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DESCRIPTION

TECHNICAL FIELD

[0001] The present disclosure refers to a greenhouse screen of the kind that comprises a plurality of flexible strips of film material, which are interconnected by a yarn framework to form a continuous product.

BACKGROUND OF THE INVENTION

[0002] Greenhouse screens are used frequently for energy saving, shading and temperature control. One known type of greenhouse screens comprises a plurality of flexible strips of film material extending in parallel to each other, and which by means of a knitting, warp-knitting or weaving process are interconnected by a yarn framework to form a continuous product, wherein the strips form a major part of the surface area of the product. Such a greenhouse screen is known for example through EP 0 109 951. Other examples of screens of this type are shown in FR 2 071 064, EP 1 342 824, WO 2008/091192 and in WO 2011/096882.

[0003] The strips of flexible film material can be of selected materials providing desired properties with respect to reflection and light, moisture and heat transmission.

[0004] DE 20 2008 004 181 U1 discloses a two-layer greenhouse screen comprising a standard greenhouse screen as bottom layer and on top of this layer reflective strips that are glued to the screen at certain intervals. This creates a screen which is less drapable. Water transportation through capillary action is prevented in the areas of the yarn framework located between the bottom and top layer strips. Water may be trapped in those areas of the yarn increasing the risk for algae growth. The double-layer structure further has the disadvantage of creating a big bundle when the screen is in rested position.

[0005] US 2004/198126 refers to a light-shading sheet for agricultural and horticultural use comprising a light-shading white film and a reinforcement made of textile fabric or a nonwoven fabric. The reinforcement is laminated to the backside of the film. The film may be slitted to from strips that are laminated spaced apart to the reinforcement. The lamination technique used is adhesive or "sandwich lamination", wherein the latter is defined as a technique of laminating the textile or nonwoven fabric and the white film via an adhesive layer made of lamination resin disposed between the layers.

[0006] JP 10327684 A discloses a shading net capable of reflecting strong solar heat and suitable for agriculture, horticulture etc, The shading net comprises tape-shaped yarns of nonwoven fabric, e g of continuous glass fiber filaments, thermally fused to the surface of a net base fabric. The yarns of the net base fabric may be formed by slitting and stretch-orienting a film.

[0007] JP 2004154078 A discloses a greenhouse formed by laminating a thermoplastic film on one or both surfaces of a clothlike material. The clothlike material consists of thermoplastic resin wire elements.

[0008] JP 2004160812 A discloses a moisture permeable sheet having water barrier properties and used as an agricultural cover material. The sheet comprises a moisture permeable film laminated on a cloth-like material and a porous sheet.

[0009] The aim of protected cultivation in greenhouses is to modify the natural environment to increase yield, to improve product quality, to conserve resources, to extend production areas and crop cycles among others. However, the current trend in horticulture is to be more energy efficient by minimizing energy use in all stages while maximizing production yield. This means that the growers tend to insulate the greenhouse as much as possible during the cold winter months to decrease the amount of energy used to heat the greenhouse, but without negatively affecting the production or quality of the crop. The insulation is normally achieved by using one to several layers of greenhouse screens. To maximize energy savings, the top layer of the upper-most screen should have low emissivity, i.e. low ability to emit energy by radiation. This is normally achieved by using aluminum laminate strips knitted into the structure. However, today's state of the art screens also often have part of the yarn framework covering the top layer aluminum, deceasing the energy saving since the yarns are made of plastic materials with high emissivity. Hence, it would be advantageous to have a screen in which the amount of yarn, especially amount of yarn facing upward, is minimized, thereby minimizing the radiation losses.

[0010] The lower-most screen in a multilayer installation is usually a transparent screen. For many crops, the rule of thumb is, 1% less light equals 1% less production. This means that light transmission losses in such a screen should be minimized to increase production when the screen is used during daytime. This can be achieved by choosing materials which maximize the light transmission of the screen. The yarn framework usually prevents a significant amount of light from being transmitted through the screen. Hence, a significant improvement of today's state of the art screen is possible if the amount of yarn used to construct the screen could be decreased without losing out on other important properties of the screen such as robustness, water transmission etc.

[0011] The water vapor transmission is a very important property of the screen since this is a significant factor controlling the humidity level in the greenhouse. The water vapor transmission is mainly controlled by the width of the strips and the type of yarn used. The yarn should therefore have liquid-transporting capacity by capillary action, in order to be able to absorb and distribute condense water along the screen. Normally, the strip should completely fill the voids between the pillar stitches to maximize the energy saving properties of the screen. In some cases, it is an advantage to have a screen that can transmit more water vapor, for example avoiding having to open the screen ("gapping") to lower the humidity level in the greenhouse. This could be achieved by using a narrower strip. However, in the state of the art screen of today it is not possible to make the strip narrower since this may cause problems with strips being pulled out of the structure of the screen by wind etc. when the strip is no longer in contact with the yarn that will hold the strip in place by friction forces.

[0012] The bundle size is an important feature of the screen. A big bundle of a single screen can cause losses of ~3% of natural light, hence to maximize production the screen bundle size should be minimized. The bundle size is controlled by the thickness of the film, and the yarn framework that is used.

[0013] The robustness of the screen is another important feature. The installation of the screen in the greenhouse is often made by unskilled labor. Hence it is vital to make a screen that can withstand rough handling during installation and use without compromising the excellent properties needed to achieve the right climate for the plant, such as high light transmission, high reflection, low emission, air tightness etc.

SUMMARY OF THE INVENTION

[0014] The invention refers to a greenhouse screen as disclosed in claim 1, aiming to solve the above problems.

[0015] The greenhouse screen may have a capillary rise of tap water as measured according to ISO9073-6:20 of at least 10 mm after 10 seconds both in longitudinal and in transverse direction of the screen.

[0016] The film material may be a multilayer film comprising at least two layers, wherein at least one top layer is a thermoplastic polymer top layer having a softening point of between 5-200°C lower than another layer of the multilayer film.

[0017] The thermoplastic polymer top layer may have a softening temperature of between 7-185°C, preferably between 10-175°C lower than the another layer of the multilayer film.

[0018] The thermoplastic polymer top layer may be chosen from polymer materials of the group consisting of polyethylene and copolymers thereof, polypropylene and copolymers thereof, polyesters and co-polyesters, and acrylics.

[0019] The strips may comprise a reflective metal foil layer laminated to the multilayer film.

[0020] The strips of film material may be bonded to the yarn framework with a peel strength of at least 1mN/mm, preferably 10mN/mm, and most preferably with a peel strength of at least 30mN/mm.

[0021] The threads making up the yarn framework may comprise at least two different components, wherein at least one component may be a thermoplastic polymer yarn component having a softening temperature of between 5-200°C lower than the other component, and in that the yarn framework may be thermally bonded to at least one side of the strips of film material.

[0022] The thermoplastic polymer yarn component may have a softening temperature of between 7-185°C, preferably of between 10-175°C lower than the other yarn component.

[0023] The thermoplastic polymer yarn component may be chosen from polymer materials of the group consisting of polyethylene or copolymers thereof, polypropylenes or copolymers thereof, polyamides, polyesters or copolymers thereof.

[0024] The thermoplastic polymer yarn component may be incorporated into the yarn framework by intertwining one or more fibers together, wherein at least one of the fibers may comprise said thermoplastic polymer yarn component.

[0025] The thermoplastic polymer yarn component may form a coat covering a fiber core material, said fiber core material may have a higher melting temperature than the thermoplastic polymer yarn component.

[0026] The thermoplastic polymer yarn component may form a coat covering at least part of the yarn framework.

[0027] Both transverse threads and longitudinal threads may comprise the thermoplastic polymer yarn component.

[0028] Alternatively only the transverse threads may comprise the thermoplastic polymer yarn component

[0029] The yarn framework may be thermally bonded to both sides of the strips of film material.

[0030] Alternatively the yarn framework may be thermally bonded to only one side of the strips of film material.

[0031] One side of the screen may have a higher amount of transverse threads than the opposite side of the screen, so that more than 50 % of the transverse threads of the yarn framework extending in a transverse (x) direction, may be located on said one side of the strips of film material.

[0032] More than 60 %, more than 70 %, more than 80 %, more than 90 % and even 100% of the transverse threads of the yarn framework may be located on said one side of the strips of film material.

[0033] At least 5%, preferably at least 10% of the transverse threads of the yarn framework may be located on said opposite side of the screen

[0034] Said strips of film material may be interconnected by the yarn framework through hosiery, knitting, warp-knitting or weaving.

[0035] The screen may comprise one or more strips of film material that has a width that is smaller than the distance between the warp threads.

[0036] A gap may be formed between said one or more strips and the adjacent strip(s), said gap permitting ventilation through said screen.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] In the following the invention will be described in a non-limiting way and in more detail with reference to exemplary embodiments illustrated in the enclosed drawings, in which:

Figure 1A shows a schematic enlarged view of a part of a first example of a warp-knitted screen.

Figure 1B shows a schematic enlarged view of a part of a second example of warp-knitted screen.

Figure 2 shows a schematic enlarged view of a part of a warp-knitted screen according to a further embodiment of the invention.

Figure 3 shows a schematic enlarged view of a part of a warp-knitted screen according to a still further embodiment of the invention.

Figure 4 illustrates schematically the method for testing peel strength of the bond between the strip and the yarn.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0038] The greenhouse screen of the invention comprises a plurality of narrow strips of film material 11 which are interconnected by a yarn framework 12, 13a, 13b, and are arranged in parallel to each other so as to form essentially a continuous surface. The screen has a longitudinal direction, y, and a transverse direction, x, wherein the strips 11 extend in the longitudinal direction y.

[0039] Fig. 1A shows an example of a mesh pattern for a fabric manufactured through a warp knitting process as described in EP 0 109 951, in which four guide bars are used, one for the strips 11, two for the weft threads 13a and 13b extending transversely to these strips 11 and one for the longitudinally extending warp threads 12.

[0040] The longitudinal warp threads 12 are generally arranged on one side of the screen, the underside, while the transverse weft threads 13a and 13b are located on both sides of the fabric, the upper and the underside. The term "transverse" in this respect is not restricted to a direction perpendicular to the longitudinal direction, but means that the transverse weft threads 13a and 13b extend across the strips 11 as illustrated in the drawings. The connection between the longitudinal warp threads and the transverse weft threads are preferably made on the underside of the fabric. Consequently, the strips 11 can be arranged closely edge to edge without being prevented by the longitudinal warp threads 12.

[0041] The longitudinal warp threads 12 in Fig. 1A extend continuously in unbroken fashion along opposite edges of adjacent strips, in a series of knitted stitches, in a so called open pillar stitch formation.

[0042] The transverse weft threads 13a and 13b pass above and below the strips, respectively, i.e. opposed to each other, to fixedly trap the strips. Each knitted stitch in the longitudinal warp threads 12 has two such transverse threads 13a and 13b engaging with it.

[0043] Fig. 1B shows another example of a mesh pattern for a fabric similar to the one in Fig. 1A. The difference is that the transverse weft threads 13a and 13b in an alternating way pass over one and two strips 11.

[0044] In both mesh patterns shown in figures 1A and 1B, and known in prior art, the amount of transverse weft threads13a and 13b passing above and below the strips, respectively, are equal. The weft threads 13a and 13b connect to the longitudinally extending warp threads 12 between, or below the strips, thereby trapping the strips 11 in the yarn framework. Consequently in the examples described in figures 1A and 1B, each strip 11 has the same number of transverse weft threads crossing its top side as its underside, thereby fixing each strip tightly in the yarn framework.

[0045] It is also known through EP 0 109 951 to submit the fabric to "thermo-setting", wherein a heat-shrinkable material is used in the weft threads and the fabric after manufacture is passed through a heat zone of about 150°C under tension. The yarn framework will then heat-shrink resulting in a strengthening of the fixation of the strips. No thermal bonding between the yarn framework and the strips however occurs during such thermo-setting according to prior art.

[0046] According to the present invention the yarn framework is thermally bonded to the strips of film material. Thermal bonding is accomplished by the application of heat and possibly also pressure. Thermal bonding may be accomplished by different methods known in the art, such as hot calendaring, through-air bonding, ultrasonic bonding, radiant heat bonding etc. Thermal bonding means that at least a part of the material in the film strips and/or the yarn framework melts or softens and will bond to other parts of the fabric (yarn framework and/or film strips) at contact points.

[0047] Through the thermal bonding of the yarn framework to the film strips the amount of threads in the yarn framework can be reduced, without the risk of the strips leaving the yarn framework. It is of special advantage to reduce the amount of threads covering the side of the strips facing upwards, in order to minimize radiation losses due to the high emissivity of the yarn. Thus for strips having a surface with a low emissivity the yarns on the upper side of the strips will deteriorate the emission properties. For strips that are transparent, the yarn will reduce the light transmission. An overall reduction of the amount of yarn will improve the light transmission of the screen.

[0048] The peel strength between the yarn framework and the film strips may be at least 1 mN/mm. The peel strength is measured by the method described below.

[0049] The strips 11 of film material of the invention may comprise any kind of film material that gives the greenhouse screen desirable properties for use in a greenhouse. Such film materials are known to the person skilled in the art. For example by using a film material transparent to sunlight, but not transparent to heat radiation, it is possible to obtain an energy screen that can be used both during the night and during cold days. Strips which are not transparent to sunlight, such as metalized plastic strips reflecting the sunlight, and having low emissivity to heat may provide greater shading effect and may provide better insulation compared to the above.

[0050] Furthermore, the strips of the invention can include a reflective metal foil layer, such as an aluminum foil, which is laminated to a multilayer film with at least two layers wherein at least one top layer is a thermoplastic polymer tip layer having a softening point of between 5-200°C lower than another layer of the multilayer film. At least one of the top layers should be able to bond to the yarn system, the other top layer can either be bonded directly to the aluminum foil or bonded with an adhesive to the aluminum foil according to standard methods known by people skilled in the art. The aluminum foil may have additional coatings or be laminated to other films.

[0051] Furthermore, strips comprising a material which is low emitting for heat radiation can be used for heat insulation at night. The emissivity of a material is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature. It is a measure of a material's ability to radiate absorbed energy. Examples of strips that are low emitting for all radiation could be foil strips, e.g. a low emitting metal foil, preferably an aluminum foil, or plastic film strips laminated with aluminum foil strips.

[0052] Furthermore the invention also encompasses strips of film material that comprises flame-retardant materials or additives, UV-stabilizers, light-reflecting pigments, dark colored pigments, or metal powder, processing aids, fillers, anti-static additives, antifogging additives, infrared absorbers, anti-block additives.

[0053] A typical width of the strips is between 2 mm and 10 mm, but they can also be wider. The person skilled in the art also realizes that the greenhouse screen of the invention may be composed of a mixture of one or more types of strips of film material described above, in one and the same screen. Furthermore, greenhouse screen of the invention may also contain strips of varying widths, the advantage of which will be discussed below.

[0054] In one embodiment of the invention at least some of the strips of film material are of a multilayer film material comprising at least two layers; at least one base layer or internal layer, and at least one top or skin layer. The base layer may be a single layer or a multilayer material. The base layer may comprise any kind of film material as described above. The top layer is preferably the layer located closest to the surface on one side, or on both sides of the multilayered film strip, and is comprised of a thermoplastic polymer material, capable of forming a heat seal bond to itself or to the yarn system. The thermoplastic polymer material of the top layer softens to a sufficient extent that its viscosity becomes low enough to allow adequate wetting for it to adhere to the surface to which it is being bonded to. The bond is accomplished by applying heat to soften the top layer, and preferably by simultaneously applying pressure, without melting the other layers, i.e. the base layer in the film or the yarns in the yarn framework. Thus the top layer should begin to soften at a temperature such that the bond can be formed at a temperature which is lower than the melting temperature of the polymeric material of the base layer.

[0055] In one embodiment, the top layer should begin to soften at a temperature which is between 5-200°C, preferably between 7-185°C, more preferably between 10-175°C below the melting point of the base layer (or the melting point of the layer with the lowest melting point in the base layer).

[0056] The choice of thermoplastic polymer of the top layer is thus dependent on the composition of the base layer. Examples of materials used for forming the film strips, i.e. the base layer, are without being limiting, aluminum, polyesters, polyethylenes (PE), ethylene vinyl acetate (EVA), polypropylenes (PP), polyvinyl chloride (PVC), polyvinylidene fluoride (PVDF), ethylene tetrafluoroethylene (ETFE), polyvinylidene chloride (PVDC), polyacrylics, polyamides (PA), ionomers, poly(lactic acid) or polylactide (PLA), polyvinylalcohol. The thermoplastic polymer material used in forming the top layer may be chosen from polymers that are able to create a peel strength of at least 1 mN/mm to itself or to the yarn system at a temperature of 80°C-220°C. Examples, of such materials are polyethylene and copolymers thereof, such as EVA; polypropylene and copolymers thereof, polyesters and co-polyesters, polyamides and co-polyamides, acrylics.

[0057] At least 50%, preferably at least 75% of the strips should in this embodiment be of a multilayer film material, comprising a base layer and at least one top layer. In one embodiment all strips are of the multilayer film material.

[0058] A typical thickness of the film strips is between 5.5 and 300µm. A suitable thickness of the top layer is between 0.5 and 50 µm, more preferably between 0.5 and 20 µm, most preferably between 0.5 and 5 µm. A suitable thickness of the base layer is between 5 and 300 µm, more preferably between 10 and 100 µm, most preferably between 10 and 70 µm.

[0059] The strips of film material, such as those described above, are interconnected by a yarn framework to form a continuous product. The yarn framework generally comprises warp threads 12 forming loops or stitches and primarily extending in the longitudinal direction, y of the screen. The warp threads 12 are connected to one another by one or more weft threads 13a and 13 b extending generally in the transverse, x direction of the continuous product.

[0060] The threads used in the yarn framework may be made from materials normally used in greenhouse screens, and which are well known to the person skilled in the art. The threads of the yarn framework may for example be made from textile materials, polymer materials such as polyesters, polyethylenes, polypropylenes, aramids, para-aramids, acrylics, modacrylics, polyamides or a mix of two or more of these materials. The threads may also be made from elastic or stretchable material. The threads of the yarn framework should have liquid-transporting capacity by capillary action, usually by being formed fro a plurality of fibers or continuous filaments that are intertwined, wherein liquid may be drawn up between the individual fibers or filaments as a result of inter-molecular attractive forces between the liquid and the fiber/filament surfaces.

[0061] Capillary action, or capillarity, is defined as the ability of a liquid to flow in narrow spaces without the assistance of and in opposition to external forces like gravity.

[0062] Furthermore, the threads may comprise flame-retardant additives, UV-stabilizers, light-reflecting pigments, dark colored pigments, or metal powder, processing aids, fillers, anti-static additives, infrared (ir)-absorbers, anti-block additives.

[0063] The invention also encompasses yarn frameworks wherein the longitudinal warp threads and transverse weft threads are not both made from the same material.

[0064] In one embodiment of the invention the threads making up the yarn framework comprise at least two different components, wherein at least one component is a thermoplastic polymer yarn component capable of forming a heat seal bond to itself, to the other components making up the yarn framework, or to the strips of film material. The thermoplastic polymer yarn component softens to a sufficient extent that its viscosity becomes low enough to allow adequate wetting for it to adhere to the surface to which it is being bonded. The bond is accomplished by heating the thermoplastic polymer yarn component, and preferably by applying pressure simultaneously, without melting the other components making up the yarn system, or melting the material in the film strip. Thus the thermoplastic polymer yarn component should begin to soften at a temperature such that the bond can be formed at a temperature which is less than the melting temperature of the materials of the other yarn components making up the yarn framework.

[0065] In one embodiment, the thermoplastic polymer yarn component has a softening temperature which is between 5-200°C, preferably between 7-185°C, and most preferably between 10-175°C below the melting point of the other yarn components making up the yarn framework (or the melting point of the component of the yarn framework or the strips with the lowest melting point).

[0066] Examples of thermoplastic polymer yarn components may be polyethylenes or copolymers thereof (such as ethylene vinyl acetates (EVA)), polypropylenes or copolymers thereof, polyamides, polyesters or copolymers thereof, among others. The thermoplastic polymer yarn component may be incorporated into the yarn by intertwining one or more fibers together, to form one thread (i.e. a weft thread or a warp thread) wherein at least one of the fibers comprises said thermoplastic polymer yarn component.

[0067] One example of a multifilament hybrid yarn of this kind can be found in US 5,618,624.

[0068] The fibers of the yarn in the yarn framework may also be bicomponent or mulitcomponent. The bi- or multicomponent fibers can be of the sheath/core type consisting of a low melting temperature sheath (i.e. a thermoplastic polymer yarn component as described above) and a higher melting temperature core. In this type of fibers the thermoplastic polymer yarn component forms a coat covering the fiber core material that has a higher melting temperature than the coating thermoplastic polymer yarn component. Common sheath/core combinations include PE/PP, PE/ (polyethylene terephtalate) PET, Co-PET/PET, PP/PET, PA-6/PET, PVA/PP etc. The multicomponent fibers can be used in 100% form as well as in blends with homopolymer fibers to create a suitable yarn. Other multicomponent fiber configurations are also possible such as for example side-by-side, segmented pie, islands in the sea etc, all of which are known to the person skilled in the art.

[0069] Furthermore, any of the threads comprised in the yarn network may comprise fibers with the thermoplastic yarn component, i.e. the transverse weft threads, the longitudinal warp threads or both. However, in a preferred embodiment of the invention the transverse weft threads (13a, and/or 13b) comprise fibers with a thermoplastic polymer yarn component having a softening point as described above, below the softening points of the other components.

[0070] In the case where the yarn framework comprises components having different melting points, as referred to above, the film strips may be of any optional kind, and may or may not, be of the multi-layer kind having a top layer with a lower melting point than the base layer.

[0071] The strips of film material are interconnected to each other and the yarn framework through hosiery, knitting, warp-knitting or weaving known in the art. Since according to the present invention the strips and the yarn are thermally bonded together it is possible to minimize the amount of yarn covering the upper side of the strips, e.g. aluminum layer, without having a negative effect on other important properties of the screen. The light transmission may also be significantly increased for screens with transparent strips if the yarn covering the top layer is minimized.

[0072] In one embodiment of the greenhouse screen of the invention one side of the screen has a higher amount of weft threads than the opposite side of the screen, which means that more than 50 % of the transverse weft threads of the yarn framework pass on said one side of the strips 11 of film material, preferably on the underside of the strips 11. More than 60%, more than 70 %, more than 80 % and even more than 90 % of the transverse weft threads may pass on the underside of the strips 11, during the knitting process. It is also possible that all weft threads of the yarn framework are located on only one side of the strips of film material. This may be accomplished by omitting one or more of the weft threads, e.g. 13a, passing on the upper side of the strips.

[0073] For example at least 10 % of the transverse weft threads that normally would pass on the upper side of the strips 11 may be omitted in the yarn framework. In further embodiments more than 20%, more than 40 %, more than 60 % and even more than 80 % of the transverse weft threads that normally would pass on the upper side of the strips 11 during the knitting process may be omitted from the yarn framework. In a still further embodiment no weft threads pass on the upper side of the strips 11 during the knitting process. Thus in this embodiment all transverse weft threads are located on only one side of the strips.

[0074] Figure 3 shows an embodiment of the invention wherein about 70% of the transversally extending weft threads pass on only one side of the film strips.

[0075] In some cases it may be advantageous that there are transversely extending weft threads on both sides of the film strips, wherein at least 5%, preferably at least 10% of the weft threads should pass on the side of the film strips having the lowest amount of weft threads.

[0076] The strips of film material are fixed to the yarn framework by either one or a combination of two methods. The yarn framework may be bonded to the top polymer layer located at one or both surfaces of the strips 11 of film material, through the application of temperature and possibly also pressure, forming a thermal bond with a peel strength of at least 1 mN/mm, preferably with a peel strength of at least 10mN/mm, more preferably with a peel strength of at least 30mN/mm. The strips 11 of film material may also be adhered to the thermoplastic polymer yarn component comprised in the threads of the yarn framework, through the application of temperature and possibly also pressure, forming a thermal bond with a peel strength of at least 1 mN/mm, preferably with a peel strength of at least 10mN/mm, more preferably with a peel strength of at least 30mN/mm.

[0077] The water vapor transmission which is an important property of the screen is mainly controlled by the width of the strips and the type of yarn used. Normally, the strips should completely fill the voids in between the pillar stitches to maximize the energy saving properties of the screen. However, occasionally it is an advantage to have a screen that can transmit more water vapor to lower the humidity level in the greenhouse. This may be achieved by using a narrower strip that does not completely fill out the void between the pillar stitches (warp threads). However, in greenhouse screens wherein the strips of film material are interconnected solely by conventional stitching this may cause problems with strips being pulled out of the structure of the screen by wind etc. when the strip is no longer in contact with the yarn that will hold the strip in place by friction forces.

[0078] In the present invention, this problem is solved by fixing the strip to the yarn by thermal bonding instead of relying on friction, avoiding the above mentioned negative consequences. This makes it possible to create a screen wherein the strips of film material have different widths, thereby forming gaps in the continuous surface to suit the specific vapor transmitting requirements. Gaps are formed because the edges of the strips of film material with a smaller width are not in contact with the adjacent strips. The distance between the longitudinal warp threads, i.e. the pillar stitches, at either side of the strips are usually the same. Strips with smaller width are held firmly in place by thermal bonding to the weft threads.

[0079] Included in the invention are embodiments wherein at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or even 100% of the strips have a smaller width than the distance between the warp threads. Said strips may have a width that is at least 10%, preferably at least 20% smaller than the width between the warp threads.

[0080] A greenhouse screen comprising strips of different widths is illustrated in Fig. 3.

[0081] The greenhouse screen of the invention may be manufactured as follows: strips of film material are interconnected to each other by a yarn framework through hosiery, knitting, warp-knitting or weaving known in the art. During the knitting/weaving process one or more of the transverse weft threads that normally pass on the upper side of the strips 11, during the knitting process may be omitted from the yarn framework, having the result that more than 50 % or more than 60% or more than 70 % or more than 80 % or more than 90 % or even 100% of the transverse weft threads of the yarn framework pass only on one side of the strips 11 of film material, preferably on the underside of the strips 11.

[0082] Thereafter the strips of film material are fixed to the yarn framework by exposing the screen to a temperature exceeding the softening point temperature of thermoplastic polymer top layer of the strips of film material and/or of the thermoplastic polymer yarn component comprised in the threads. Through the application of such a temperature the polymer layer or composition softens and connects the yarn framework to the strips of film material. Pressure may also be applied to strengthen the thermal bond between the strips and the yarn framework.

[0083] The other layer, the base layer, of the film and/or the other component of the threads are substantially unaffected by this thermal bonding, so that the structural integrity of the strips and/or the yarn framework is maintained.

[0084] The yarn framework should maintain at least a substantial part of its water-transporting capacity by capillary action also in those areas that are thermally bonded to the strips. This means that the yarn should not be completely melted by the thermal bonding, to keep the capillaries in the yarn open for water transport.

[0085] The capillary action, or also called the liquid wicking rate, may be tested according to ISO9073-6:2000. The greenhouse screen according to the invention should have a capillary rise of at least 10 mm after 10 seconds in both longitudinal (warp) direction and transverse (weft) direction. In one embodiment the greenhouse screen has a capillary rise of at least 20 mm after 10 seconds in both longitudinal (warp) direction and transverse (weft) direction.

[0086] This invention gives a significant improvement compared to the state of the art screens, since significantly less yarn can be used in the screen due to the fact that the strips and the yarns are thermally bonded together and hence less yarn is needed to fix the strip in its position. This makes it possible to make a screen with higher energy savings, because less yarn is covering the low emitting side of the strips in the screen, decreasing the emissivity of the screen. Similarly, less yarn is covering the transparent strips increasing the light transmission. Moreover, less yarn will further reduce the bundle size of the screen. In addition, the thermal bonding between the strip and the yarn further makes the screen stronger and it can withstand rougher handling before it gets deformed.

METHOD FOR TESTING PEEL STRENGTH

[0087] The peel strength between the strips and the yarn is tested according to ISO11339:2010. In this test the peel strength between the plastic strip and the yarn can be tested only on one side at a time. Accordingly, all peel strength values in this text and in the claims refer to the peel strength between one side of one strip and the yarn. The minimum values given for the peel strength should apply for any side of the strip with respect to the yarn. Of course the total peel strength can be higher if the peel strengths on the two sides of the strip are summed.

[0088] The samples are prepared by cutting a sample according to the standard. The test is performed with respect to the peel strength between one strip and the yarn framework on one side of the strip. Any yarn crossing the strip on the opposite side of the strip to the tested side has to be cut loose to prevent erroneous values in the test. If the amount of yarn in the yarn framework on the opposite sides of the strip is different the test should be performed on both sides of the strip.

[0089] The crosshead separation rate is 100mm/min.

[0090] Bonding has occurred if the average peel force to remove the strip from the yarn framework on any side of the strip is at least 1 mN/mm, i.e. the peel force should be at least 1 mN/mm. Preferably the peel force should be at least 10mN/mm, and more preferably at least 30mN/mm.

METHOD FOR TESTING CAPILLARY ACTION (Liquid wicking rate)

[0091] The capillary action of the screen is tested according to ISO9073-6:2000. The liquid was tap water coloured by Foron Blue RD-GLF supplied by Sandoz AG, Basel, Switzerland. The height of the capillary rise of the liquid was recorded after 10s, and after 30s. The samples were tested both in warp (longitudinal) and weft (transverse) direction. The mean value of five measurements was taken.

EXAMPLE 1

[0092] One example of a greenhouse screen according to the invention is a woven or knitted screen comprising plastic strips of Hostaphan RPSM from Mitsubishi Polyester Film Gmbh, Wiesbaden, Germany, which is commercially available. The film has a thickness of 25µm.The film is a multilayer polyester film comprising an outer layer with a thermoplastic polymer material, capable of forming a thermal bond to the yarn framework. The layer thicknesses are within the ranges described in this application.

[0093] A warp-knitted screen was produced with strips of this film connected by a flat polyester yarn framework comprising longitudinal warp threads and transverse weft threads as illustrated in Fig. 1. The weft treads cross the strip 6 times on each side per 10mm of the length of the strip. The strips are arranged closely edge to edge. The screen was subsequently exposed to 120°C and a pressure when the screen is rapped around a roller with diameter of 150mm and pulled with a force of 20kg.

[0094] An average peel force of 3,8 mN/mm width over a 100 mm distance is needed to break the bond between the yarn and the 4 mm wide strip (ISO11339:2010) on the side of the strip capable of forming a thermal bond. No bonding could be measured for the opposite side of the strip (<1mN/mm).

[0095] The capillary rise of tap water was measured according to ISO9073-6:2000. In the warp direction the capillary rise after 10s was 28 mm (standard deviation 2 mm) and after 30s 37 mm (standard deviation 2 mm). In the weft direction the capillary rise after 10s was 34 mm (standard deviation 2 mm) and after 30s 41 mm (standard deviation 3 mm).

EXAMPLE 2

[0096] One example of a greenhouse screen according to the invention is a woven or knitted screen comprising plastic strips of Hostaphan RPSM from Mitsubishi Polyester Film Gmbh, Wiesbaden, Germany, which is commercially available. The film has a thickness of 25µm. The film is a multilayer polyester film comprising an outer layer with a thermoplastic polymer material, capable of forming a thermal bond to the yarn framework. The layer thicknesses are within the ranges described in this application.

[0097] A warp-knitted screen was produced with strips of this film connected by a flat polyester yarn framework comprising longitudinal warp threads and transverse weft threads as illustrated in Fig. 1. The weft treads cross the strip 6 times on each side per 10mm of the length of the strip. The 4mm strips are arranged closely edge to edge. The screen was subsequently exposed to 185°C and a pressure of 60g/cm2.

[0098] An average peeling force of 32 mN/mm width over a 100mm distance is needed to break the bond between the yarn and the 4mm wide strip (ISO11339:2010) on the side of the strip capable of forming a thermal bond. No bonding could be measured for the opposite side of the strip (<1mN/mm).

[0099] The capillary rise of tap water was measured according to ISO9073-6:2000. In the warp direction the capillary rise after 10s was 24 mm (standard deviation 3 mm) and after 30s 31 mm (standard deviation 3 mm). In the weft direction the capillary rise after 10s was 32 mm (standard deviation 2 mm) and after 30s 38 mm (standard deviation 2 mm).

EXAMPLE 3

[0100] One example of a greenhouse screen according to the invention is a woven or knitted screen comprising plastic strips of Hostaphan RPSM from Mitsubishi Polyester Film Gmbh, Wiesbaden, Germany, which is commercially available. The film has a thickness of 25µm. The film is a multilayer polyester film comprising an outer layer with a thermoplastic polymer material, capable of forming a thermal bond to the yarn framework. The layer thicknesses are within the ranges described in this application.

[0101] A warp-knitted screen was produced with strips of this film connected by a yarn framework comprising longitudinal warp threads and transverse weft threads as illustrated in Fig. 1. The weft treads cross the strip 6 times on each side per 10mm of the length of the strip. The warp threads consist of a flat polyester yarn. The weft yarn on the side of the strip with the thermoplastic polymer material capable of forming a thermal bond to the yarn framework consists of an air texturized yarn consisting of three flat polyester yarns, and a low melt yarn on one side of the strip. The weft yarn on the opposite side of the strip to the side with the thermoplastic polymer material capable of forming a thermal bond to the yarn framework consists of a flat polyester yarn. The 4mm strips are arranged closely edge to edge. The screen was subsequently exposed to 185°C and a pressure of 60g/cm2.

[0102] An average peeling force of 41 mN/mm width over a 100mm distance is needed to break the bond between the yarn and the 4mm wide strip (ISO11339:201 on the side of the strip capable of forming a thermal bond. No bonding could be measured for the opposite side of the strip (<1 mN/mm).

[0103] The capillary rise of tap water was measured according to ISO9073-6:200 In the warp direction the capillary rise after 10s was 25 mm (standard deviation 2 mm) and after 30s 29 mm (standard deviation 4 mm). In the weft direction the capillary rise after 10s was 37 mm (standard deviation 2 mm) and after 30s 50 mm (standard deviation 2 mm).

EXAMPLE 4

[0104] One example of a greenhouse screen according to the invention is a woven or knitted screen comprising plastic strips of standard packaging polyester film. The film has a thickness of 19µm.

[0105] A warp-knitted screen was produced with strips of this film connected by a yarn framework comprising longitudinal warp threads and transverse weft threads as illustrated in Fig. 1. The weft treads cross the strip 6 times on each side per 10mm of the length of the strip. The warp threads consist of a flat polyester yarn. The weft yarn on the side of the strip with the thermoplastic polymer material capable of forming a thermal bond to the yarn framework consists of an air texturized yarn consisting of three flat polyester yarns, and a low melt yarn on one side of the strip. The weft yarn on the opposite side of the strip to the side with the thermoplastic polymer material capable of forming a thermal bond to the yarn framework consists of a flat polyester yarn. The 4mm strips are arranged closely edge to edge. The screen was subsequently exposed to 185°C and a pressure of 60g/cm2.

[0106] An average peeling force of 71 mN/mm width over a 100mm distance is needed to break the bond between the yarn and the 4mm wide strip (ISO11339:2010) on the side of the strip capable of forming a thermal bond. No bonding could be measured for the opposite side of the strip (<1 mN/mm).

[0107] The capillary rise of tap water was measured according to ISO9073-6:2000. In the warp direction the capillary rise after 10s was 29 mm (standard deviation 3 mm) and after 30s 34 mm (standard deviation 1 mm). In the weft direction the capillary rise after 10s was 44 mm (standard deviation 1 mm) and after 30s 54 mm (standard deviation 2 mm).

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP0109951A **[0002] [0039] [0045]**
- FR2071064 **[0002]**
- EP1342824A **[0002]**
- WO2008091192A **[0002]**
- WO2011096882A **[0002]**
- DE202008004181U1 **[0004]**
- US2004198126A **[0005]**
- JP10327684A **[0006]**
- JP2004154078A **[0007]**
- JP2004160812A **[0008]**
- US5618624A **[0067]**

Patentkrav

1. Drivhusskærm omfattende strimler (11) af filmmateriale, hvilke strimler strækker sig i en langsgående retning (y) af skærmen og er indbyrdes forbundet af en garnramme af tværgående tråde (13a, 13b) og langsgående tråde (12) for at danne et kontinuerligt produkt, hvor garnrammen har kapacitet til væsketransport ved kapillærvirkning, **kendetegnet ved at** garnrammen er termisk bundet til mindst en side af strimlerne (11) af filmmateriale, således at mindst en del af materialet i filmstrimlerne og/eller garnrammen er blevet smeltet eller blødgjort og binder til andre dele af stoffet (garnramme og/eller filmstrimler) ved kontaktpunkter, hvor også disse dele af garnrammen som er termisk bundet til strimlerne har kapacitet til væsketransport ved kapillærvirkning.

2. Drivhusskærm ifølge krav 1, **kendetegnet ved at** drivhusskærmen har en kapillarstigning af ledningsvand som målt ifølge ISO9073-6:2000 på mindst 10 mm efter 10 sekunder både i langsgående og i tværgående retning af skærmen.

3. Drivhusskærm ifølge krav 1 eller 2, **kendetegnet ved at** filmmaterialet er en flerlagsfilm omfattende mindst to lag, hvor mindst et toplag er et termoplastisk polymertoplag med et blødgøringspunkt på mellem 5-200°C lavere end et andet lag af flerlagsfilmen.

4. Drivhusskærm ifølge krav 3, **kendetegnet ved at** det termoplastiske polymertoplag har en blødgøringstemperatur på mellem 7-185°C, fortrinsvis mellem 10-175°C lavere end det andet lag af flerlagsfilmen.

5. Drivhusskærm ifølge krav 3 eller 4, **kendetegnet ved at** det termoplastiske polymertoplag er valgt fra polymermaterialer af gruppen bestående af polyethylen og copolymerer deraf, polypropylen og copolymerer deraf, polyestere og co-polyestere, polyamider og co-polyamider, akryler.

6. Drivhusskærm ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** strimlerne omfatter et reflekterende metalfolielag lamineret til flerlagsfilmen.

7. Drivhusskærm ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** strimlerne (11) af filmmateriale er bundet til garnrammen med en peelstyrke ifølge ISO 11339:2010 på mindst 1mN/mm, fortrinsvis 10mN/mm, og mere fortrinsvis mindst 30mN/mm.

8. Drivhusskærm ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** trådene som udgør garnrammen omfatter mindst to forskellige komponenter, hvor mindst en komponent er en termoplastisk polymergarnkomponent med en blødgøringstemperatur på mellem 5-200°C lavere end den anden komponent, og **ved at** garnrammen er termisk bundet til mindst en side af strimlerne (11) af filmmateriale.

9. Drivhusskærm ifølge krav 8, **kendetegnet ved at** den termoplastiske polymergarnkomponent har en blødgøringstemperatur på mellem 7-185°C, fortrinsvis på mellem 10-175°C lavere end den anden garnkomponent.

10. Drivhusskærm ifølge krav 8 eller 9, **kendetegnet ved at** den termoplastiske polymergarnkomponent er valgt fra polymermaterialer af gruppen bestående af polyethylener eller copolymerer deraf, polypropylener eller copolymerer deraf, polyamider, polyestere eller copolymerer deraf.

11. Drivhusskærm ifølge et hvilket som helst af kravene 8-10, **kendetegnet ved at** den termoplastiske polymergarnkomponent er inkorporeret i garnrammen ved at sammenflette en eller flere fibre sammen, hvor mindst en af fibrene omfatter den termoplastiske polymergarnkomponent.

12. Drivhusskærm ifølge et hvilket som helst af kravene 8-10, **kendetegnet ved at** den termoplastiske polymergarnkomponent danner en coating som dækker et fiberkernemateriale, hvilket fiberkernemateriale har en højere smeltetemperatur end den termoplastiske polymergarnkomponent.

13. Drivhusskærm ifølge et hvilket som helst af kravene 8-12, **kendetegnet ved at** den termoplastiske polymergarnkomponent danner en coating som dækker mindst en del af garnrammen.

14. Drivhusskærm ifølge et hvilket som helst af kravene 8-13, **kendetegnet ved at** både de tværgående tråde (13a, 13b) og de langsgående tråde (12) omfatter den termoplastiske polymergarnkomponent.

15. Drivhusskærm ifølge et hvilket som helst af kravene 8-14, **kendetegnet ved at** kun de tværgående tråde (13a, 13b) omfatter den termoplastiske polymergarnkomponent

16. Drivhusskærm ifølge et hvilket som helst af kravene 1-15, **kendetegnet ved at** garnrammen er termisk bundet til begge sider af strimlerne af filmmateriale.

17. Drivhusskærm ifølge et hvilket som helst af kravene 1-15, **kendetegnet ved at** garnrammen er termisk bundet til kun en side af strimlerne af filmmateriale.

18. Drivhusskærm ifølge et hvilket som helst af kravene 1-17, **kendetegnet ved at** en side af skærmen har en højere mængde af tværgående tråde (13a, 13b) end den modsatte side af skærmen, således at mere end 50 % af de tværgående tråde af garnrammen er placeret på den ene side af strimlerne (11) af filmmateriale.

19. Drivhusskærm ifølge krav 18, **kendetegnet ved at** mere end 60 %, fortrinsvis mere end 70 %, mere fortrinsvis mere end 80 % og mest fortrinsvis mere end 90 % af de tværgående tråde af garnrammen er placeret på den ene side af strimlerne (11) af filmmateriale.

20. Drivhusskærm ifølge krav 18 eller 19, **kendetegnet ved at** mindst 5%, fortrinsvis mindst 10% af de tværgående tråde af garnrammen er placeret på den modsatte side af skærmen.

21. Drivhusskærm ifølge krav 18, **kendetegnet ved at** alle tværgående tråde af garnrammen er placeret på den ene side af strimlerne (11) af filmmateriale.

22. Drivhusskærm ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** strimlerne af filmmateriale er indbyrdes forbundet af garnrammen via trikotage, strikning, kædestrikning eller vævning.

23. Drivhusskærm ifølge et hvilket som helst af de foregående krav, **kendetegnet ved at** skærmen omfatter en eller mere strimler af filmmateriale som har en bredde som er smaller end afstanden mellem de langsgående tråde.

24. Drivhusskærm ifølge krav 23, **kendetegnet ved at** et mellemrum er dannet mellem den ene eller flere strimler og den/de tilstødende strimler, hvilket mellemrum tillader ventilation igennem skærmen.

DRAWINGS

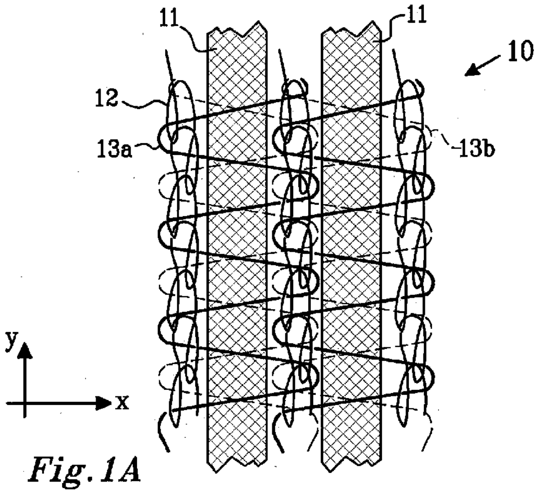


Fig. 1A

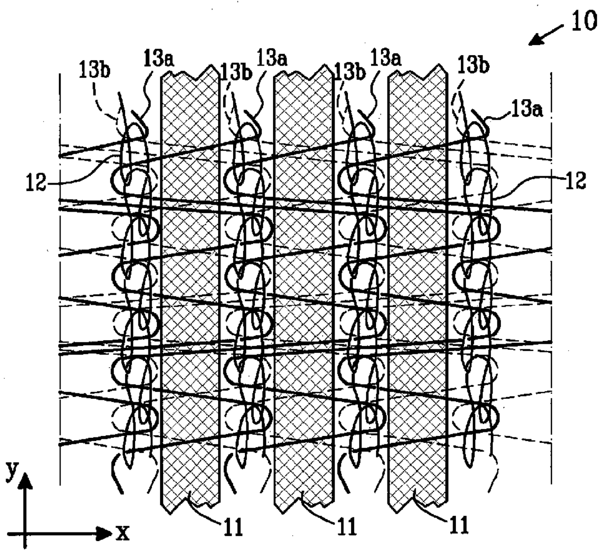
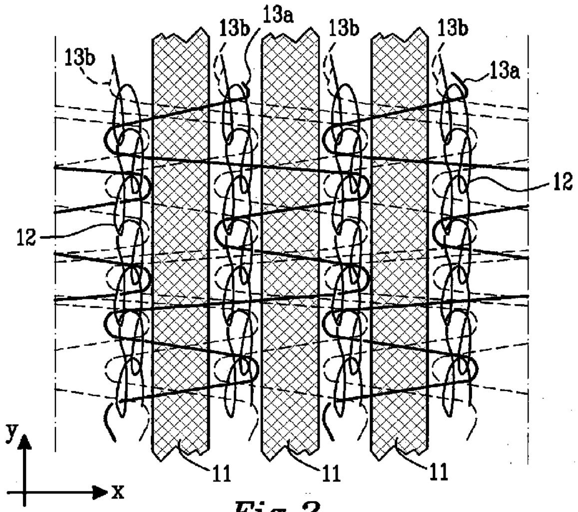


Fig. 1B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13a
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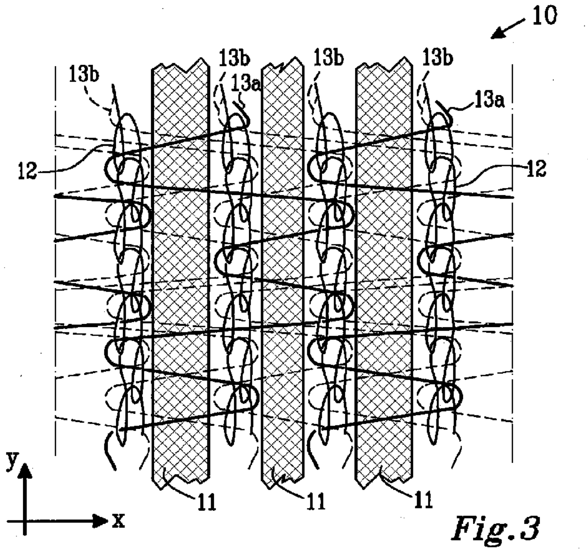
11
11
11
y
x

Fig.2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13a
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11
11
11
y
x

Fig.3

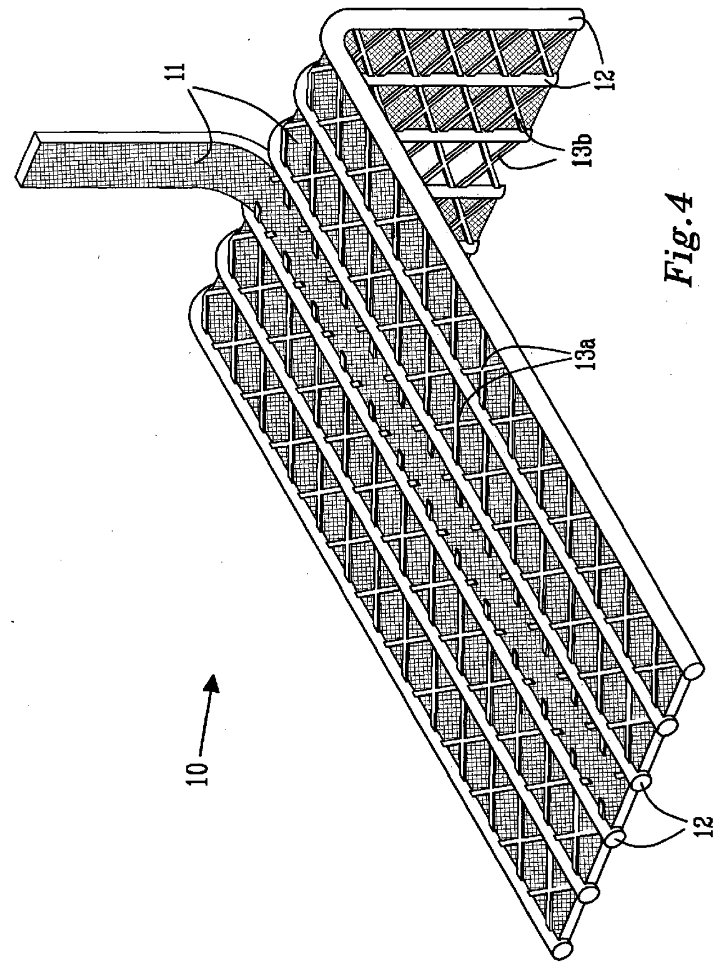

Fig. 4