(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 327 395 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.05.2018 Bulletin 2018/22

(51) Int Cl.:
F26B 3/28 *(2006.01)* ***F26B 13/00*** *(2006.01)*
F26B 3/30 *(2006.01)*

(21) Application number: **16201040.9**

(22) Date of filing: **29.11.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(54) RADIATION DEVICE FOR TREATING A FIBER WEB AND/OR ELIMINATING BUBBLES OF A COATING OF A FIBER WEB AND METHOD OF TREATING A FIBER WEB AND/OR ELIMINATING BUBBLES OF A COATING OF A FIBER WEB BY RADIATION

(57) The invention relates to a radiation device (12) for treating a fiber web (11) and/or eliminating bubbles of a coating of a fiber web (11), which radiation device (12) comprises an electric power source (14) and a radiation unit (13) having more than one radiation resistor (15) connected to the power source (14), which radiation unit (13) is arranged in a lattice form comprising at least two parallel lattice elements (16) to provide a radiation surface, which is directed towards the fiber web (11), which is treated by thermal radiation radiating from the radiation resistors (15). The radiation resistors (15) are made of graphite and that coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 70 - 120 % provided by the graphite radiation resistors (15). The invention relates also to a method of treating a fiber web and/or eliminating bubbles of a coating of a fiber web by radiation device to be carried out by the radiation device.

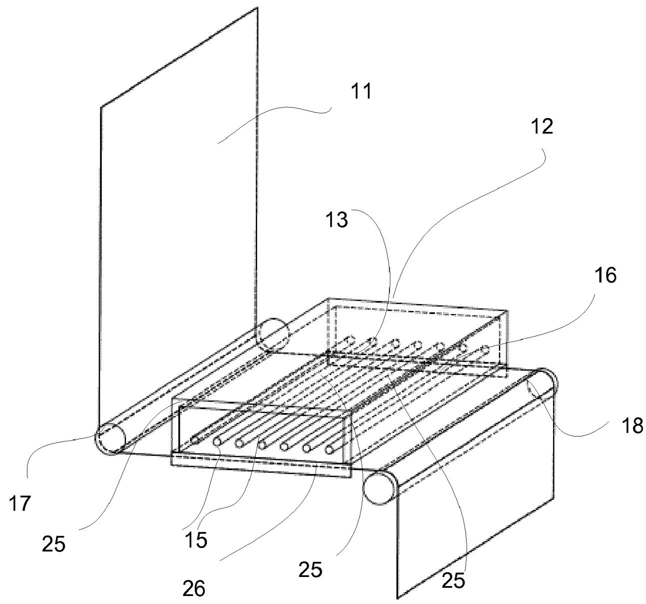

Fig. 9

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Description

[0001] The invention relates to a radiation device and method of treating by radiation. More especially the invention relates to a radiation device according to the preamble of claim 1 and to a method according to the preamble of claim 8.

[0002] It is known from prior art to dry web-like material by radiation device comprising an electric power source and a radiation unit having at least one radiation resistor connected to the power source, which radiation unit is arranged in a lattice form comprising at least two parallel lattice bars to provide a radiation surface, which is directed towards the web-like material, and the web-like material is dried by thermal radiation radiating from the radiation resistor. Radiation devices of this type are disclosed for example in publications US2003110659A1, GB2332844A, US4202112A and US4100395. In US2003110659A1 is disclosed a radiation device for web-like or sheet-like material, which radiation resistor is carbon heating tube lamp. In GB2332844A is disclosed a metallic radiator for an infra-red radiator. In US4202112A is disclosed a method for pre-drying of textile material by an infra-red dryer. In US4100395 is disclosed a metallic radiator with a plate-like corrugated heating surface element.

[0003] As known from the prior art fiber web making processes typically comprise an assembly formed by a number of apparatuses arranged consecutively in the process line. A typical production and treatment line comprises a head box, a wire section and a press section as well as a subsequent drying section and a reel-up. The production and treatment line can further comprise other devices and sections for finishing the fiber web, for example, a sizer, a calender, and a coating section. The production and treatment line also comprises at least one slitter-winder for forming customer rolls as well as a roll packaging apparatus. In this description and the following claims by fiber webs are meant for example paper and board webs.

[0004] It is known from prior art that in fiber web production processes the fiber web is dried in different stages in order to remove moisture from the fiber web. It is also known from prior art that in the production of fiber webs, for example of paper or board webs, various substances are added onto the fiber web in order to achieve the desired end-use properties of the fiber web. For instance the strength and absorption properties of fiber webs can be improved by using surface sizing by applying sizing agents, such as starch or other glue chemicals, onto at least one surface of the fiber web. Typically after sizing the fiber web is dried in order to remove moisture originating from the sizing agent from the fiber web. In the coating process one or more layers of coating color, i.e. mixture of pigments, binders and other additives is added on at least one surface of the fiber web. Typically the main purpose of the coating is to improve the appearance and printability of the fiber web by providing a smooth, flat and opaque surface. Typically after coating the fiber web is dried in order to remove moisture originating from the coating color from the fiber web.

[0005] In drying of fiber webs it is known to apply various types of contacting and non-contacting methods of drying. Non-contacting methods can be based on drying of the fiber web by thermal radiation, in which drying energy is electromagnetic thermal radiation, which mainly absorbs into the fiber web. When wave length of the electromagnetic spectra is 1-100 μm the thermal radiation is called infrared radiation. In drying of fiber webs the radiating material is heated by electric current or by gas flame to required temperature, whereby radiator is emitting infra-red wave lengths. In fiber web drying applications typically is used radiators comprising a quartz lamp, in which a metallic filament is located inside a glass and heated by electric current and power is adjusted by altering voltage. In fiber web drying it is also known to use as radiator based on a by gas flame heated ceramic surface.

[0006] One disadvantage in the known arrangements of radiation drying using quartz lamp or ceramic surface based radiators is need of using high temperatures in order to achieve effective enough drying of fiber webs, which leads to need of effective cooling systems for the lamp or the ceramic surface and thus also to need of cooling energy.

[0007] The lamps and ceramic surfaces also break easily for example due to vibration, and they need to be cooled in order to minimize the breakability risks. This cooling is also needed in order to keep the construction in working conditions such that the parts are not damaged due to the heating effect, which when using lamps or ceramic surfaces as resistors is very high in order to provide effective enough drying. The cooling systems also have high energy consumption as part of the cooling air flows also passes through the fiber web, into the surroundings and heats construction parts around. Thus also much energy is needed in order to provide the drying effect of the fiber web. The life time of these lamps or ceramic surfaces is often shortened due to the surrounding hot and humid environment and due to the vibrations of the surrounding machine parts, which lead to short maintenance intervals and thus to high maintenance costs.

[0008] In the coating of a fiber web typically a coating device - a coater - is used and in surface sizing a sizer is used. In connection with the coaters and the sizers different kinds of application technologies for application of the substance on the fiber web are employed. It is known from prior art to use foam application in a coating-like process to add substance on a web, especially in connection of production of nonwoven products. A foam coating system comprises typically a mixing device, a pumping device, a foaming device, a piping system and an application unit. The foam application unit comprises an application head with a slot nozzle for extruding the foam onto the web. The foaming is based on powerful mixing for adding air into the liquid-based substance with a surfactant additive, resulting substantial increase in the specific volume and thus making the handling and application of the coating color much easier at small dry coat weights. Coating foam typically comprises 80 - 95 volume-% of air and the air is in the foam as bubbles, which are to be eliminated by breaking the bubbles such that bubbles' foils and vertices of coating material create the coating layer. The foam coating is especially used when certain properties are to be achieved by the coating, for example a barrier layer, which can function as a barrier for grease, oil, gas, steam, aromas and/ or water. The foam coating can also be used in situations, where first a porous surface structure has been created to the fiber web in order to increase the penetration of the coating color and then to create a foil-like surface by the coating color. Also the fiber dust can be bound by the coating. Further for example by creating by the foam coating a very thin coating layer, to which foam coating is very well suitable, to smoothen the surface of the fiber web for further coating layers provided by using foam or other type of coating technique.

[0009] Typically the bubbles are broken by pressing in a roll nip or by doctoring by a doctor or a rod or by heating by infra-red radiation using quartz lamp or ceramic surface based radiators. The foam coating is advantageous when different coating colors are to be coated simultaneously, when coating with new coating colors such as nanoparticles or -fibers, when coating color comprises pigments and/or fillers. The foam coating is also suitable for various sizing substances such as natural and/or synthetic polymers, for example resins. The foam coating is used for example for coating with materials that cannot be coated by the other coating techniques for example different types of oil or bio material based coating colors, recyclable or non-recyclable coating colors. The coating composition may contain one or more of surface active agents, pigments, fillers, dyestuffs, and vapor phase corrosion inhibitors.

[0010] One disadvantage in the known arrangements of radiation drying and foam bubble breaking by infra-red radiation using quartz lamp or ceramic surface based radiators, is the need of using high temperatures in order to achieve effective enough drying of fiber webs, which leads to need of effective cooling systems for the lamp or the ceramic surface and thus also to need of cooling energy.

[0011] An object of the invention is to provide a radiation device and a method, in which the disadvantages of prior art are eliminated or at least minimized.

[0012] A particular object of the invention is to create a radiation device, in which energy consumption is lower than in radiation devices known from prior art.

[0013] One particular object is to provide a radiation device in connection of which no cooling system is required.

[0014] Another particular, non-limiting object is to create a radiation device and a method, in which the disadvantages relating to the easy breakability of the lamps or ceramic surfaces are avoided.

[0015] Another particular, non-limiting object is to create a radiation device and a method, in which effective and uniform treating is achieved.

[0016] In order to achieve the above objects and those that will come apparent later the radiation device according to the invention is mainly characterized by the features of claim 1. The method according to the invention is mainly characterized by the features of claim 8. Advantageous aspects and features of the invention are presented in the dependent claims.

[0017] According to the invention the radiation device for treating a fiber web and/or eliminating bubbles of a coating of a fiber web comprises an electric power source and a radiation unit having more than one radiation resistors connected to the power source. The radiation unit is arranged in a lattice form comprising at least two parallel lattice elements to provide a radiation surface, which is directed towards the fiber web, which is treated by thermal radiation radiating from the radiation resistor/-s. The radiation resistors or the radiation device are made of graphite and that the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 70 - 120 %.

[0018] In this description and the claims by treating the fiber web is in particularly meant drying of the fiber web but it also means any treatment of the fiber web to effect to the properties of the fiber web by thermal radiation of the radiation device.

[0019] According to an advantageous feature of the invention the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 70 - 100 %. This is provided by using longitudinally located, sheet-like graphite resistors, which are located next to each other.

[0020] According to an advantageous feature of the invention the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 100 - 120 %. This is provided by using laterally located, rod-like graphite resistors and advantageously by using reflective surfaces around the graphite resistor area to focus the heating energy towards the fiber web surface.

[0021] According to an advantageous feature of the invention the radiation device comprises reflective elements in order to focus and direct the heating effect.

[0022] According to an advantageous feature of the invention the intensity of the heating energy provided by the heating radiation of the graphite resistors is adjusted by selecting the number of the resistors at a surface area and by selecting the mutual locations of the resistors.

[0023] According to an advantageous feature of the invention the lattice elements are arranged longitudinally at least partially overlapping.

[0024] According to an advantageous feature of the invention the lattice elements are U-formed or spiral-like elements.

[0025] According to an advantageous feature of the invention the lattice elements are bar-like and/or plate-like elements.

[0026] According to an advantageous feature of the invention the radiation resistors are located in respect of the running direction of the fiber web in running direction of the fiber web or in cross-direction of the running direction of the fiber web or in vertical direction in respect of the surface direction of the fiber web.

[0027] According to an advantageous feature of the invention the radiation device comprises means to control the radiation of the radiation resistors.

[0028] According to the invention the method of treating a fiber web and/or eliminating bubbles of a coating of a fiber web by radiation device to be carried out by a radiation device according to the invention and the fiber web is treated by thermal radiation provided by the radiation device and/or the bubbles of the coating is eliminated by breaking the bubbles by thermal radiation provided by the radiation device.

[0029] According to an advantageous feature of the invention the fiber web is coated by foam coating and the bubbles of the foam coating are eliminated by breaking the bubbles by thermal radiation provided by the radiation device.

[0030] According to an advantageous feature of the invention in the method the radiation of the radiation device is controlled to wave lengths that maximize the absorption of the radiation

[0031] Advantageously in connection with foam coating of a fiber web after a foam coating has been applied onto at least one surface of the fiber web the foam coating is heated by a radiation device such that bubbles in the foam coating break by the heating effect of the thermal radiation the electromagnetic radiation of the radiation device provided by the graphite radiation resistors of the radiation device.

[0032] By the invention is achieved considerable energy savings, for example due to no need of cooling energy is saved at least 30% compared to the systems of prior art using quartz lamps as the cooling system is no longer needed. The energy savings are created by firstly not needing the cooling energy, also the spreading of heating energy to the surroundings can be decreased by using according to an advantageous feature of the invention reflective surfaces around the graphite resistor area. The invention also provides for costs savings as the maintenance interval is longer and the graphite resistors do not break easily and stands vibration. As the cooling system is no longer needed also whole construction can be made simpler. Maximum power available of the radiation device with graphite radiation resistors is even over two times higher than the maximum power available of a radiation device with lamps as the graphite is more durable and suitable to be used in higher temperatures. The radiation device according to the invention and/or its advantageous features provides several advantages: in connection with the radiation device comprising carbon radiation resistors no cooling systems are needed thus construction of the radiation device and its peripherals and support structures are simpler and also cost and space saving. The life time of the graphite radiation resistors is thousands of hours and thus maintenance advantages are achieved as the maintenance interval can be increased. Furthermore the maintenance is easier and faster as there are fewer components due to the no need of cooling systems.

[0033] In accordance with the present invention and its advantageous features, when infrared treating with graphite resistors is used for treating after the foam coating, the wave length of the infrared radiation can be selected of wide range of wave lengths for breaking the bubbles of the foamed coating color. The wave length of the infrared radiation can also be optimized in view of penetration; when the wave length is increased the penetration depth decreases. The wave length can be selected to the range where the water absorption is highest and to correspond to the emission/absorption factor of the coating color such that the bubbles are most effectively broken. For a coating color spectrum of wave lengths is measured to define which wave lengths provide the best heating radiation to break the bubbles of the foamed coating color and to create the desired penetration in view of the absorbability of the fiber web grade. By the present invention this is effectively achieved as the graphite resistors are adjustable in wide range of wave lengths.

[0034] In the following the invention is further explained in detail with reference to the accompanying drawing in which

in figures 1 - 2 are shown schematical examples of a radiation device according to advantageous examples of the invention,

in figures 3A - 3B, 4A - 4B, 5A - 5B and 6 - 8 are schematically shown examples of a radiation device according to the invention in applications for eliminating the foam bubbles in foam coating,

in figures 9, 10A - 10B and 11 are shown schematical examples of a radiation device according to advantageous examples of the invention and

in figures 12A -12D are shown schematical calculation examples of the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation in different advantageous examples.

[0035] During the course of this description like numbers and signs will be used to identify like elements according to the different views which illustrate the invention.

[0036] In figures 1 - 2 are schematically shown two examples of a radiation device 12 for drying a fiber web 11. The fiber web 11 is guided by two rolls 17, 18. The radiation device 12 comprises an electric power source 14 and a radiation unit 13 having at least one radiation resistor 15 connected to the power source 14. The radiation unit 13 is arranged in a lattice form comprising at least two parallel lattice elements 16 to provide a radiation surface, which is directed towards the fiber web 11, which is dried by thermal radiation radiating from the radiation resistor 15 of the lattice elements 16. The radiation resistor 15 is made of graphite. The lattice elements 16 in figure 1 are bar-like and in figure 2 plate-like elements and arranged longitudinally at least partially overlapping. The coverage relation of the radiation surface area and the fiber web surface area effected by the radiation in the example of figure 1 is 70 - 100% and temperature can be up to 1200 °C. The coverage relation of the radiation surface area and the fiber web surface area effected by the radiation in the example of figure 2 is 100 - 120 % and temperature can be over 1200 °C. The greater the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is the lower temperature can be used to achieve the same drying effect. Alternatively greater drying capacity can be used using the same temperature. There is no need to cool the radiation unit because the graphite resistors withstand high enough temperatures so that effective drying is achieved.

[0037] In figures 3A-3B is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto the surface of the fiber web 11 by the foam coater 21. In figure 3B is shown the A-A view of the figure 3A. The radiation device 12 is located above the fiber web 11 guided by two rolls 17, 18. The radiation device 12 located at the run of the fiber web 11 between the two rolls 17, 18 for heating the upper side of the fiber web 11. There are also located between the radiation device 12 and the fiber web 11 around the edges of the radiation device 12 side elements 26 that prevent escape of the heat from area covered by the radiation device 12. Prior to this run the upper side of the fiber web 11 has been foam coated and the radiation device 12 heats the coating and thus breaks the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Correspondingly the radiation device 12 can be located for drying the fiber web 11 at a run between two rolls 17, 18.

[0038] In figures 4A-4B is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto the surface of the fiber web 11 by the foam coater 21. In figure 4B is shown the B-B view of the figure 4A. The radiation device 12 is located above the fiber web 11 guided by two rolls 17, 18. The radiation device 12 located at the run of the fiber web 11 between the two rolls 17, 18 for heating the upper side of the fiber web 11. There are also located between the radiation device 12 and the fiber web 11 around the edges of the radiation device 12 side elements 26 that prevent escape of the heat from area covered by the radiation device 12. Prior to this run the upper side of the fiber web 11 has been foam coated and the radiation device 12 heats the coating and thus breaks the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Under the run is located a counter heating device 20 for heating the lower side of the fiber web 11 or a radiation cover plate with insulation material. There are also located between the counter heating device 20 and the fiber web 11 around the edges of the counter heating device 20 side elements 26 that prevent escape of the heat from area covered by the counter heating device 20. Correspondingly the radiation device 12 with the counter heating device 20 can be located for drying the fiber web 11 at a run between two rolls 17, 18.

[0039] In figures 5A-5B is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto the fiber web 11 by the foam coater 21. In figure 5B is shown the C-C view of the figure 5A. The radiation device 12 is located above the fiber web 11 guided over a roll 19. The radiation device 12 located at the run of the fiber web 11 on the roll 19 for heating the upper side of the fiber web 11. There are also located between the radiation device 12 and the fiber web 11 around the edges of the radiation device 12 side elements 26 that prevent escape of the heat from area covered by the radiation device 12. Prior to this run the upper side of the fiber web 11 has been foam coated and the radiation device 12 heats the coating and thus breaks the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Correspondingly the radiation device 12 can be located for drying the fiber web 11 at a run on a roll 19.

[0040] In figure 6 is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto the surfaces of the fiber web 11 by the foam coaters 21. The foam coaters 21 are located in connection with corresponding coating rolls 22, 23, which form a coating nip in between of themselves, through which nip the fiber web 11 is guided. The foam coaters 21 apply a coating color layers L onto the coating rolls 22, 23, by which the coating color is applied on each side of the fiber web 11. First radiation device 12 is located below the fiber web 11 and the second radiation device is located above the fiber web 11 on a fiber web run guided by two rolls 17, 18. The first radiation device 12 for heating the lower side of the fiber web 11 is located on the fiber web run between the coating nip and a turn device 24. The second radiation device 12 located at the run of the fiber web 11 between the two rolls 17, 18 for heating the upper side of the fiber web 11. Prior to these drying runs the lower and upper sides of the fiber web 11 have been foam coated by the foam coaters 21 and the radiation devices 12 heat the coating and thus break the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Correspondingly the radiation devices 12 can be located for drying the fiber web 11.

[0041] In figure 7 is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto one surface of the fiber web 11 by a foam coater 21. The foam coater 21 is located in connection with a corresponding coating roll 22, which form a coating nip with another coating roll 23 in between of them, through which nip the fiber web 11 is guided. The foam coater 21 apply a coating color layer L onto the coating roll 22, by which the coating color is applied on the upper side of the fiber web 11. The radiation device 12 is located above the fiber web 11 on a fiber web run guided by two rolls 17, 18. Prior to the radiation device 12 is located on the fiber web a turn device 24. Prior to the drying run the upper side of the fiber web 11 has been foam coated by the foam coater 21 and the radiation device 12 heats the coating and thus breaks the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Correspondingly the radiation device 12 can be located for drying the fiber web 11.

[0042] In figure 8 is schematically shown an example of a radiation device 12 according to the invention in an application for eliminating the foam bubbles in foam coating provided onto the surfaces of the fiber web 11 by the foam coaters 21. The foam coaters 21 are located in connection with corresponding coating rolls 22, 23, which form a coating nip in between of themselves, through which nip the fiber web 11 is guided. The foam coaters 21 apply a coating color layers L onto the coating rolls 22, 23, by which the coating color is applied on each side of the fiber web 11. In this example radiation devices 12 are located on both sides of the fiber web 11. First radiation devices 12 are located on the fiber web run between the coating nip and a roll 17. The second radiation devices 12 are located at the run of the fiber web 11 between two rolls 17, 18. Prior to these drying runs the lower and upper sides of the fiber web 11 have been foam coated by the foam coaters 21 and the radiation devices 12 heat the coating and thus break the bubbles in the foam such that bubbles' foils and vertices of coating material create the coating layer. Correspondingly the radiation devices 12 can be located for drying the fiber web 11.

[0043] In the examples of figures 6 and 8 the nip between the coating rolls 22, 23 can be used to break the bubble structure of the coating foam when the nip is closed. In these examples of figures 6 and 8, when the nip is open and there is about a 0,1 - 6 mm gap in between the coating rolls 22, 23, the bubble structure of the coating foam is broken by the radiation device/-s 12. In the example of figure 7 the nip between the coating rolls 22, 23 can be used to break the bubble structure of the coating foam when the nip is closed. The nip can also be closed and unloaded. Also the wrap angle on the coating rolls 22, 23 may be used in connection of breaking the bubbles of the coating foam in connection with the example of figures 6 - 8. The wrap angel on a roll is the angle the fiber web covers of the surface of the roll, when running on the surface of the roll. In the example of figure 7 if the nip is open the wrap can be used between the web and the roll for breaking the bubbles of the coating foam.

[0044] In figures 9 - 11 are schematically shown examples of a radiation device 12 for drying a fiber web 11. The fiber web 11 is guided by two rolls 17, 18. The radiation device 12 comprises a radiation unit 13 having several radiation resistors 15. The radiation unit 13 is arranged in a lattice form comprising several parallel lattice elements 16 to provide a radiation surface, which is directed towards the fiber web 11, which is dried by thermal radiation radiating from the radiation resistors 15 of the lattice elements 16. The radiation resistors 15 are made of graphite. The lattice elements 16 with the radiation resistors 15 in are rod-like. Around each lattice elements 16 with the graphite radiation resistors 15 reflection elements 25 are located for focusing the radiation towards the fiber web 11. In the example of figure 9 the lattice elements 16 with the radiation resistors 15 are located spaced apart longitudinally in cross-direction of the fiber web 11 next to each other. In the example of figure 10A - 10B the lattice elements with the radiation resistors 15 are located spaced part vertically in respect of the surface of the fiber web 11. In the example of figure 11 the lattice elements 16 with the radiation resistors 15 are located spaced apart longitudinally in longitudinal direction of the fiber web 11 next to each other. As shown in figure 10B the radiation device 12 may also comprise support structures 27 to help in keeping the run of the fiber web 11 planar and prevent the fiber web 11 from contacting the radiation resistors 15. The distance of the radiation resistors 15 from the surface of the fiber web is typically 30 - 80 mm. The coverage relation of the radiation surface area and the fiber web surface area effected by the radiation in the examples of figures 9 and 11 is 70 - 100% and temperature can be up to 1200 °C. The coverage relation of the radiation surface area and the fiber web surface area effected by the radiation in the example of figures 10A - 10B is 100 - 120 % and temperature can be over 1200 °C. The greater the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is the lower temperature can be used to achieve the same drying effect. Alternatively greater drying capacity can be used using the same temperature. There is no need to cool the radiation unit because the graphite resistors withstand high enough temperatures so that effective drying is achieved.

[0045] In figures 12A -12D are shown schematical calculation examples of the coverage relation of the radiation surface area of the radiation resistors 15 and the fiber web 11 surface area effected by the radiation in different advantageous examples.

[0046] In the example of the figure 12A the coverage for one radiation resistor 15 is calculated by equation: H*L*2 + H*W*2+ L*W. In this example the radiation resistors 15 have a rectangular cross-section and H is height of the radiation resistor 15, L is length of the rectangular cross-section of the radiation resistor 15 and W is width of the rectangular cross section of the radiation resistor. The fiber web surface area effected by the radiation is width L1 of the fiber web 11 multiplied by the distance in running direction of the fiber web between the first edge in the running direction of the first row of the radiation resistors 15 and the last edge of the last row of the radiation resistors 15.

[0047] In figure 12B the coverage relation is calculated for one radiation resistor 15 by equation: L2(wave-line length of the straightened bottom surface) * W (width of the radiation resistor 15). The fiber web surface area effected by the radiation is width L1 of the fiber web 11 multiplied by the distance in running direction of the fiber web between the first edge of the first radiation resistor and the last edge of the last radiation resistor 15.

[0048] In figure 12C the coverage relation is calculated for one resistor 15 by equation $\pi * d / 2 * L2$. In this example the radiation resistors 15 are located spaced apart longitudinally in cross-direction of the fiber web 11 and the radiation resistors 15 have a circular cross-section and H is height of the radiation resistor 15, L2 is length of the radiation resistor 15 and d is diameter of the cross section of the radiation resistor. The fiber web surface area effected by the radiation is width L1 of the fiber web 11 multiplied by the distance in running direction of the fiber web between the first edge in the running direction of the first of the radiation resistors 15 and the last edge of the last of the radiation resistors 15.

[0049] In figure 12D the coverage relation of one radiation resistor 15 is calculated by equation $\pi * d * H + \pi (d/2)^2$. In this example the radiation resistors 15 are located spaced part vertically in respect of the surface of the fiber web 11 and the radiation resistors 15 have a circular cross-section and H is height of the radiation resistor 15 and d is diameter of the cross section of the radiation resistor. The fiber web surface area effected by the radiation is width L1 of the fiber web 11 multiplied by the distance in running direction of the fiber web between the first edge in the running direction of the first row of the radiation resistors 15 and the last edge of the last row of the radiation resistors 15.

[0050] Above only some advantageous examples of the inventions has been described to which examples the invention is not to be narrowly limited and many modifications and alterations are possible within the invention.

Reference signs used in the drawing

[0051]

- 11 fiber web
- 12 radiation device
- 13 radiation unit
- 14 electric power source
- 15 radiation resistor
- 16 lattice element
- 17, 18, 19 roll
- 20 counter heating device or radiation cover
- 21 foam coater
- 22, 23 coating roll
- 24 turn device
- 25 reflection element
- 26 side element
- 27 support structure
- L coating layer

Claims

1. Radiation device (12) for treating a fiber web (11) and/or eliminating bubbles of a coating of a fiber web (11), which radiation device (12) comprises an electric power source (14) and a radiation unit (13) having more than one radiation resistor (15) connected to the power source (14), which radiation unit (13) is arranged in a lattice form comprising at least two parallel lattice elements (16) to provide a radiation surface, which is directed towards the fiber web (11), which is treated by thermal radiation radiating from the radiation resistors (15), **characterized in that** the radiation resistors (15) are made of graphite and that coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 70 - 120 % provided by the graphite radiation resistors (15).

2. Radiation device according to claim 1, **characterized in that** the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 70 - 100 %.

3. Radiation device according to claim 1, **characterized in that** the coverage relation of the radiation surface area and the fiber web surface area effected by the radiation is 100 - 120 %.

4. Radiation device according to any of the previous claims, **characterized in that** the radiation resistors (15) are located in respect of the running direction of the fiber web (11) in running direction of the fiber web or in cross-direction of the running direction of the fiber web or in vertical direction in respect of the surface direction of the fiber web.

5. Radiation device according to any of the previous claims, **characterized in that** the lattice elements (16) are arranged longitudinally at least partially overlapping.

6. Radiation device according to any of the previous claims, **characterized in that** the lattice elements are bar-like and/or rod-like and/or plate-like elements.

7. Radiation device according to any of the previous claims, **characterized in that** the radiation device comprises means to control the radiation of the radiation resistors (15).

8. Method of treating a fiber web and/or eliminating bubbles of a coating of a fiber web by radiation device to be carried out by a radiation device according to any of claims 1 - 7, **characterized in that** the fiber web (11) is treated by thermal radiation provided by the radiation device (12) and/or the bubbles of the coating is eliminated by breaking the bubbles by thermal radiation provided by the radiation device (12).

9. Method according to claim 8, **characterized in that** the fiber web (11) is coated by foam coating and the bubbles of the foam coating are eliminated by breaking the bubbles by thermal radiation provided by the radiation device (12).

10. Method according to claim 8 or 9, **characterized in that** in the method the radiation of the radiation device (12) is controlled to wave lengths that maximize the absorption of the radiation.

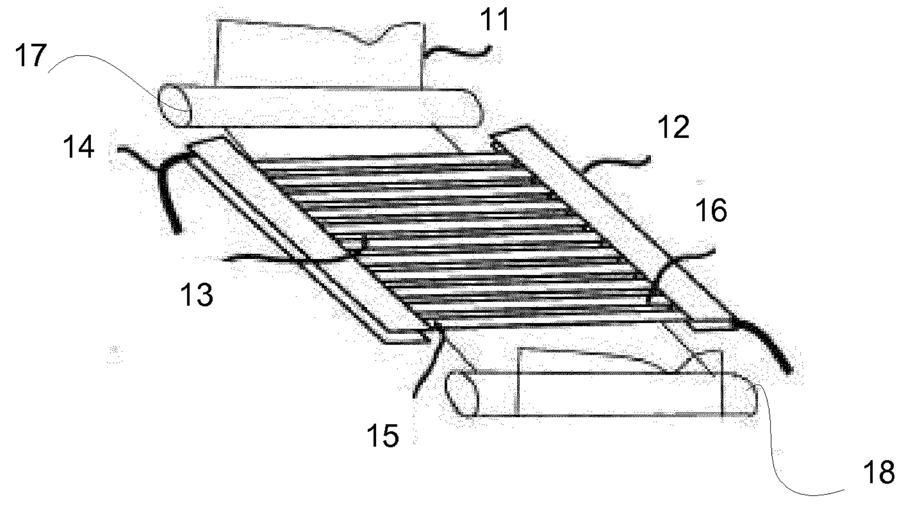

Fig. 1

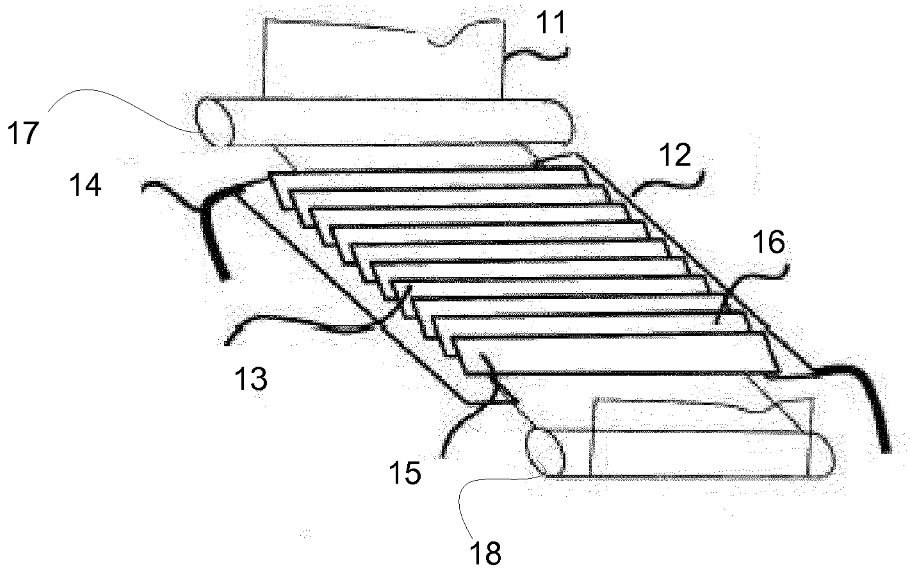

Fig. 2

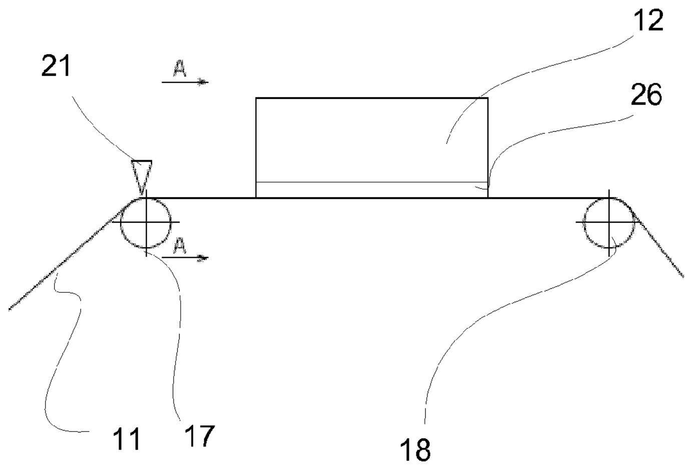

Fig. 3A

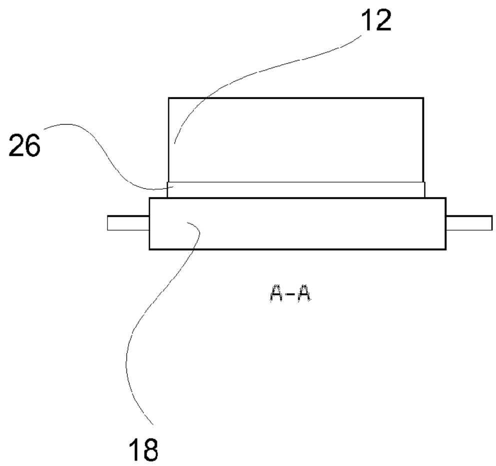

Fig. 3B

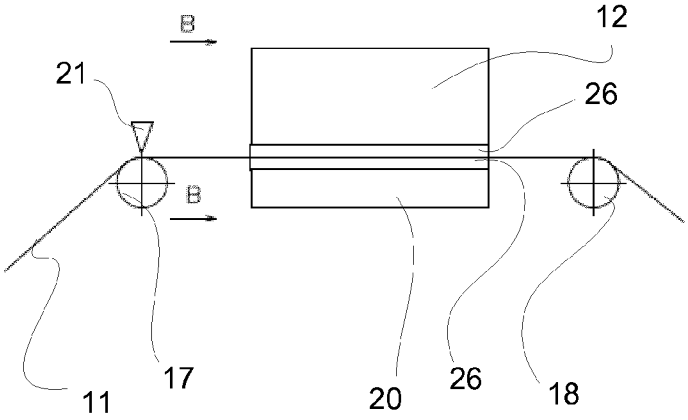

Fig. 4A

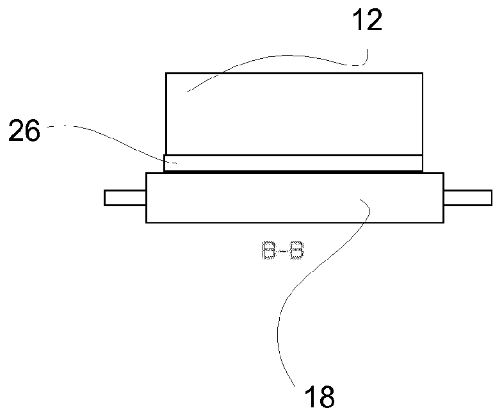

Fig. 4B

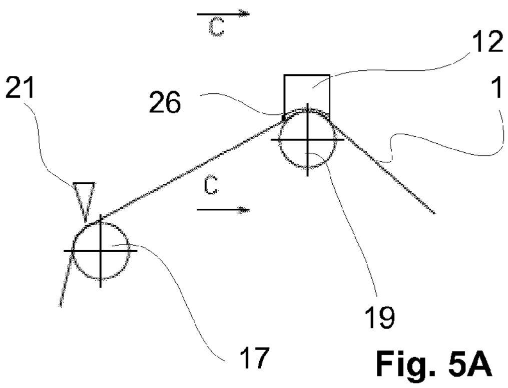

Fig. 5A

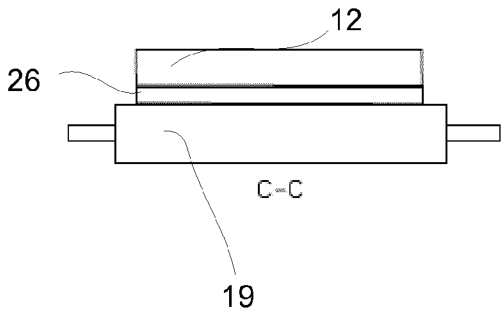

Fig. 5B

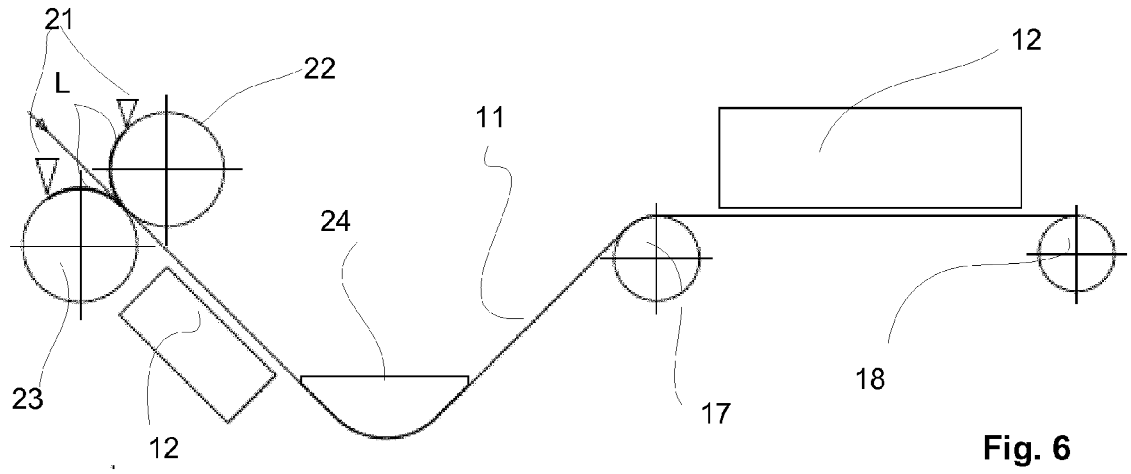

Fig. 6

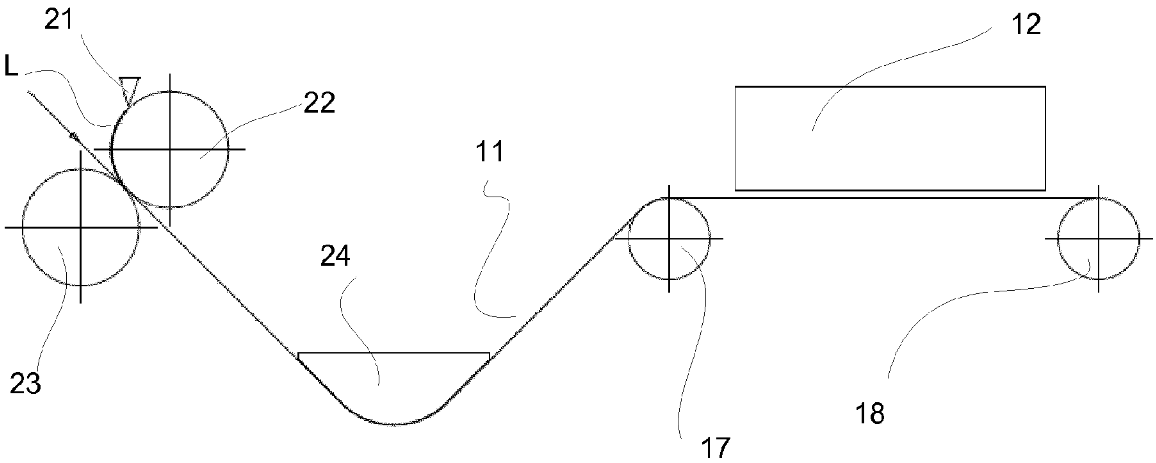

Fig. 7

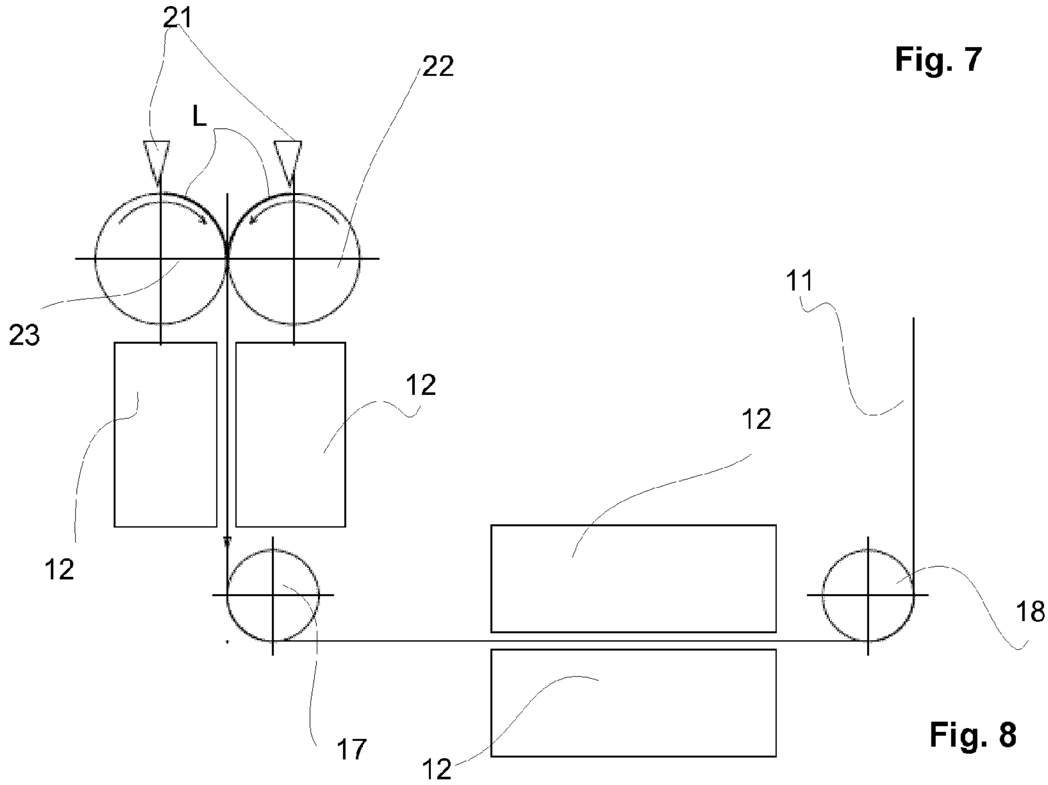

Fig. 8

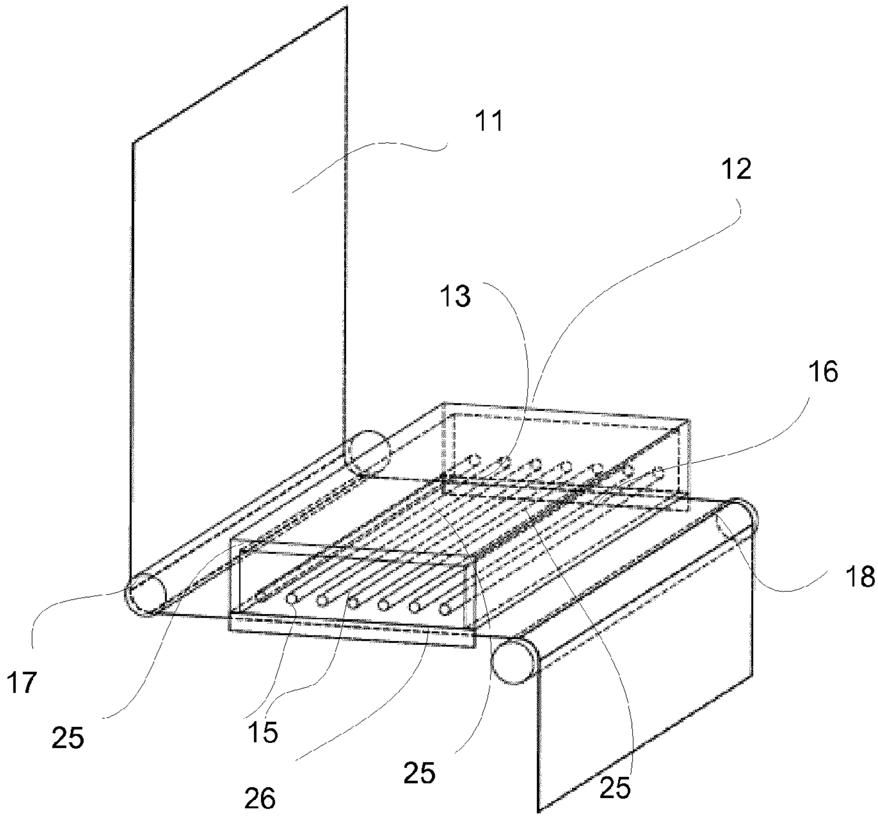

Fig. 9

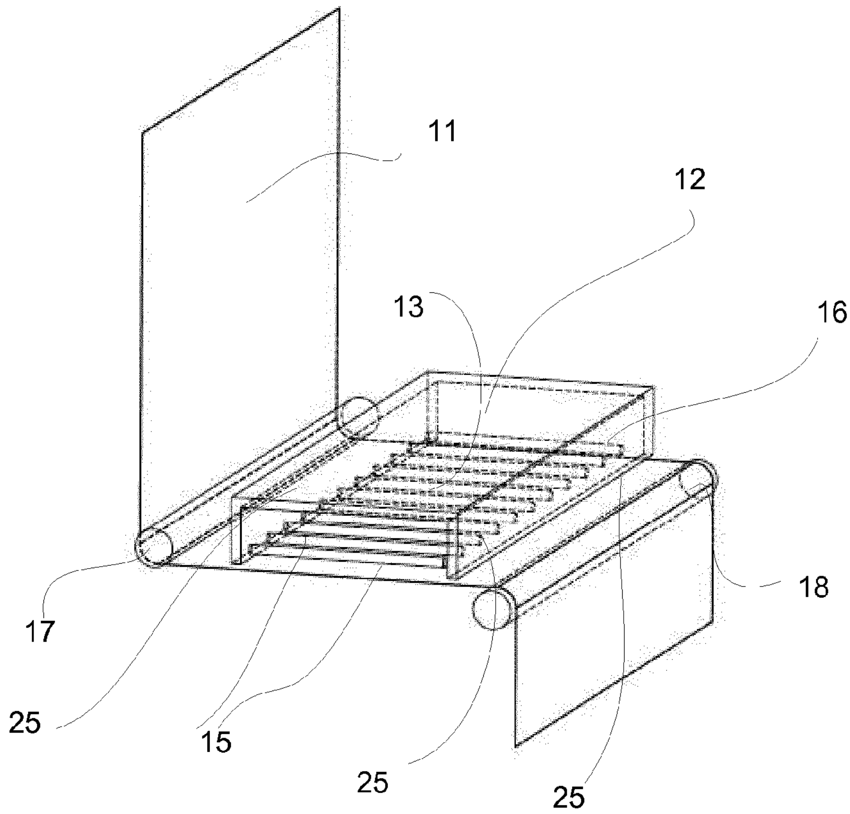

Fig. 11

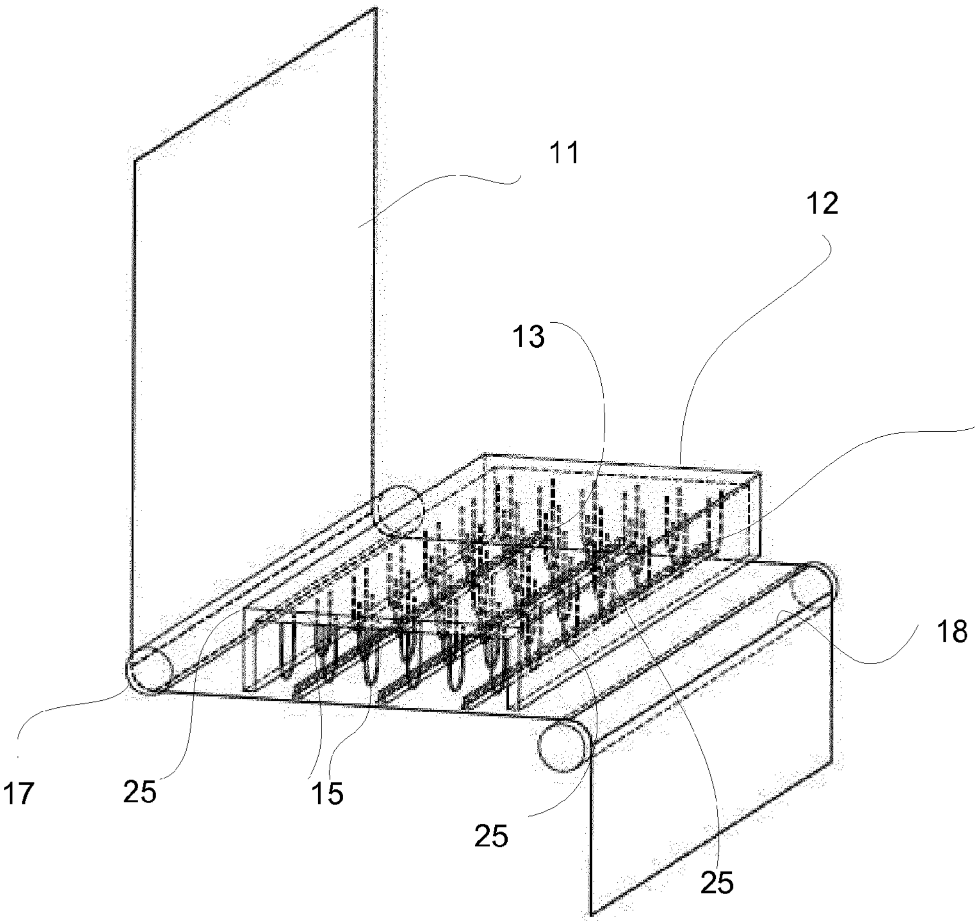

Fig. 10A

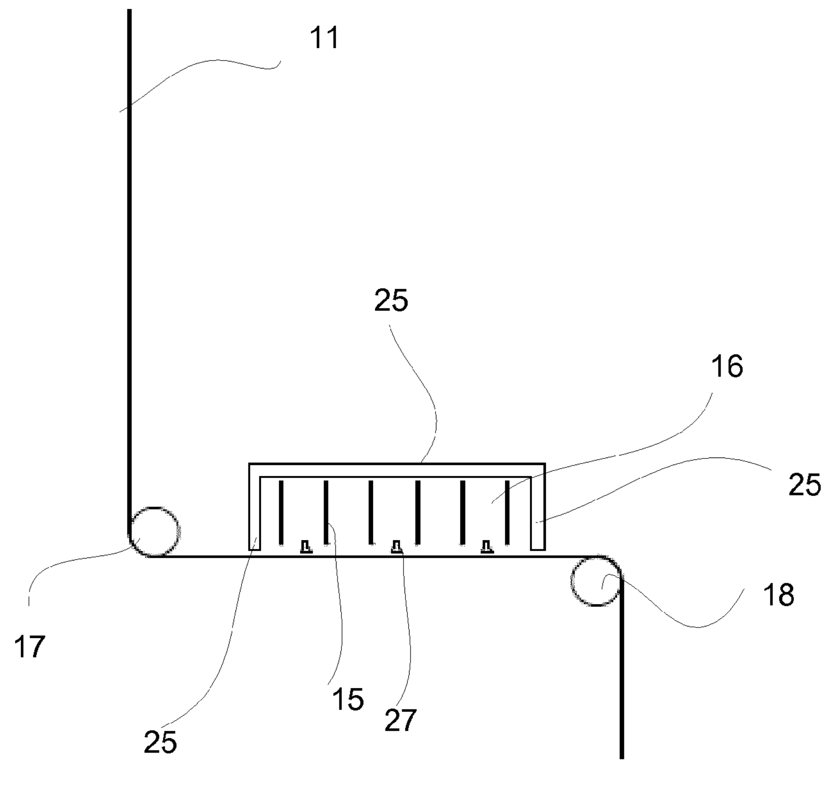

Fig. 10B

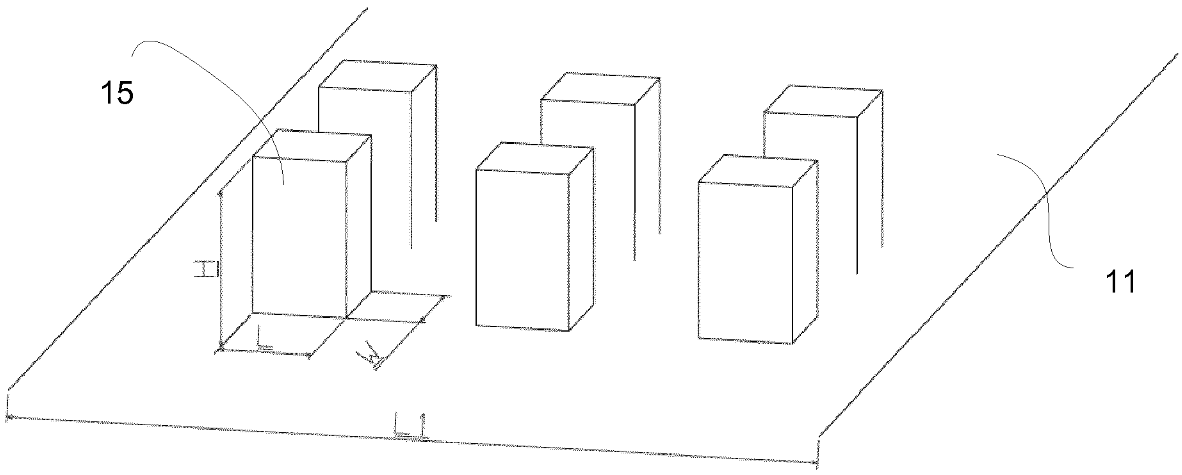

Fig. 12A

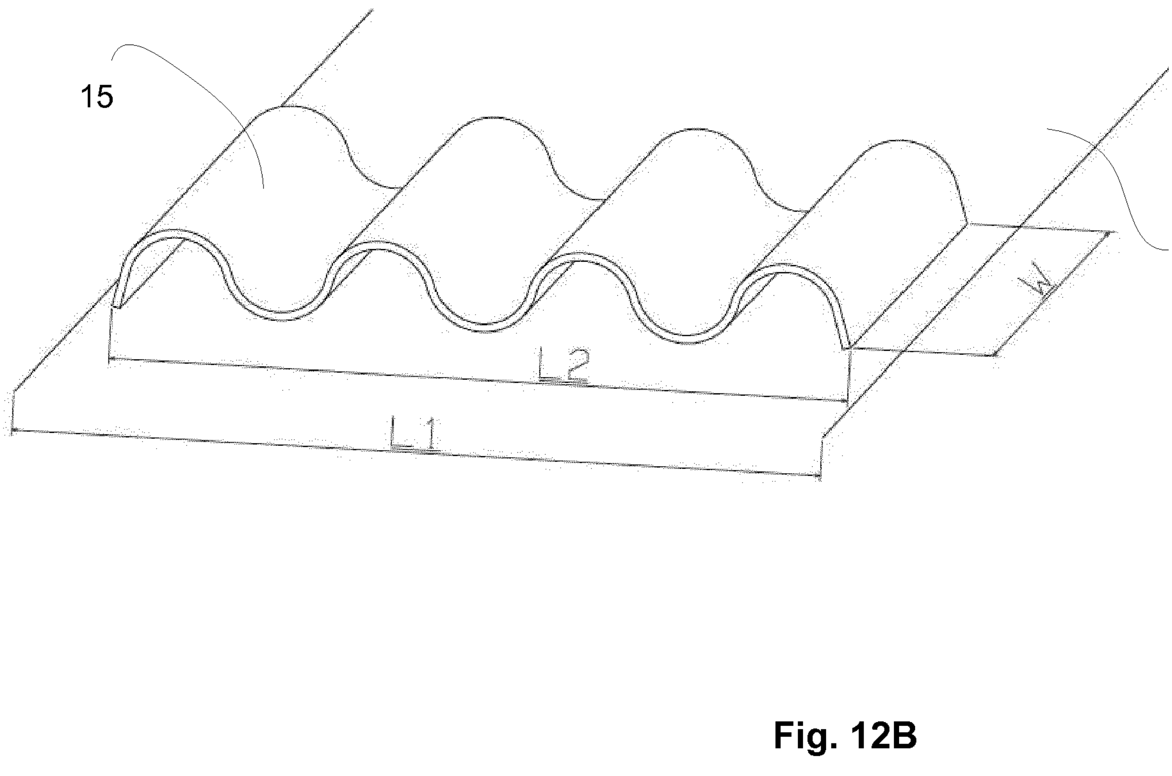

Fig. 12B

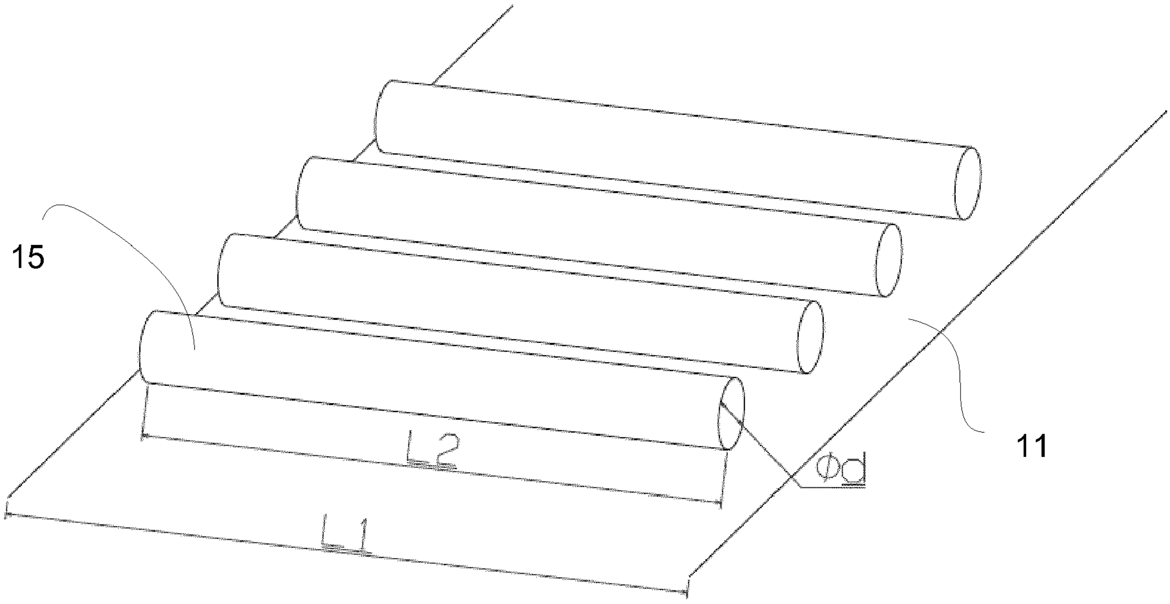

Fig. 12C

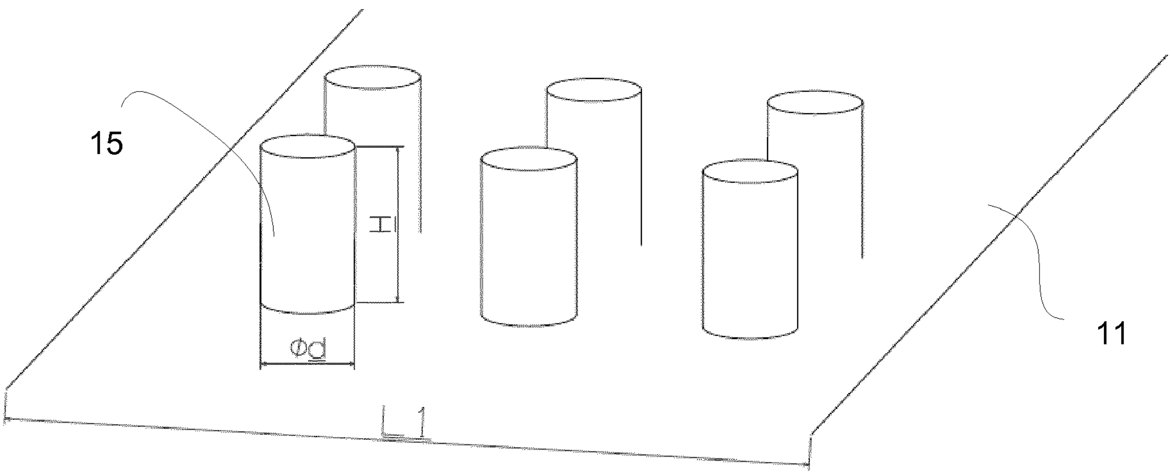

Fig. 12D

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 1040

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 May 2017	De Meester, Reni

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