition with respect to the second and third rollers **6** and **7** which are perfectly synchronized in axial oscillation. In the example illustrated in the drawings, the driving system **15** includes an electric motor **16** synchronously driving, by means of a transmission **17** such as a belt, first **19** and second **20** camshafts giving the possibility of exerting an axial force on the rollers. As this clearly emerges from **Fig. 1**, the cams of the camshafts **19** and **20** are angularly shifted from each other by a value equal to 180°.

The first camshaft **19** acts on the second end of the first roller **5** and more specifically, on the transverse face of a shaft **21** axially extending from the first roller **5**. According to an advantageous alternative embodiment, the first camshaft **19** acts on the shaft **21**, via a plate **21a** borne by the shaft **21**. Thus, even when the first roller **5** is moved vertically, the camshaft **19** continues to exert an axial force on the shaft **21,** as this will be explained in more detail in the continuation of the description.

The second camshaft **20** acts on the second end of the second roller **6** and in the illustrated example, of the third roller **7** also. According to this illustrated alternative, the second and third rollers **6** and **7** are axially equipped, at their second end, with shafts **22** in contact, through their transverse face, with the camshaft **20** which ensures synchronized axial oscillation of the second and third rollers **6** and **7**. Thus, the second and third rollers **6** and **7** have a perfectly synchronized axial oscillation.

The first ends of the first, second and third rollers **5**, **6** and **7** are urged by an elastic system **25** which will compensate for the action exerted by the camshafts **19**, **20** on the second ends of the first, second and third rollers **5**, **6** and **7**. In the illustrated exemplary embodiment, the elastic system **25** includes stacks of Belleville washers interposed between a support **28** on the one hand, and each shaft **14** and a shaft **29** on the other hand extending axially from the first end of the first roller **5**. According to an advantageous alternative embodiment, a stack of Belleville spring washers **25** acts on the shaft **29** via a plate **29a** borne by the shaft **29**. Thus, even when the first roller **5** is moved vertically, the stack of Belleville spring washers **25** continues to exert an axial force on the shaft **29** as this will be explained in more detail in the continuation of the description.

The driving system **15** as described above, gives the possibility of ensuring perfect control of the amplitude of operation in phase opposition between the first roller **5** on the one hand and the second and third rollers **6**, **7** on the other hand. Moreover, this solution gives the possibility of guaranteeing the desired movement of the rollers in spite of wear phenomena due to suppression of the mechanical play between camshafts and the rollers.

Of course, the axial vibration frequency is adjustable, for example, from 5 to 50Hz via the adjustment of the electric motor **16**. Typically, the amplitude of the axial oscillation of the rollers is of the order of 0.5 mm.

The spreading machine **1** also includes for the second and third rollers **6** and **7**, a series of rigid supports **31** giving the possibility of supporting without any flexure, the rollers while allowing their movements of rotation and oscillation. In the illustrated example, each rigid support **31** includes a fork or a cradle **32** rigidly attached to a chassis **33** preferably rigidly anchored to the ground. Each fork or cradle **32** thus has two supporting branches **34** each equipped with a rolling member **35** for a roller **6**, **7**, which may both receive the movement of rotation and the movement of oscillation. In the example illustrated in **Fig. 1**, four rigid supports **31** support the rollers. Of course, the number of rigid supports **31** may be different notably depending on the length of the rollers.

According to the invention, the spreading machine **1** includes a system **40** for producing the first pressure generator **G1** and in the illustrated example also the second pressure generator **G2**, with adjustable pressure values distributed along the generator(s), for spreading the sheet **2** with low thickness variability. In other words, the system **40** allows modulation of the pressure at will, along these pressure generators **G1**, **G2** in order to apply uniform pressure on the sheet while taking into account initial thickness differences of the sheet, with view to spreading the sheet with a low thickness variability.

According to a preferred embodiment, the system **40** includes as a first roller **5**, a flexible roller and a series of localized supports **42** with adjustable pressure, spread along the axis of the flexible roller **5** and acting on the flexible roller **5**. As this more specifically emerges from **Fig. 2**, the first roller **5** is mounted in a flexible way along its axis **A** in the sense that it is free of any guiding bearing at both of its ends.

The flexible roller **5** may thus position itself automatically, without any stress, between the two other rollers **6** and **7**. Conversely, the second and third rollers **6** and **7** are rigid since they are supported without any flexure by the chassis **33**. Each localized support **42** exerts its pressure on the flexible roller **5**, via rolling members **43** with axial displacement. Thus, each localized support **42** is able to exert a substantially vertical pressure force perpendicular to the axis of the flexible roller **5** while accepting the movement of rotation and axial oscillation of the flexible roller **5**. For example, each localized support **42** is a pressure actuator **44**, the rod of which is equipped with a rolling member **43**. Each pressure actuator **44** is connected to a control unit not shown but known per se, allowing adjustment of the pressure exerted on the flexible roller **5**. In the example illustrated in **Fig. 1**, the spreading machine **1** includes four pressure actuators. Of course, the number of pressure actuators **44** may be different.

According to an advantageous alternative embodiment, the localized supports **42** are equipped with a device **46** for adjusting their position along the axis of the flexible roller **5**. Thus, the localized supports **42** may be moved independently of each other along the axis of the flexible roller **5** so as to be able to exert their pressure force in all the selected locations of the sheet **2**. In the illustrated example, the actuators **44** are slidably mounted along a gantry **45** overhanging from a distance the flexible roller **5**. Each actuator **44** is placed in a fixed position by means of a system for locking the body of the actuator on the frame, not shown, but of all types known per se.

According to an advantageous alternative embodiment, the spreading machine **1** according to the invention includes a system **48** for raising the flexible roller **5** in order to allow operations for placing the sheet **2** between the flexible roller **5** and the rigid rollers **6**, **7**. In the illustrated example, the raising system **48** includes two actuators **49** attached through their bodies onto the gantry **45** and the rods **49a** of which act on the shafts **21** and **29** extending from both ends of the flexible roller **5**. It should be noted that the elastic system **25** acts on the shaft **29** of the flexible roller **5** while the camshaft **19** continues to exert an axial force on the shaft **21**, even during operations for raising the flexible roller **5** because of the presence of the end plates **21a** and **29a**, as illustrated in **Fig. 3**.

According to an advantageous embodiment characteristic, the spreading machine according to the invention includes a system **51** for heating the sheet and the rollers during the passing of the sheet between the pressure generators. The heating system **51** includes a nozzle **52** for supplying the hot air produced by a hot air production unit not shown but known per se. This supply nozzle **52** opens between both rigid rollers **6** and **7** by directing the hot air flow towards the flexible roller **5** along its portion located between both pressure generators **G1** and **G2**. Typically, a heating unit of the Leister type is used for ensuring heating of the sheet **2** and of the rollers up to a temperature of 80°C.

In the foregoing description, the spreading machine **1** includes a flexible roller **5** and two rigid rollers **6**, **7** defining two pressure generators **G1**, **G2**. Of course, the spreading machine **1** according to the invention may have a similar operation by applying a single rigid roller **6** defining with the flexible roller **5**, a single pressure generator **G1**. Moreover, the spreading machine **1** described above, includes as localized supports **42**, actuators exerting a pressure force on the flexible roller **5**. Other solutions may be contemplated with view to producing pressure generators with adjustable pressure values.

The spreading machine **1** according to the invention is particularly adapted for spreading warp yarns **3** and also weft yarns **4** when the sheet **2** is a fabric.

The application of a spreading method directly results from the foregoing description.

According to the method for spreading a sheet **2**:

- the sheet **2** is caused to run between at least two rotary rollers **5**, **6–7**, the axes A of which extend parallel with each other and are substantially perpendicular to the running direction of the sheet,

- the sheet under pressure is passed between at least one pressure generator **G1** of the rollers driven into axial oscillation and in phased opposition,

- and at least one pressure generator **G1** of the rollers **5**, **6–7** is produced with adjustable pressure values along said generator so as to spread the sheet **2** with a low thickness variability.

It should be understood that it is thus possible to modulate the pressure between the centre and the edges of the sheet **2** so that the flexible roller **5** applies a uniform pressure on the sheet **2** taking into account the thickness differences of the sheet. Of course, it may be contemplated that the pressures be identical along the contact generator.

During this spreading operation, the sheet **2** is maintained under tension with a substantially constant small value, by means of suitable systems for tensioning the sheet **2**, located on its travel, upstream and downstream, from the pressure rollers and designed for compensating the forces which may for example appear upstream, at the outlet of the weaving machine and downstream, at the winder of the sheet.

According to a preferred alternative embodiment, one of the rollers **5** is made flexible and the other one **6–7** made rigid and, localized supports **42** distributed along the axis of the roller and with adjustable values are exerted on this flexible roller, substantially perpendicularly to its axis in order to produce the generator with adjustable pressure value. Thus, different pressure values are exerted in different locations of the pressure generator in order to ensure proper spreading of the yarns of the sheet **2**.

According to an advantageous feature of the invention, the method consists of adjusting the position of the localized supports **42** along the axis of the flexible roller so as to selectively choose the locations where the pressures are to be applied. For example, it is possible to distribute the localized supports **42** in a regular way along the axis of the flexible roller. However, the adjustment consists of distributing the localized supports **42** at most over the whole width of the sheet **2**. Indeed, regardless of the length of the sheet, the localized supports **42** should always act inside the delimited area overhanging the width of the sheet **2**. In other words, the localized supports **42** should not act on an area of the flexible roller which is never in contact with the sheet **2**. According to a preferred exemplary embodiment, the position of the actuators which are close to the edges of the sheet are positioned so as to be at a distance of at least 50 mm from these edges. Typically, the actuators which are close to the edges of the sheet are positioned so as to be at a distance of 150 mm from these edges. The actuators located between both of these actuators close to the edges are positioned so that all the actuators are regularly spaced apart. For example, the number of actuators is selected so that the distance between two neighbouring actuators is of at least 300 mm. According to a preferred embodiment alternative, the sheet **2** is caused to pass over the periphery of the flexible roller **5** between two pressure generators **G1**, **G2** with adjustable localized pressure values. Both of these generators are delimited between the flexible roller **5** and two driven rigid rollers **6**, **7**, synchronously, in rotation and in oscillation. Advantageously, the sheet **2** is caused to pass over the flexible roller **5**, between 1/6 and 1/3 of the periphery of the flexible roller **5**.

According to a feature of the invention, the sheet **2** and the rollers are heated during its passing between the pressure generator(s).

It emerges from the foregoing description that the invention gives the possibility of spreading the warp yarns of a one–directional sheet of warp yarns or interlaced warp yarns and/or weft yarns of a fabric. The spread out textile sheets will, at least, partly be formed of reinforcing fibres of the carbon, glass or aramide type which conventionally consists of a set of filaments extending along the direction of the yarn.

Advantageously, within the scope of the invention, the textile sheet to be spread out will either exclusively consist of a one–directional sheet of warp yarns, or a fabric consisting of interlacing of warp yarns and weft yarns. Of course, in every case, the yarns are not secured to each other by any binder or mechanical binding method of the sewing or knitting type which would hamper their displacement relatively to each other and would not allow them to be spread out. In the case of a fabric, the warp yarns and the weft yarns are only held together by the weaving. In particular, in the case of a textile sheet consisting of a one–directional sheet of warp yarns, the latter will consist of carbon, glass or aramide yarns. In the case of a fabric consisting of an interlacing of warp yarns and weft yarns, it is either possible to spread out the weft yarns exclusively which, in this case, will be interlaced with yarns playing the role of a support such as yarns in a thermoplastic material, or to spread out both the warp yarns and the weft yarns. In every case, the yarns intended to be spread out in the method according to the invention consist of a set of filaments which may freely move relatively to each other, and in particular of carbon yarns. Such yarns may initially have a circular section or preferably rectangular section but at the outlet of the method according to the invention, they will have a rectangular section following the application of pressure forces. In order to allow their spreading out, the yarns to be spread out and therefore the constitutive yarns of the fabrics according to the invention, will neither be impregnated, nor coated, nor associated with any polymeric binder which would hamper free displacement of the filaments relatively to each other. The yarns to be spread out are nevertheless most often characterized by a mass standard sizing level which may represent at most 2% of their mass.

A carbon yarn consists of a set of filaments and generally includes from 1,000 to 80,000 filaments, advantageously from 12,000 to 24,000 filaments.

More preferably, within the scope of the invention, carbon fibres of 1 to 24K, for example, 3K, 6K, 12K or 24K, and preferentially 12 and 24K are used. The carbon yarns present within one–directional sheets, have a titer of 60 to 3,800 Tex, and preferentially from 400 to 900 tex. The one–directional sheet may be produced with any type of carbon yarns, for example high resistance (HR) yarns for which the tensile modulus is comprised between 220 and 241GPa and the tensile breaking stress of which is comprised between 3,450 and 4,830MPa, yarns of intermediate modulus (IM) for which the tensile modulus is comprised between 290 and 297GPa and the tensile breaking stress of which is comprised between 3,450 and 6,200MPa and high modulus (HM) yarns, for which the tensile modulus is comprised between 345 and 448GPa and for which the tensile breaking stress is comprised between 3,450 and 5,520Pa (according to the "ASM Handbook", ISBN 0–87170–703–9, ASM International 2001).

Fig. 4A schematically shows a fabric before its spreading out consisting of an interlacing of warp yarns and weft yarns with a slightly different width because of the weaving. These may notably be 3K carbon yarns. Each of the warp yarns and weft yarns consist of a set of filaments. Initially, the openness factor of the textile fabric is 4%.

Fig. 4B illustrates the fabric obtained after applying the spreading method according to the invention. This fabric has an OF level of 0% and warp and weft yarns of different width.

Within the scope of the invention, it is possible that the textile sheet before being subject to the method according to the invention has a zero or non–zero openness factor. When initially the openness factor is non–zero, applying the method according to the invention causes a reduction of the openness factor which accompanies the obtaining of homogenization of the thickness of the textile sheet. Whether initially the openness factor is zero or non–zero, applying the method according to the invention causes a reduction in the thickness of the fabric by homogenization of the thickness of the yarns making it up.

The invention is not limited to the described and illustrated examples since diverse modifications may be provided thereto without departing from its scope.

Examples of carbon yarn fabrics obtained by means of the method according to the invention are described in the examples hereafter:

MEASUREMENT METHODS USED

Measurements of the thicknesses

I. The following equipment is used:

- Vacuum pump from Leybold systems vacuum pump with reference 501902
- Three–dimensional machine Tesa "micro–hite DCC 3D"
- A glazed plate in toughened glass, with a thickness of 8 mm
- A vacuum cover film with ref. 818260F 205°C Nylon 6, green from the supplier Umeco, Aerovac.
- Bidim. AB1060HA 380gsm 200°C polyester, non–compressed rated thickness 6 mm, supplier Umeco Aerovac.
- PC with the software PC–Dmis V42
- A ball sensor ø3 with a maximum trigger of 0.06N
- A cutting wheel of the Robuso type
- A cutting template 305x305 mm
- Connection for a vacuum pump
- A vacuum gasket SM5130 from the supplier Umeco Aerovac.

II. Description of the measurement

- Put the glass plate with the stack of three pieces of a same fabric, as well as the environment, in the order from bottom to top:
  - bidim (a felt known to one skilled in the art)
  - stack of fabrics in the same direction, with the warp yarns extending in the direction parallel to an edge of the square of 305 x 305 mm
  - vacuum cover

Check the vacuum level (a vacuum of less than 15mbars).

- Establish a pressure reduced by a minimum of 15mbars in the vacuum cover, so as to place the stack under a pressure of 972mbars +/- 3mbars.
- Dimensional stabilization of the stack of fabrics under reduced pressure has to be attained.
- Leave the stack under this reduced pressure for at least 30 minutes before taking the points.
- Take a physical point on the table in a manual mode (white point on the top left of the table) by means of the joystick (***joy*** on the stick), validate and then switch to automatic mode (***auto*** on the stick):
- Switch to automatic mode and wait till the measurement is made.

The program proceeds with taking 25 measurement points by means of its triggering sensor.

The measurement of 25 « blank » points is repeated i.e. without the stack of the three fabrics in order to measure the thickness of the vacuum cover and of the glass.

Thus by a differential altitude measurement in between, with or without a stack, we have a thickness average on 25 points, on the stack.

Openness factor measurements

The openness factors were measured according to the following method.

The device consists of a camera of the brand SONY™ (model SSC-DC58AP), equipped with a 10x objective and with a luminous table of the brand Waldmann™, model W LP3 NR,101381 230V 50Hz 2x15W. The sample to be measured is laid on the luminous table, the camera is attached a bracket, and positioned at 29cm from the sample, then the sharpness is adjusted.

The measurement width is determined according to the textile fabric to be analysed, by means of the ring (zoom), and of a ruler: 10 cm for open textile fabrics (OF>2%), 1.17 cm for not very open textile sheets (OF<2%).

By means of the diaphragm and of a control photograph, the luminosity is adjusted so as to obtain an OF value corresponding to the one given on the control photograph.

The contrast measurement software package Videomet™, from Scion Image (Scion Corporation, USA) is used. After capturing the image, the latter is processed in the following way: by means of a tool, a maximum surface area is defined corresponding to the selected calibration, for example, for 10cm - 70 holes, and including an integer number of patterns. An elementary surface in the textile sense of the term, i.e. a surface which describes the geometry of the fabric by repetition is then selected.

The light of the luminous table passing through the apertures of the fabric, the OF as a percentage is defined by a hundred multiplied by the ratio between the white surface area divided by the total surface area of the elementary pattern: 100* (white surface/elementary surface).

It should be noted that the adjustment of the luminosity is important since diffusion phenomena may modify the apparent size of the holes and therefore the OF. An intermediate luminosity will be retained, so that no too significant saturation or diffusion phenomenon is visible.

The fabrics with a width of 127cm having basis weights, thickness standard deviations, openness factor, openness factor variability and shown in **Table 2** below were able to be obtained by means of the method according to the invention, by using the parameters as defined in **Table 1**.

The machine used complies with **Figs. 1** and **2**, with rollers of a diameter of 60 mm and a length of 1,700 mm, the actuators being spaced apart by 320 mm, the two located at the ends being distant from the edge of the fabric by 155 mm. **Table 1** gives as an example, for the fabrics shown in **Table 2**, the pressure force of the 4 pressure actuators **44** (No. 1 to 4) taken from one edge to the other of the fabric, with a running speed of the textile sheet (mm/min), a frequency (Hz) and a temperature (°C). According to these exemplary embodiments, more significant forces are applied in the central area of the fabric **2** allowing good spreading of the fabric **2,** by compensating for the thickness difference existing initially between the centre and the edges of the fabric, as illustrated in **Fig. 5**.

The AS4 3K yarns provided by Hexcel Corporation (Stamford USA) are high breaking stress resistance yarns of 4,433 Mpa, of a tensile modulus of 231GPa having a titer of 200 Tex with filaments of 7.1 microns.

The AS4 12K yarns provided by Hexcel Corporation (Stamford USA) are high breaking stress resistance yarns of 4,433 Mpa, of tensile modulus of 231GPa having a titer of 800 Tex with filaments of 7.1 microns.

The AS7 12K yarns provided by Hexcel Corporation (Stamford, USA) are high breaking stress resistance yarns of 4,830 Mpa, of tensile modulus of 241GPa and having a titer of 800 Tex with filaments of 6.9 microns.

The IM7 6K yarns provided by Hexcel Corporation (Stamford, USA) are yarns with an intermediate breaking stress modulus of 5,310 Mpa, of a tensile modulus of 276 Gpa and having a titer of 223 Tex with filaments of 5.2 microns.

The IM7 12K yarns provided by Hexcel Corporation (Stamford, USA) are yarns with an intermediate breaking stress module of 5,670 Mpa, of a tensile modulus of 276 Gpa and having a titer of 446 Tex with filaments of 5.2 microns.

As an example, the tissue of 199 g/m^2 with AS4 3K before spreading has an average openness factor of 10.5% (12.5% on the edges of the fabric, 6.5% on the centre of the fabric) i.e. a variation of 6% of the openness factor between centre and edge, and an average thickness of 0.191 mm (0.201 mm on the edges of the fabric, 0.187 mm on the centre of the fabric) i.e. a 12% thickness variation between centre and edge. The thickness standard deviation of the stack of three folds of the non–spread fabric is 0.055 mm.

After spreading out, the openness factor of this same fabric passes to 0.1% on average, i.e. a 99% reduction as compared with the non–spread out fabric, with a maximum variation of 0.5% which moreover is not due to an increase in the values on the edges, the average openness factor of the edges and of the centre being equal to 0.1%. A large portion of the measured openness factors are close to 0%, and a small population above 0.1% up to 0.5% in rare cases, inducing an average at 0.1% with a maximum variation of 0.5%. The thickness of the fabric after spreading is 0.177 mm, i.e. reduced by 8% as compared with the non–spread fabric. The standard deviation of the stack of three folds of the spread fabric is 0.030 mm, i.e. a 45% gain as compared with the non–spread fabric. This information is gathered in **Table 3** hereafter.

As an another example, a tissue of 75 g/m² in AS4C 3K will have an average openness factor before spreading of 45%, and an average openness factor after spreading of 0.8%, i.e. a 98% gain.

In every case, the application of the method according to the invention causes a significant reduction in the standard deviation of the thickness, of the average thickness, of the openness factor and of its variability. In particular, regardless of the basis weight of the fabric and the yarn used, by applying the method according to the invention, the gain in thickness standard deviation of 3 folds under the pressure of 972mbars is equal at least to 20%, and in most cases is greater than 30%.

Table 1

	Warp and Weft Density	Material designation	Yarn titer	Actuator pressure force (N)				Speed	Frequency	Temperature
	yarns/cm		Tex	No.1	No.2	No.3	No.4	mm/min	Hz	°C
75g/m² - IM7 6K - Web	1.88	IM7GP 6K HSCP5000	223	200	400	400	200	420	17	55
75g/m² - AS4 3K - Web	1.88	AS4GP 3K HSCP5000	200	200	400	400	200	420	17	55
98g/m² - IM7 6K - Web	2.2	IM7GP 6K HSCP6000	223	200	400	400	200	340	17	55
98g/m² - AS4 3K - Web	2.45	AS4GP 3K HSCP5000	200	200	400	400	200	340	17	55
160g/m² IMA 12 K - Web	1.79	IMAGS 12K HSCP6000	446	400	500	500	400	417	27	55
199g/m² AS4 3K - Web	4.98	AS4GP 3K HSCP5000	200	200	400	400	200	500	17	55
199g/m² - AS4 12K - Web	1.24	AS4GP 12K HSCP3000	800	200	400	400	200	600	40	55
300g/m² - AS7 12K - Twill 2/2	1.24	AS7GP 12K HSCP4000	800	200	400	400	200	600	40	55

Table 2

	Thickness (mm)			Openness Factor (%)	
	Average of the 3 fold stack	**Standard deviation of the 3 fold stack**	**Average thickness per fold**	**Average**	**Variability**
75g/m² - IM7 6K - Web	0.169	0.023	0.056	0.2	0.5
75g/m² - AS4 3K - Web	0.145	0.028	0.048	0.8	0.8
98g/m² - AS4 3K - Web	0.232	0.025	0.077	0.6	0.6
98g/m² - IM7 6K - Web	0.222	0.024	0.074	0.1	0.5
160g/m² IMA 12 K - Web	0.340	0.046	0.113	0.4	0.4
199g/m² AS4 3K - Web	0.531	0.030	0.177	0.1	0.5
199g/m² - AS4 12K - Web	0.446	0.038	0.149	0	0.1
300g/m² - AS7 12K - Twill 2/2	0.742	0.078	0.247	0	0.1

Table 3

	Thickness (mm)						Openness Factor (%)		
	Measured average thickness per fold on a stack of three folds			Standard deviation of the stack of three folds					
							Average	Maximum variability	
	Before spreading	After spreading	**Gain**	Before spreading	After spreading	**Gain**	Before spreading	After spreading	**Gain**
199g/m² AS4 3K - Web	0.191	0.177	**8%**	0.055	0.030	**45%**	10.5	0.1	**99%**

CLAIMS:

1. A fabric consisting of warp and weft yarns, comprising one of the combinations of following characteristics:

- a basis weight greater than or equal to 40 g/m² and less than 100 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 35 µm,

- a basis weight greater than or equal to 100 g/m² and less than or equal to 160 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 50 µm,

- a basis weight greater than 160 g/m² and less than or equal to 200 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 60 µm, or

- a basis weight greater than 200 g/m² and less than or equal to 400 g/m² and a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 90 µm,

and wherein the warp yarns and/or the weft yarns consist of a set of filaments wherein the warp yarns and weft yarns are neither impregnated nor coated nor associated with any polymeric binder so that the filaments within each warp yarn and weft yarn are adapted to freely move relatively to the others within said yarn.

2. The fabric according to claim 1, wherein the fabric consists of warp yarns identical with each other and of weft yarns identical with each other.

3. The fabric according to claim 2, wherein the warp yarns are identical to the weft yarns.

4. The fabric according to any one of claims 1 to 3, wherein the warp yarns and the weft yarns comprise carbon yarns.

5. The fabric according to claim 4, wherein the fabric consists, by at least 99% by mass, of the carbon yarns.

6. The fabric according to claim 4, wherein the fabric exclusively consists of the carbon yarns.

7. The fabric according to any one of claims 1 to 6, wherein the fabric has a basis weight greater than or equal to 40 g/m² and less than 100 g/m², a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 35 μm and an average openness factor from 0 to 1%.

8. The fabric according to claim 7, wherein the fabric has an openness factor variability of at most 1%.

9. The fabric according to claim 7 or claim 8, wherein the fabric consists of yarns having a titer from 200 to 3,500 Tex.

10. The fabric according to claim 9, wherein the titer of the yarns is from 200 to 1,700 Tex.

11. The fabric according to any one of claims 1 to 6, wherein the fabric has a basis weight greater than or equal to 100 g/m² and less than or equal to 160 g/m², a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 50 μm and an average openness factor from 0 to 0.5%.

12. The fabric according to claim 11, wherein the fabric has an openness factor variability of at most 0.5%.

13. The fabric according to any one of claims 1 to 6, wherein the fabric has a basis weight greater than 160 g/m² and less than or equal to 200 g/m², a thickness standard deviation measured on a stack of three identical fabrics deposited on each

other and along the same direction which is less than or equal to 60 μm and an average openness factor from 0 to 0.5%.

14. The fabric according to claim 13, wherein the fabric has an openness factor variability of at most 0.5%.

15. The fabric according to any one of claims 11 to 14, wherein the fabric consists of yarns having a titer from 200 to 3,500 Tex.

16. The fabric according to claim 15, wherein the titer of the yarns is from 400 to 1,700 Tex.

17. The fabric according to any one of claims 1 to 6, wherein the fabric has a basis weight greater than 200 g/m^2 and less than or equal to 400 g/m^2, a thickness standard deviation measured on a stack of three identical fabrics deposited on each other and along the same direction which is less than or equal to 90 μm and an average openness factor from 0 to 0.1%.

18. The fabric according to claim 17, wherein the fabric has an openness factor variability of at most 0.1%.

19. The fabric according to claim 17 or claim 18, wherein the fabric consists of yarns having a titer from 200 to 3,500 Tex.

20. The fabric according to claim 19, wherein the titer of the yarns is from 800 to 1,700 Tex.

21. The fabric according to any one of claims 7 to 20, wherein the average openness factor and the openness factor variability are measured by conducting 60 openness factor measurements distributed over a surface of 305 x 915 mm of fabric.

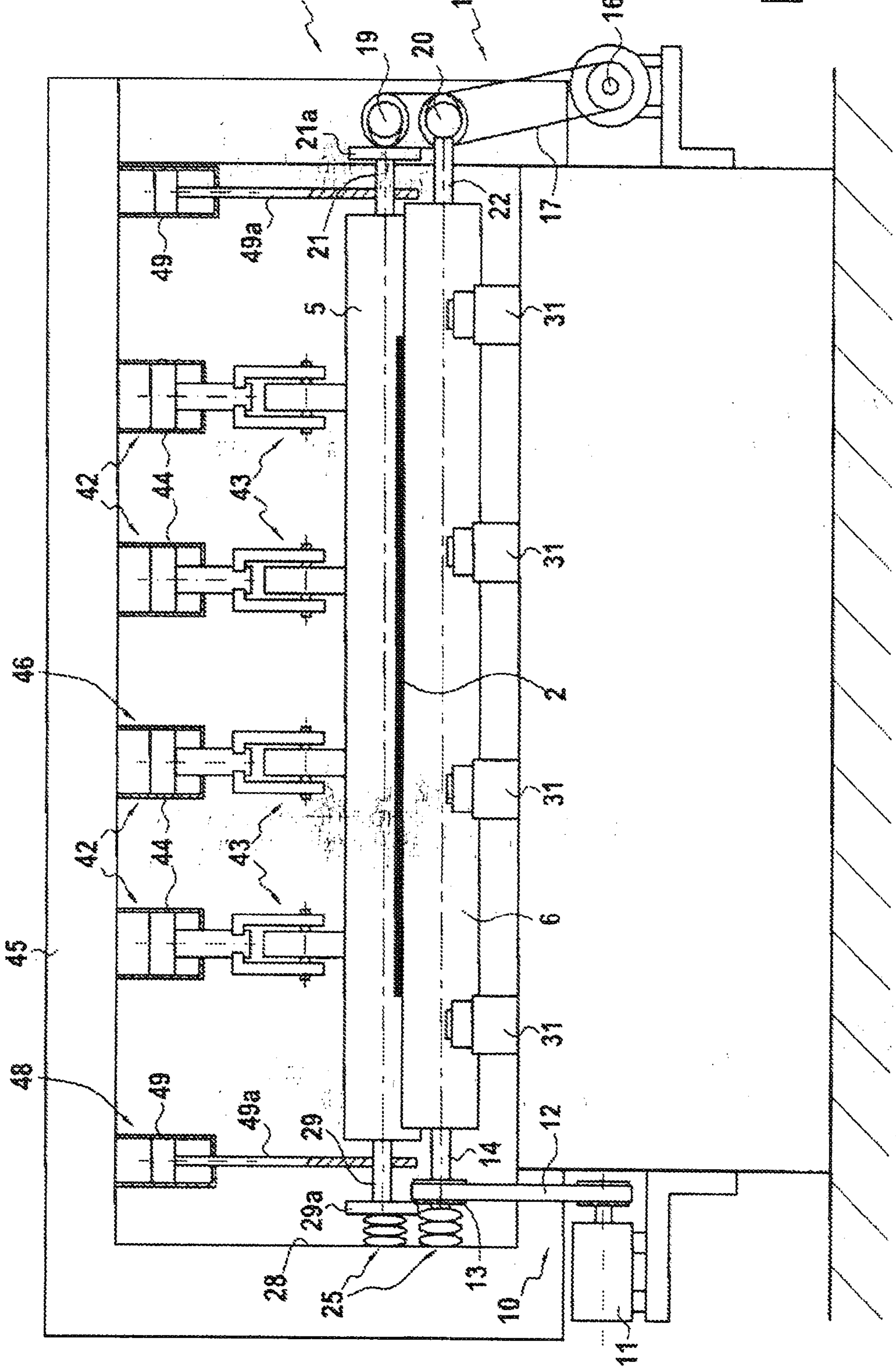
22. The fabric according to any one of claims 1 to 21, wherein the fabric has a width of at least 100 cm.

23. The fabric according to claim 22, wherein the width of the fabric is from 100 to 200 cm.

24. The fabric according to any one of claims 1 to 23, wherein the thickness standard deviation is measured on a stack of three identical fabrics deposited on each other and oriented in the same direction and placed under a pressure of 972 mbar +/- 3 mbar by conducting 25 point measurements distributed over a surface of 305 x 305 mm.

25. The fabric according to any one of claims 1 to 24, wherein the fabric has an architecture of the web, twill, basket weave or satin type.

FIG.1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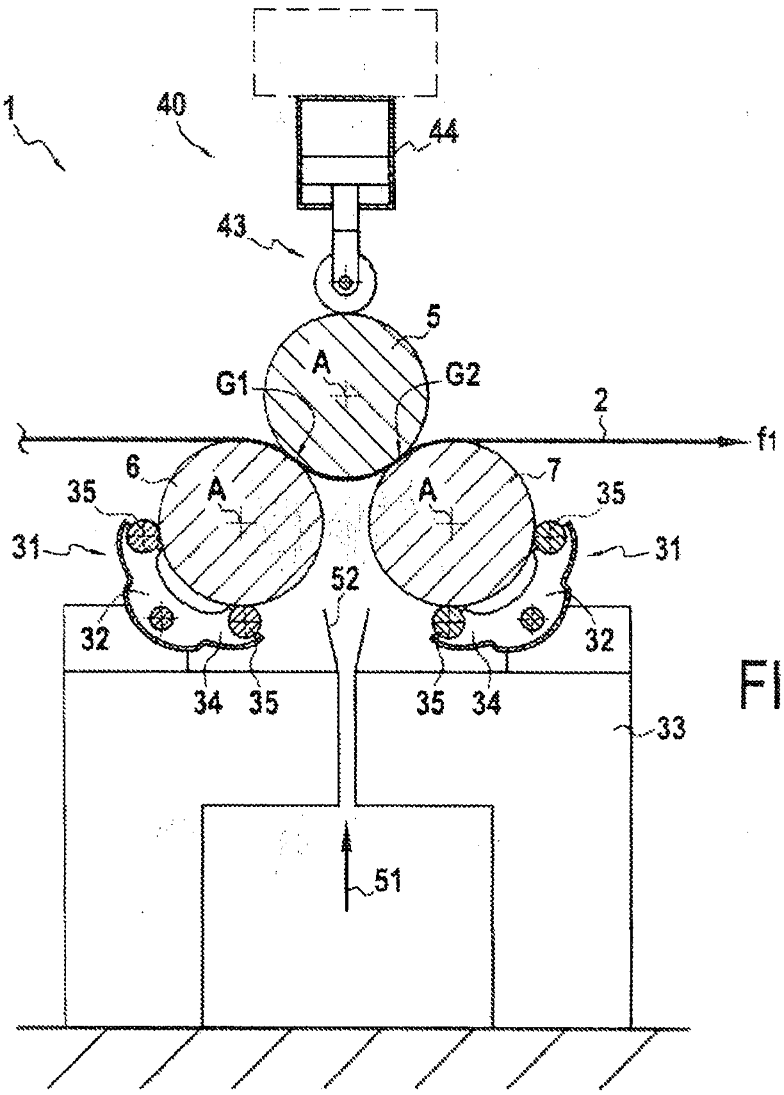


FIG.2

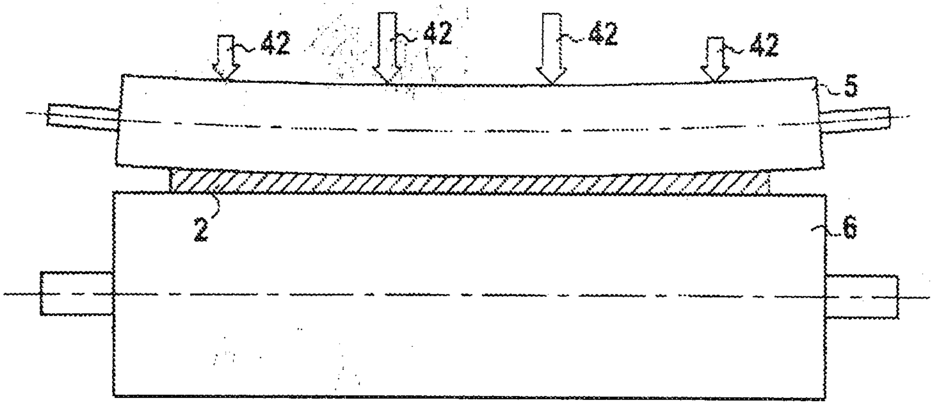
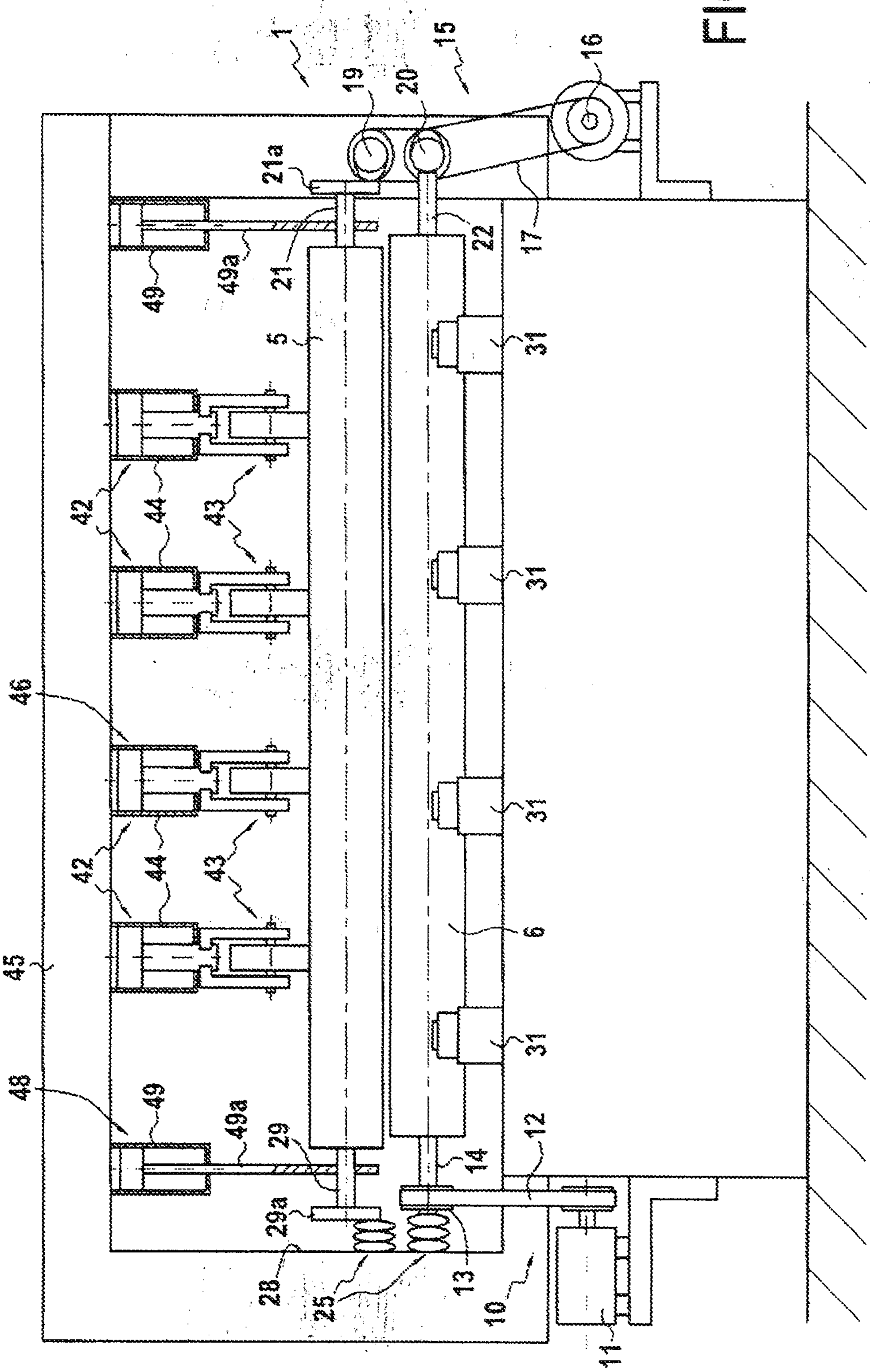


FIG.5

FIG.3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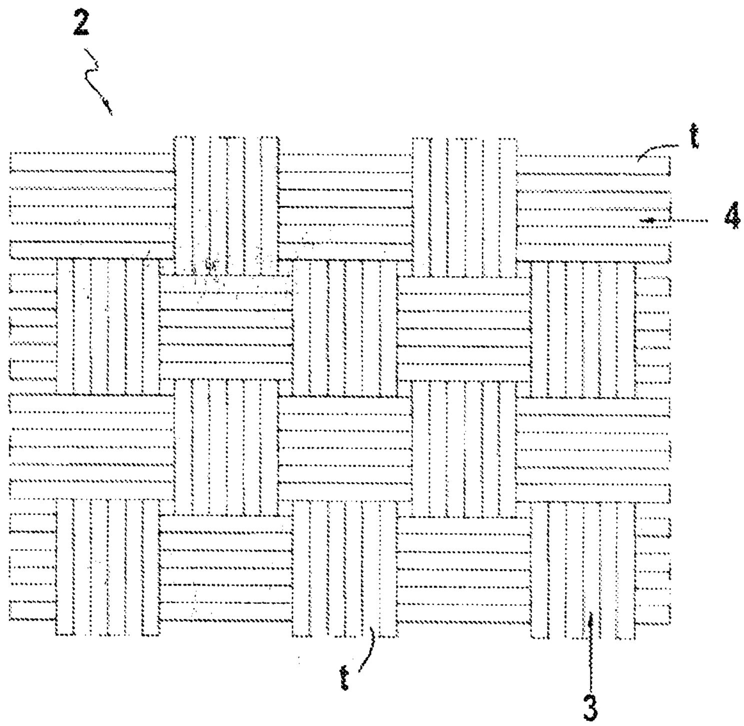


FIG.4A

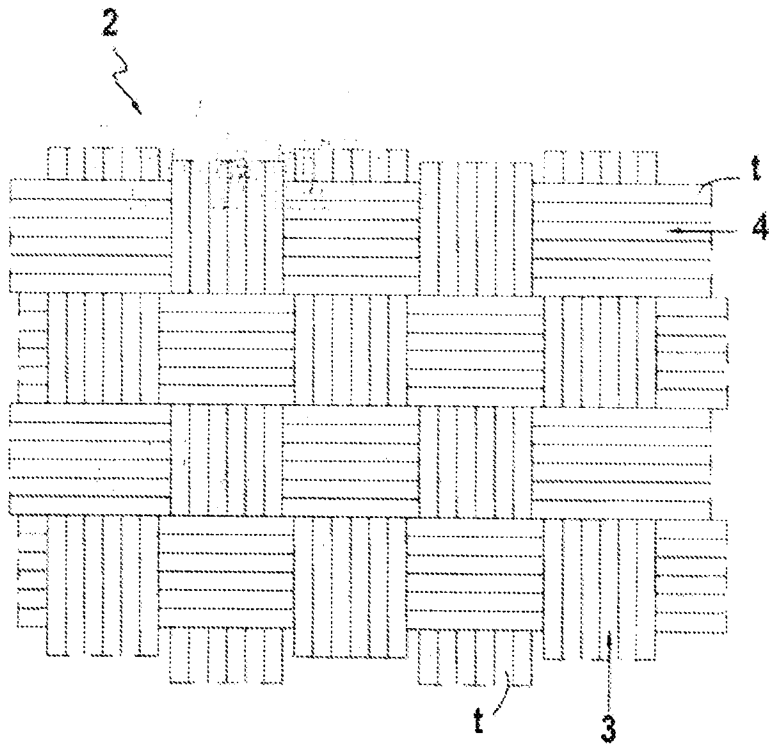
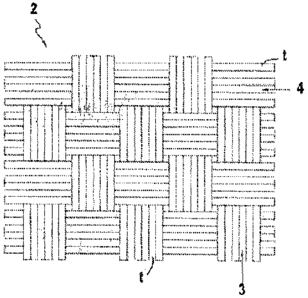
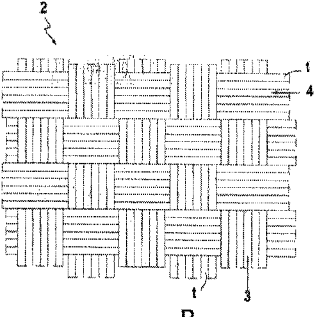


FIG.4B



A



B