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(54) PRODUCTION METHOD OF LAYERED SOUND ABSORPTIVE NON-WOVEN FABRIC

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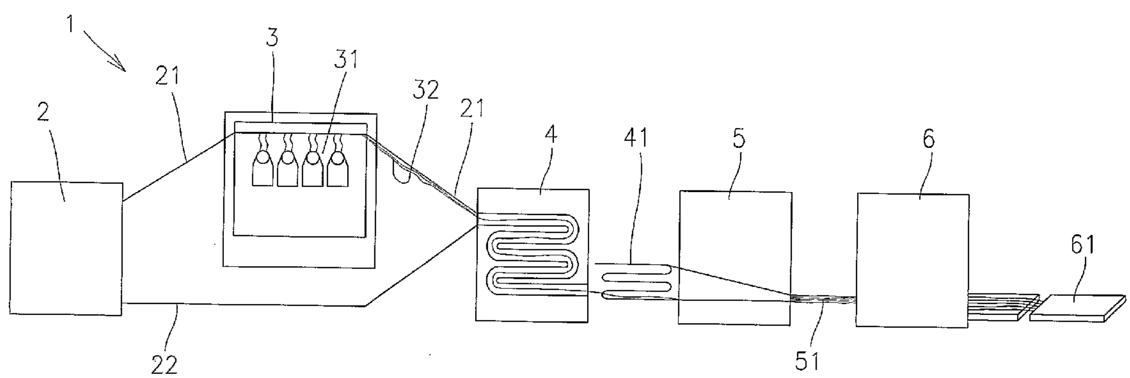
(57) **ABSTRACT**

Production method of layered sound absorptive non-woven fabric, which comprises a resonance membrane which is positioned between two layers of the card fibrous web, while both layers of the card fibrous web are produced simultaneously in carding machine, from which each layer of the card fibrous web is separately brought into the device for production of nanofibres through electrostatic spinning, in which to the side of at least one layer of the card fibrous web adjacent to the remaining layer of the card fibrous web a layer of nanofibres is applied, after then both layers of the card fibrous web near to one another until their adjacent sides sit down one on another, they are laid one on another in a selected quantity of layers and the layers join mutually.



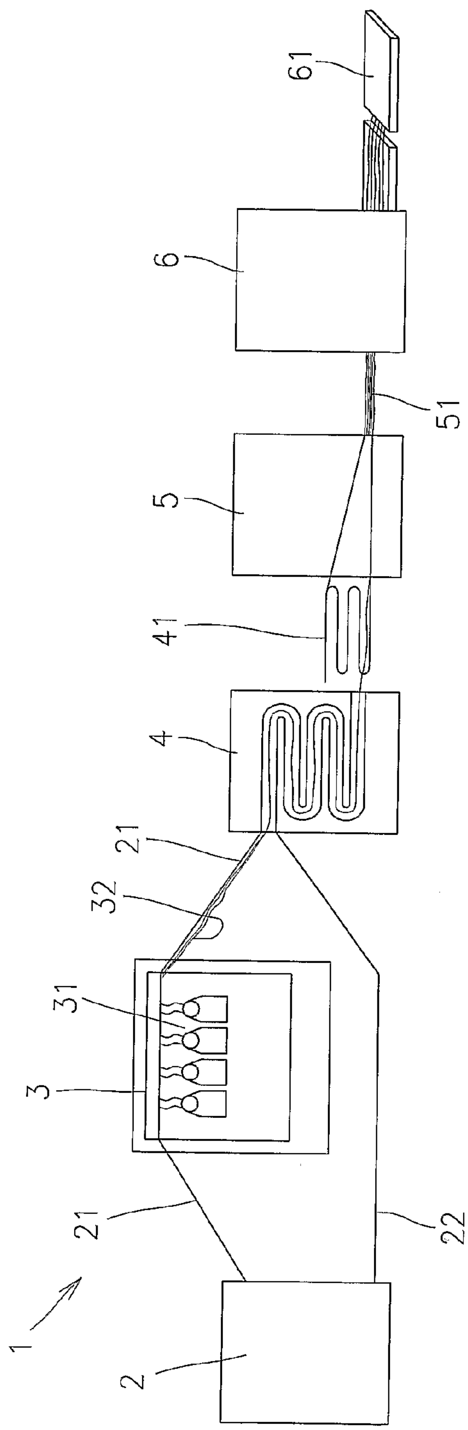


Fig. 1

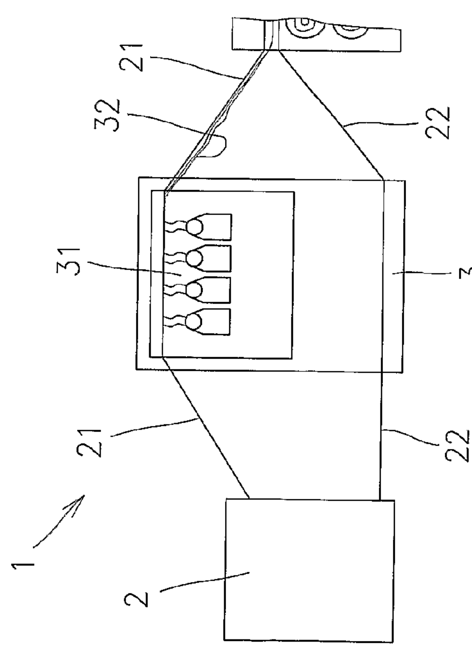


Fig. 2

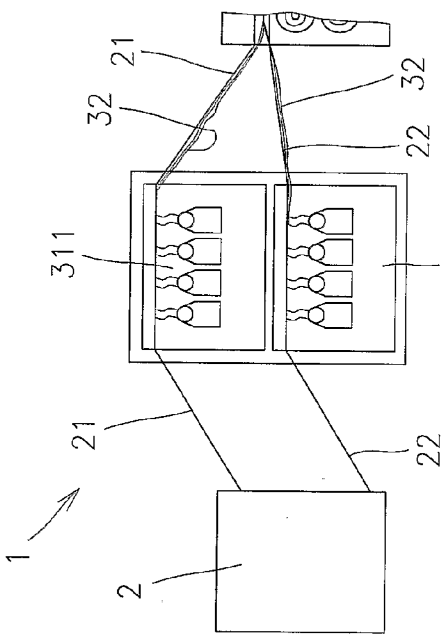


Fig. 3

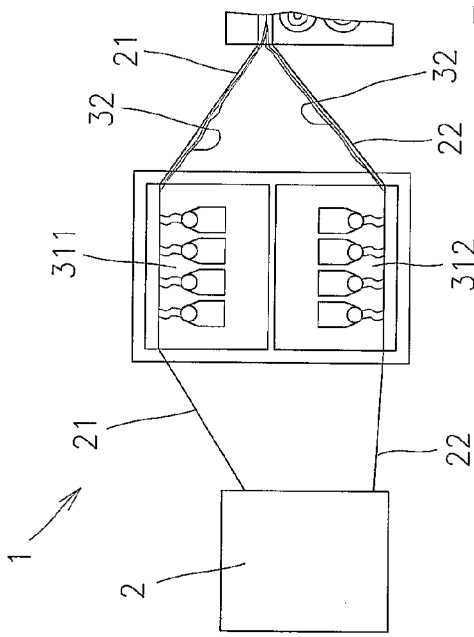


Fig. 4

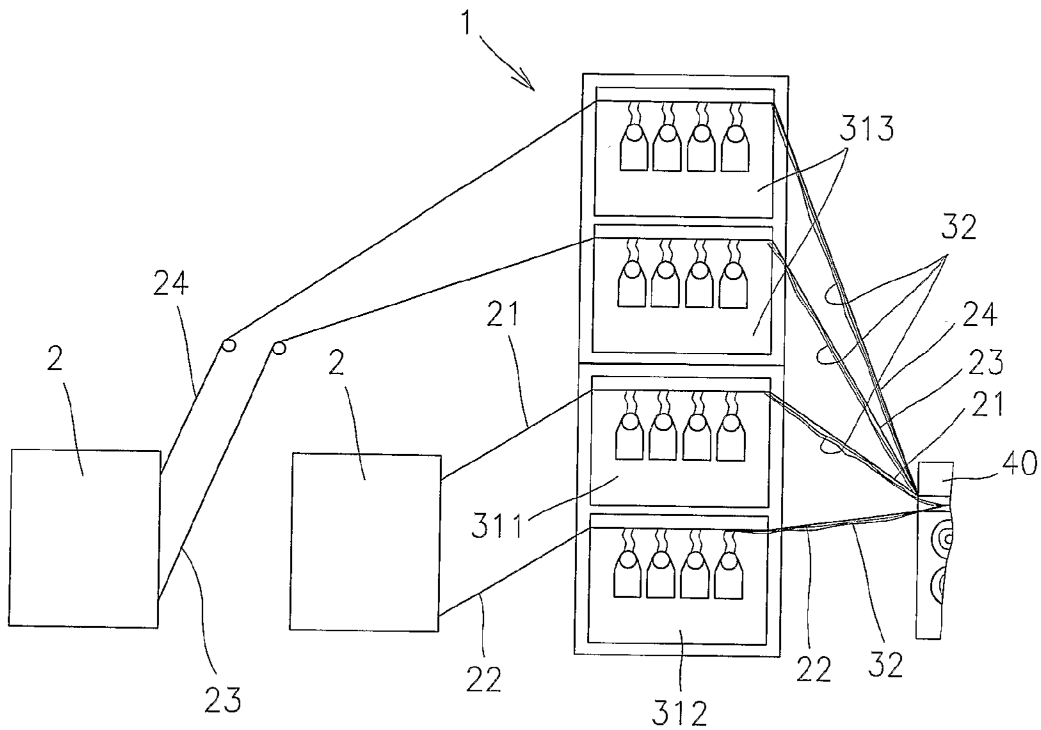

1
313
32
24
2
21
2
24
23
21
40
311
22
23
22
32
312

Fig. 5

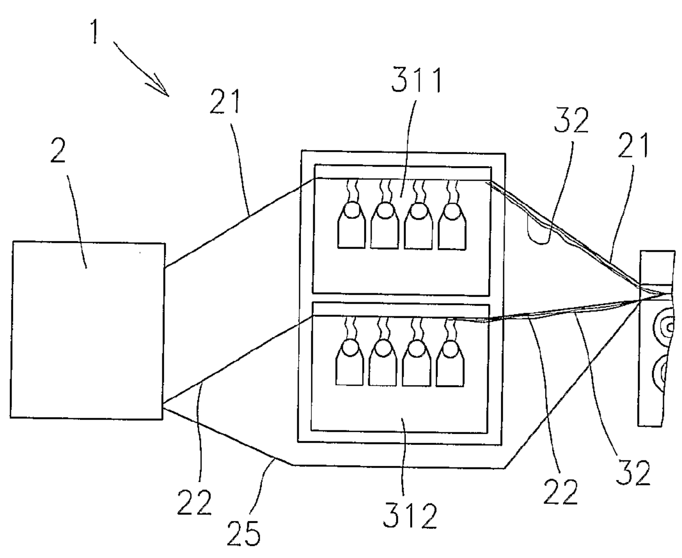

1
311
21
32
21
2
22
32
22
25
312

Fig. 6

PRODUCTION METHOD OF LAYERED SOUND ABSORPTIVE NON-WOVEN FABRIC

TECHNICAL FIELD

[0001] The invention relates to the production method of layered sound absorptive non-woven fabric, which comprises a resonance membrane formed by a layer of nanofibres having diameter to 600 nanometers and basis weight of 0,1 to 5 gm^{-2}, which is positioned between two layers of the card fibrous web.

BACKGROUND ART

[0002] The CZ PV 2005-226 discloses a layered sound absorptive non-woven fabric containing a resonance membrane and at least one another layer of fibrous material. The resonance membrane is formed by a layer of nanofibres having diameter to 600 nanometers and basis weight of 0,1 to 5 gm^{-2} and the resultant fabric is formed by a cross laying to the required thickness and weight.

[0003] In an advantageous embodiment the layer of card fibrous web here forms the bearing layer on which during electrostatic spinning the layer of produced nanofibres is being deposited, and consequently both layers join together in a known manner at the specified temperature in the hot air chamber.

[0004] To increase the efficiency, according to the mentioned document another layer of card fibrous web may be applied on the fabric, namely from the originally disposable side of nanofibrous layer. Possibly there may be another layer, the double or triple one.

[0005] Nevertheless the background art for such three- and more layered fabric requires that at least one fibrous web is prepared separately and the same after then is joined to the nanofibrous layer of already produced two-layer fabric. This complicates the production and makes it more expensive.

[0006] The goal of the invention is to eliminate the shortcomings of the known solutions or to restrict them considerably.

THE PRINCIPLE OF INVENTION

[0007] The goal of the invention has been reached by a production method of layered sound absorptive non-woven fabric containing a resonance membrane formed by a layer of nanofibres, which is positioned between two layers of card fibrous web according to the invention, whose principle consists in that, both layers of card fibrous web are produced simultaneously in carding machine from which at least one layer of card fibrous web is brought into the device for production of nanofibres through electrostatic spinning, in which to the side of this layer of card fibrous web adjacent to the remaining layer the layer of nanofibres is applied, after then after exiting the device for production of nanofibres through electrostatic spinning, both layers of card fibrous web near to one another until their adjacent parts, out of which at least on one there is applied a layer of nanofibres forming the resonance membrane, touch one another.

[0008] From the point of view of spatial complexity and arrangement of individual elements of the device for production of nanofibres through electrostatic spinning it is advantageous if the layer of nanofibres is being applied only on one of layers of the card fibrous web, while the lower layer of card fibrous web also passes the device for production of nanofibres through electrostatic spinning, nevertheless outside its spinning compartment.

[0009] In case the structure of the device for production of nanofibres does not enable passage of a layer of card fibrous web on which the layer of nanofibres is not applied outside the spinning compartment, this layer is guided totally outside the device for production of nanofibres through electrostatic spinning, and to the layer of card fibrous web passing through the spinning compartment it is nearing only after the device for production of nanofibres through electrostatic spinning.

[0010] According to the claim **3** it is advantageous if both layers of card fibrous web are guided separately into the device for production of nanofibres through electrostatic spinning, while at least one layer of the card fibrous web passes through the spinning compartment of this device and to the side of this layer of the card fibrous web adjacent to the second layer the layer of nanofibres is applied.

[0011] Guiding of the second layer of the card fibrous web enables its passage outside the spinning compartment of the device for production of nanofibres through electrostatic spinning.

[0012] In embodiment according to the claim **5** both layers of the card fibrous web are guided through the spinning compartment of the device for production of nanofibres through electrostatic spinning, in which one, the upper, layer of nanofibres is applied on the side of the first layer of the card fibrous web adjacent to the second layer of the card fibrous web, and the second, the lower, layer of nanofibres is applied on the side of the second, the lower, layer of the card fibrous web reverse to the first, the upper, layer of the card fibrous web. This embodiment achieves a higher sound absorption capacity as it contains two resonance membranes formed by layers of nanofibres, while each of these membranes may absorb a different range of sound waves.

[0013] Another increasing of absorption capacity may be achieved according to the claim **6** by that, to the layer of nanofibres applied on the side of lower layer of the card fibrous web there is joined at least one another layer of the card fibrous web with a layer of nanofibres applied on the reverse side of this another layer of the card fibrous web.

[0014] At the same time it is advantageous especially from the point of view of costs, if this further layer of the card fibrous web is produced on the same carding machine as the upper and lower layer of the card fibrous web.

[0015] Or it may be advantageous if this further layer of the card fibrous web is produced in another carding machine than the upper and lower layer of the card fibrous web. This embodiment is rather more expensive, but it allows adding of another one up to three further layers of the card fibrous web.

[0016] Especially due to protection of lower layer of nanofibres it is advantageous if to the layer of nanofibres applied on the outer side of lower layer of the card fibrous web reverse to the previous layer of the card fibrous web an auxiliary layer of the card fibrous web is joined.

[0017] The auxiliary layer of the card fibrous web may be produced on the same carding machine as the upper and lower layer of the card fibrous web or on another carding machine.

[0018] The advantage of another variant of solution according to the invention consists in that both layers of card fibrous web are guided through the spinning compartment of the device for production of nanofibres through electrostatic spinning, in which to the mutually adjacent sides of both layers of the card fibrous web there is applied always one layer of nanofibres.

[0019] In this method it is possible to produce a layered fabric with combination of nanofibrous layers of a different thickness, possibly of a different nanofibrous material and so to reach a broader spectra of the sound being absorbed.

[0020] At the same time it is advantageous, if after exiting the device for production of nanofibres through electrostatic spinning the fabric containing at least two layers of the card fibrous web, in between of which there is arranged at least one layer of nanofibres is formed by means of cross laying into layers.

[0021] Or according to the claim **14** the fabric containing at least two layers of the card fibrous web, in between of which there is arranged at least one layer of nanofibres, after exiting the device for production of nanofibres through electrostatic spinning may be guided into the laying device in which it is laid into layers.

[0022] In this manner it is possible to produce a continuous stripe of layered fabric of a constant composition and specified thickness, which after then, as the need may be, is divided into panels of desired dimensions.

[0023] Further it is advantageous if layers of the fabric are mutually joined by heating to the temperature of melting the material with the lowest melting temperature, which is contained in layers of the fabric.

[0024] Through this method it is possible to choose between which layers of the final layered product the joint will be created by means of mutual smelting of adjacent surfaces.

DESCRIPTION OF THE DRAWING

[0025] The embodiments of production lines for performance of the production method according to the invention are schematically shown on the drawing, where the

[0026] FIG. **1** represents the production line with passage of one card fibrous web outside the device for production of nanofibres through electrostatic spinning, the

[0027] FIG. **2** a section of the production line with passage of both card fibrous webs through the device for production of nanofibres through electrostatic spinning, while one of them is passing outside the spinning compartment, the

[0028] FIGS. **3** and **4** a section of the production line, in which the nanofibres are applied on both layers of the card fibrous web, while according to the FIG. **3** after exiting the spinning device there is only one layer of nanofibres between the two layers of card fibrous web, while according to the FIG. **4** there are after exiting the spinning device both layers of nanofibres positioned together between the two layers of the card fibrous web. The

[0029] FIG. **5** represents a section of the production line, in which the layers of nanofibres are applied on four layers of the card fibrous web and the

[0030] FIG. **6** a section of the production line according to the FIG. **3**, at which on the carding machine simultaneously three layers of the card fibrous web are being produced, while the third layer forms the auxiliary covering layer.

EXAMPLES OF EMBODIMENT

[0031] The FIG. **1** schematically represents the production line **1** for performance of the production method of layered sound absorptive non-woven fabric, known e.g. from the patent application CZ PV 2005-226, according to the invention.

[0032] At the beginning of the production line **1** there is arranged the known carding machine **2**, which in a known manner prepares the upper layer **21** of the card fibrous web and the lower layer **22** of the card fibrous web for production of layered sound absorptive non-woven fabric. The layers **21**, **22** of the card fibrous web may be produced from staple bicomponent fibres of the type core-coating or of another suitable material.

[0033] After exiting from the carding machine the upper layer **21** of the card fibrous web is guided into the device **3** for production of nanofibres through electrostatic spinning, which is for example the device for production of nanofibres through electrostatic spinning of polymer solutions according to the patent application CZ PV 2005-360. The lower layer **22** of the card fibrous web is guided outside the device **3** for production of nanofibres through electrostatic spinning.

[0034] The upper layer **21** of the card fibrous web in the device **3** for production of nanofibres is brought in between the pair of electrodes arranged in the spinning compartment **31** of the device **3** for production of nanofibres through electrostatic spinning. After bringing the high voltage of opposite polarity to these electrodes an electric field with a high intensity is created, which through its action of force to the polymer solution in electrostatic field, e.g. on surface of one of the electrodes from this polymer solution creates the polymer nanofibres. The created polymer nanofibres after their creation are deposited on the lower side of upper layer **21** of the card fibrous web and they create a layer **32** of nanofibres, which is adjacent to the lower layer **22** of the card fibrous web.

[0035] After applying the layer **32** of polymer nanofibres of desired thickness and/or desired basis weight, the upper layer **21** of the card fibrous web with deposited layer **32** of nanofibres is exiting the device **3** for production of nanofibres through electrostatic spinning. The upper layer **21** of the card fibrous web with deposited layer **32** of nanofibres is after then brought to the lower layer **22** of the card fibrous web passing outside the device **3** for production of nanofibres through electrostatic spinning and both layers **21**, **22** are then together brought into the cross laying device **4** positioned after the device **3** for production of nanofibres. In the cross laying device **4** there is performed a known continuous cross laying of layers **21**, **22**, which contain a layer **32** of nanofibres, and the non-reinforced layered sound absorptive fabric **41** is produced.

[0036] The non-reinforced layered sound absorptive fabric **41** is from the cross laying device **4** brought into the hot-air chamber **5**, where through the effect of streaming hot air the upper layer **21** containing the card fibrous web and the nanofibres are joined with the lower layer **22** of the card web, and so the layered sound absorptive non-woven fabric **51** is produced.

[0037] After the hot-air chamber **5** in the production line **1** there is arranged the cutting device **6**, which from the sound absorptive non-woven fabric **51** produces panels **61** of desired dimensions.

[0038] The cross laying device **4** may be replaced by any suitable laying device, which is able to lay the continuously brought layers **21**, **22**, which contain a layer **32** of nanofibres one on another and thus to produce the non-reinforced layered sound absorptive fabric.

[0039] Variant of embodiment according to the invention, in which the lower layer **22** of the card fibrous web is guided through the device **3** for production of nanofibres through electrostatic spinning outside the spinning compartment **31** is represented in the FIG. **2**. The device **3** for production of nanofibres through electrostatic spinning here forms a compact unit serving to guide also the lower layer **22** of the card fibrous web.

[0040] In another variants of method according to the invention the layer of nanofibres **30** is applied not only on the upper layer **21** of the card fibrous web, but also on the lower layer **22** of the card fibrous web, possibly only on the lower layer **22** of the card fibrous web.

[0041] In the variant according to the invention represented in the FIG. **3** the device **3** for production of nanofibres through electrostatic spinning comprises a spinning compartment **31**, possibly two separated spinning compartments **311**, **312**. Upon passage of upper and lower layer **21**, **22** of the card fibrous web the nanofibres are here applied on lower surfaces of both layers **21**, **22**. When the layers **21**, **22** comprising always the card fibrous web and the layer **32** of nanofibres enter the cross laying device **4**, one layer **32** of nanofibres is to be found between the layers **21**, **22** of the card fibrous web and the second layer **32** of nanofibres is to be found on the lower surface of the lower layer **22**.

[0042] Exemplary embodiment according to the FIG. **3** may be added by another layers of the card fibrous web with applied layer of nanofibres. In embodiment according to the FIG. **5** the device **3** for production of nanofibres through electrostatic spinning of polymer solutions comprises four spinning compartments **311**, **312**, **313**, **314**, into which there are brought four layers of the card fibrous web **21**, **22**, **23**, **24** from two carding machines. Upon passage of layers **21**, **22**, **23**, **24** of the card fibrous web the nanofibres are applied on the lower surface of layers **21**, **22**, **23**, **24**. When the layers **21**, **22**, **23**, **24** of the card fibrous web containing the layer **32** of nanofibres enter the laying device **40** the layers **21**, **22**, **23**, **24** are nearing one to another until their contact occurs, while between the layers **21**, **22**, **23**, **24** of the card fibrous web there is always one layer **32** of nanofibres. On the bottom surface of the lower layer **22** of the card fibrous web there is also a layer of **32** of nanofibres. By this layer **32** of nanofibres the lower layer **22** of the card fibrous web is laid in the laying device on the upper layer **24** of already applied layers of the card fibrous web **21**, **22**, **23**, **24**. The disadvantage of this solution is a fact, that one of the outer layers of the resultant layered sound absorptive non-woven fabric **51** is the layer **32** of nanofibres deposited on the utmost lower layer **22** of the card fibrous web, which is a part of the layered sound absorptive non-woven fabric **51**. This problem is solved by exemplary embodiments according to the FIGS. **4** and **6**.

[0043] According to the FIG. **6** the carding machine **2** according to the FIG. **3** provided by means for creation of three layers **21**, **22**, **25** of the card fibrous web, out of which the layers **21**, **22** are brought into the spinning compartments **311**, **312** of the device **3** for production of nanofibres through electrostatic spinning of polymer solutions, and the layer **25** of the card fibrous web is guided outside the spinning compartments or also outside the device **3** for spinning and to the layers **21**, **22** on which in the spinning compartments **311**, **312** of the device **3** for spinning there were applied layers **32** of nanofibres, it joins before entering or on entry into the laying device **40** and so it creates the auxiliary layer **25** of the card fibrous web serving for protection of nanofibrous layer applied on the lower layer **22** of the card fibrous web.

[0044] Also the device according to the FIG. **5** may be provided by an auxiliary layer **25**.

[0045] Also in a variant represented in the FIG. **4** the device **3** for production of nanofibres through electrostatic spinning comprises the spinning compartment **31**, possibly two separated spinning compartments **311**, **312**, as it is described at the embodiment according to the FIG. **3**. Nevertheless the nanofibres are here applied on layers **21**, **22** so that the applied layers **32** of nanofibres are positioned on mutually adjacent surfaces of layers **21**, **22** of the card fibrous web. The method of application of nanofibres down from top on the upper surface of the carrying layer is described e.g. in the CZ 294274. Here the polymer solution is filled into a closed vessel, out of which the polymer solution is brought to the surface of the charged electrode, while with the polymer solution there is wetted e.g. the upper section of circumference of the cylinder, which from the vessel carries out on its circumference the necessary quantity of polymer solution.

[0046] In all variants represented in the FIGS. **2** to **6** the production procedure of layered sound absorptive non-woven fabric **51**, possibly of it created panels **61** proceeds in a manner shown in the first embodiment variant of the production line **1** according to the invention, while for the purpose of the invention it is not important which laying device **40** was applied.

[0047] It is obvious, that alternatives of embodiment of the production line **1** enable to reach various inner arrangements of the sound absorptive non-woven fabric **51** and to fulfil in a variable manner the requirements as to properties of means absorbing the sound. Especially it is possible to each layer **21**, **22**, **23**, **24** of the card fibrous web to apply a layer **32** of nanofibres of different properties, at the same time under the different properties it is primarily understood the different material, out of which the nanofibres are produced, the different thickness of the layer **32** of nanofibres, the different diameter and/or length of nanofibres and other properties influencing absorbing of the sound.

[0048] The described examples of embodiment permit to create further combinations, which are not described in a detail as they are quite obvious for an average specialist.

LIST OF REFERENTIAL MARKINGS

[0049] **1** production line
[0050] **2** carding machine
[0051] **21** upper layer of the card fibrous web
[0052] **22** lower layer of the card fibrous web
[0053] **3** device for production of nanofibres through electrostatic spinning
[0054] **31** spinning compartment
[0055] **311** upper section of spinning compartment
[0056] **312** lower section of spinning compartment
[0057] **32** layer of nanofibres
[0058] **4** cross laying device
[0059] **41** non-reinforced layered sound absorptive fabric
[0060] **5** hot-air chamber
[0061] **51** layered sound absorptive non-woven fabric
[0062] **6** cutting device
[0063] **61** panel

1. Production method of layered sound absorptive non-woven fabric, which comprises a resonance membrane formed by a layer of nanofibres having diameter to 600 nanometers and basis weight of 0,1 to 5 gm $^{-2}$, which is positioned between two layers of the card fibrous web, wherein both layers of the card fibrous web are produced simultaneously in carding machine, from which at least one layer of the card fibrous web is brought into the device for production of nanofibres through electrostatic spinning, in which to the side of this layer of the card fibrous web adjacent to the remaining layer the layer of nanofibres is applied, after then after exiting the device for production of nanofibres through electrostatic spinning both layers of the card fibrous web near one to another until their adjacent parts, out of which at least on one there is applied a layer of nanofibres forming the resonance membrane, sit down one on another.

2. The method according to claim **1**, wherein the lower layer of the card fibrous web is passing outside the device for production of nanofibres through electrostatic spinning.

3. The method according to claim **1**, wherein both layers of the card fibrous web are guided separately into the device for production of nanofibres through electrostatic spinning, while at least the upper layer of the card fibrous web is passing through the spinning compartment of this device and to the side of this upper layer of the card fibrous web adjacent to the lower layer the layer of nanofibres is applied.

4. The method according to claim **3**, wherein the lower layer of the card fibrous web is passing outside the spinning compartment of the device for production of nanofibres through electrostatic spinning.

5. The method according to claim **1**, wherein both layers of the card fibrous web are guided through the spinning compartment of the device for production of nanofibres through electrostatic spinning, in which one layer of nanofibres is applied to the side of the upper layer of the card fibrous web adjacent to the lower layer of the card fibrous web and the second layer of nanofibres is being applied to the side of lower layer of the card fibrous web reverse to the upper layer of the card fibrous web.

6. The method according to claim **5**, wherein the layer of nanofibres applied to the side of lower layer of the card fibrous web reverse to the first layer of the card fibrous web there is joined at least one another layer of the card fibrous web with a layer of nanofibres applied on the reverse side of this another layer of the card fibrous web.

7. The method according to claim **6**, wherein further layer of the card fibrous web is produced on the same carding machine as the upper and lower layer of the card fibrous web.

8. The method according to claim **6**, wherein this further layer of the card fibrous web is produced on another carding machine than the upper and lower layer of the card fibrous web.

9. The method according to claim **5**, wherein the layer of nanofibres applied on outer side of lower layer of the card fibrous web reverse to the previous layer of the card fibrous web an auxiliary layer of the card fibrous web is joined.

10. The method according to claim **9**, wherein the auxiliary layer of the card fibrous web is produced on the same carding machine as the upper and lower layer of the card fibrous web.

11. The method according to claim **9**, wherein the auxiliary layer of the card fibrous web is produced on another carding machine than the upper and lower layer of the card fibrous web.

12. The method according to claim **1**, wherein both layers of the card fibrous web are guided through the spinning compartment of the device for production of nanofibres through electrostatic spinning, in which to the mutually adjacent sides of both layers of the card fibrous web there is applied always one layer of nanofibres.

13. The method according to claim **1**, wherein after exiting the device for production of nanofibres through electrostatic spinning the fabric containing at least two layers of the card fibrous web, in between of which there is arranged at least one layer of nanofibres, is formed by means of cross laying into layers.

14. The method according to claim **1**, wherein after exiting the device for production of nanofibres through electrostatic spinning the fabric containing at least two layers of the card fibrous web, in between of which there is arranged at least one layer of nanofibres, is guided into the laying device in which it is laid into layers.

15. The method according to claim **1**, wherein the layers of the fabric are mutually joined by heating to the temperature of melting the material with the lowest melting temperature, which is contained in layers of the fabric.

* * * * *