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(54) A ROLL AND AN ARRANGEMENT FOR MANUFACTURE OF PAPER, BOARD, TISSUE OR THE LIKE

(57) The invention relates to a roll for manufacture of paper, board, tissue or the like. The roll has a first end and a second end, and it comprises a cylindrical roll body with a hollow inner space and an outer mantle surface. The roll further comprises a roll cover comprising at least a base layer arranged on the outer mantle surface of the roll body, and an elastomer layer arranged on the base layer. The elastomer layer forms an outer surface of the roll cover. The first end and the second end of the roll have a protection region, where the base layer is uncovered by the elastomer layer and forms the outer surface of the roll. The invention relates also to an arrangement comprising such roll.

EP 4 015 705 A1

Description

[0001] The present invention relates to a roll and an arrangement for manufacture of paper, board, tissue or the like according to the preambles of the enclosed independent claims.

[0002] Various polymer coated rolls are used in manufacture of fibrous webs, such as paper, board and tissue. For example, press rolls and suction rolls are used in a press section of paper, board or tissue machines for removal of water from the fibrous web by pressing. These rolls usually comprise a hollow roll body and a soft elastomer cover, typically polyurethane, arranged to form the outer surface of the roll body. The elastomer covered rolls are used, for example, as counter rolls for heated drying cylinders, such as Yankee drying cylinders, and their surfaces are often exposed to heat and/or moisture. The rolls have, however, relatively cool roll body surface, i.e. mantle surface, as the roll body is often internally cooled. For example, the sealing elements of the suction rolls are lubricated by water, which is usually unheated circulation water of the mill. The lubrication water simultaneously cools the mantle surface of the roll body and gives rise to a temperature gradient through the roll cover, between the roll body surface and the elastomer cover surface exposed to environmental heat and moisture. The same phenomenon occurs when the roll body is deliberately cooled with water.

[0003] Elastomer covers, however, may show rapid degradation if the temperature and/or moisture content of the environment becomes too high. Especially, when the elastomer cover comes in a direct contact with a heated surface of another cylinder or when the elastomer cover is subjected to a large temperature gradient, there is a risk for cover failure demonstrated by swelling, structural degradation, loss of strength and/or wear resistance of the elastomer cover. In the worst case, even debonding and detaching of the cover as pieces may result. Consequently, there is a need for new solutions for improving the durability of elastomer covered rolls under adverse conditions.

[0004] An object of this invention is to minimise or even totally eliminate the disadvantages existing in the prior art.

[0005] Another object of the present invention is to provide a roll and an arrangement with improved durability, increased reliability, and prolonged operational lifetime, especially in hot and/or moist environment.

[0006] The invention is defined in the characterising parts of the enclosed independent claims. Some preferable embodiments of the invention are defined in the dependent claims. All described features apply for all aspects of the invention, both the roll and the arrangement, whenever applicable, even if it not necessarily always stated so.

[0007] A typical roll according to the present invention for manufacture of paper, board, tissue or the like, has a first end and a second end, and it comprises

- a cylindrical roll body with a hollow inner space and an outer mantle surface,
- a roll cover comprising at least a base layer arranged on the outer mantle surface of the roll body, and an elastomer layer arranged on the base layer, the elastomer layer forming an outer surface of the roll cover,
- optionally a plurality of suction holes extending from the outer surface of the roll to the hollow inner space of the roll body,

wherein the first end and the second end of the roll have a protection region, where the base layer is uncovered by the elastomer layer and forms the outer surface of the roll.

[0008] A typical arrangement according to the present invention for manufacture of paper, board, tissue or the like, comprises

- a heated cylinder, such as a Yankee drying cylinder or the like,
- a roll according to the present invention, arranged to act as a counter roll to the heated cylinder, whereby a nip is formed between the heated cylinder and the roll, and
- a fabric, arranged to run through the nip and having a first fabric edge and a second fabric edge.

[0009] Now it has been surprisingly found that the operating life of an elastomer layer of a roll cover is increased and the risk for cover failure is significantly decreased when the first end and the second end of the roll have a protection region, where the base layer of the roll cover forms the outer surface of the roll. This means that at the protection regions the base layer is uncovered by the elastomer layer, and freely visible. In this manner the direct exposure of the elastomer layer for excess heat and large temperature gradients is minimised and the probability for elastomer layer failure through swelling, degradation, debonding, loss of strength and/or wear resistance is reduced.

[0010] The roll cover comprises at least a base layer and at least one elastomer layer arranged on top of the base layer, preferably in a direct and immediate contact with the base layer. Preferably the base layer is less heat-sensitive than the elastomer layer. The roll cover may further comprise one or more intermediate layers between the base layer and the elastomer layer.

[0011] In the present context the term "protection region" denotes a region of the outer mantel surface of the roll body which is solely covered by the base layer of the roll cover. The base layer thus forms the outer surface the roll or roll cover at the protection region. A protection region is located both at the first end and the second end of the roll. Preferably the protection region is arranged on the area of the outer mantle surface of the roll body that is uncovered by the fabric, i.e. on the area between the roll end and the fabric edge. The protection region may have a width, i.e. length in axial direction of the roll,

seen from the fabric edge, of at least 10 mm, and a possible maximum width, which may extend up to the roll end. The width of the protection region depends on the roll width. The protection region width is preferably large enough to allow slight wandering of the fabric edge. In practice, the position of fabric edge is not stable but it may wander to some extent in cross-machine direction, i.e. with respect to the centreline of the machine/roll due to changing fabric width caused by aging and/or non-uniform stretching of the fabric. Sometimes the fabric may even be deliberately oscillated. In any case, with the help of the present invention, the areas of the roll surface that are exposed to the heat from the heated cylinder, such as Yankee drying cylinder, are covered solely by the base layer, and the risk for elastomer layer failure can be minimised. At the same time, however, the contact area between the base layer and the outer mantel surface of the roll body remains essentially the same as in the corresponding conventional rolls, thus providing similar bonding area between the base layer and outer mantel surface. Thus, the existence of the protective regions does not negatively impact the bonding of the roll cover to the roll body.

[0012] In general, the roll according to present invention is suitable for manufacture of paper, board, tissue or the like. The roll may be, for example, a press roll with a solid unperforated surface or a suction roll with a perforated surface. The roll has a first end and a second end, and the longitudinal axis of the roll extends from the first end to the second. The roll comprises a cylindrical roll body with a hollow inner space, an inner mantel surface and an outer mantle surface. The roll body, and consequently its inner and outer mantel surfaces, are made of metal, such as cast iron, stainless steel, hardened steel, bronze or the like. Typically, the length of roll body may be in the range of 2.5 - 12 m, usually 4 - 8 m.

[0013] The roll may comprise means for feeding, circulating and/or transferring cooling and/or lubricating liquid medium, such as water, located inside the roll body.

[0014] According to one preferable embodiment of the invention the roll is a suction roll. The suction roll comprises a stationary suction box arranged within the hollow space inside the cylindrical roll body, wherein the roll body is arranged to rotate around the suction box. The rotation is provided by a drive means which may be arranged in a functional contact with the roll body. The suction box comprises seals which restrict a suction area in the longitudinal direction inside the hollow space of the roll body, as well as at the ends of the roll body. These seals are usually lubricated by a liquid medium, such as water, in order to reduce the seal wearing and for improving the sealing performance. The suction roll thus comprises means for providing liquid medium between the seal surface and the inner mantle surface of the roll body.

[0015] When the roll is a suction roll, the roll comprises a plurality of suction holes, which are arranged through the roll cover and the roll body. The suction holes extend from the outer surface of the roll to the hollow inner space of the roll body. According to one preferable embodiment of the invention the elastomer layer of the roll cover may have a first edge region and a second edge region, which comprise a plurality of blind holes that extend from the outer surface of the roll only partly within the elastomer layer. The edge regions comprise, in radial direction of the roll, a solid part and a blind-drilled part with blind holes. It has been observed that the edge regions with blind holes further reduce the negative impacts caused by high temperature gradients, temperature and moisture exposure. The edge regions of the elastomer layer may be seen as further safety regions, in case the fabric would not perfectly cover and protect the elastomer layer. Seen from the first end of the roll towards the second end of the roll in the direction of the longitudinal axis of the roll, the roll surface would then comprise a first protection region, a first edge region of an elastomer layer, the elastomer layer with suction holes, a second edge region of the elastomer layer and a second protection region.

[0016] According to one embodiment of the invention the first and second edge regions may comprise blind holes, which have a depth which is at most 90%, preferably at most 80%, more preferably at most 60%, of the total thickness of the elastomer layer. The blind holes in the edge regions may be arranged to follow the same hole pattern as the holes in the elastomer layer in general or alternatively they may be arranged to follow a different pattern or to form surface contour, e.g. grooving. The first edge region and the second edge region may have a width of which is corresponds the thickness of the elastomer layer(s) or is less than the thickness of the elastomer layer(s). In some embodiments, the edge region may have a width, for example, from 5 mm to 15 mm. The width of the first and second edge regions are usually identical.

[0017] According to one embodiment of the invention the roll may further comprise bare regions, where the outer mantle surface of the roll body is naked, i.e. uncovered and free of any applied layer or roll cover. The bare regions showing uncovered outer mantle surface of the roll body are preferably located between the protection regions and the end of the roll. This means that seen from the first end of the roll to the second end of the roll in the direction of the longitudinal axis of the roll, the roll surface comprises an optional first bare region, a first protection region, an optional first edge region, an elastomer layer, an optional second edge region, a second protection region and an optional second bare region. The width of the elastomer layer usually coincides with the width of the fabric used in the arrangement. The bare regions typically have a width of 0 - 50 mm or 0.5 - 50 mm.

[0018] The roll according to the invention comprises a roll cover which comprises at least a base layer and an elastomer layer. The roll cover may comprise plurality of elastomer layers, which are arranged on top of each other. The total thickness of the roll cover is typically 15 - 50 mm. The total thickness of the roll cover comprises the base layer an all possible elastomer layers included in

the roll cover.

[0019] The base layer is arranged on the outer mantle surface of the roll body, in direct and immediate contact with the outer mantle surface. The base layer is heat-resistant and/or non-sensitive to heat. According to one embodiment of the invention the base layer may be made of a composite material comprising reinforcement fibres in an epoxy matrix. The reinforcement fibres may be glass fibres or carbon fibres embedded in the continuous epoxy matrix. The thickness of the base layer may be 10 - 20 mm. The base layer is arranged to enclose the outer mantel surface of the roll body or the preceding cover layer and to form a continuous sleeve around the outer mantel surface of the roll body. The base layer thus forms a continuous layer on the outer mantel surface of the roll body, the layer extending from the first end to the second end of the roll.

[0020] At least one elastomer layer is further arranged on the base layer, the elastomer layer forming the outer surface of the roll. The elastomer layer is usually a heat-sensitive layer. According to one embodiment of the invention the elastomer layer may comprise at least two or even more sub-layers. The sub-layers may be chemically different and/or have different mechanical properties, such as abrasion resistance or softness.

[0021] The elastomer layer may preferably comprise or be polyurethane elastomer layer. The polyurethane elastomer suitable for use in the present invention may be formed by chemical reaction of elastomer precursors based on polyols and isocyanates, i.e. polyol precursors and isocyanate precursors, and a chain extender. The chain extender cures the polyurethane elastomer formed by the reaction between isocyanate precursors and polyol precursors. The chain extender may be selected from diols and diamines having weight average molecular weight $\leq$ 4000 g/mol, for example 60 - 4000 g/mol. Examples of suitable chain extenders are 1,4-butanediol, hydroquinone bis(2-hydroxyethyl)ether, diethyl toluene diamine and 4,4'-methylenebis(3-chloro-2,6-diethylaniline).

[0022] Isocyanate precursors for the polyurethane elastomer may be selected from aromatic isocyanates, aliphatic isocyanates, or their mixtures. It is also possible that the elastomer layer may be formed from two or more different isocyanate precursors, which are based on aliphatic or aromatic isocyanates. By selecting the used isocyanate precursor(s) it is possible to tailor the chemical and/or mechanical properties of the elastomer layer that is formed. The aromatic isocyanate precursor may be selected from a group consisting of 2,4-toluene diisocyanate, 2,6-toluene diisocyanate, 4,4'- methylene diphenyl diisocyanate, 2,4'-methylene diphenyl diisocyanate, 2,2'-methylene diphenyl diisocyanate, 1,5-naphthalene diisocyanate, para-phenylene diisocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate, 1,4-benzene diisocyanate, 1,3-xylylene diisocyanate, 4,6-xylylene diisocyanate, and tetramethyl xylylene diisocyanate. The aliphatic isocyanate precursor may be selected from a group consisting of 1,6-hexamethylene diisocyanate, isophorone diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, tetramethylxylidene diisocyanate, trimethylhexamethylene diisocyanate, 1,3-bis(isocyanatomethyl) cyclohexane, 1,4-cyclohexyl diisocyanate and cyclohexamethylene diisocyanate.

[0023] The polyol precursor for the polyurethane elastomer may be selected from a group consisting of polyesters, polyethers, polycarbonate polyols and polycaprolactone polyols. The elastomer layer may be formed by using one polyol precursor or alternatively two or more different polyol precursors.

[0024] The roll according to the present invention is especially suitable for acting as a counter roll to a heated cylinder, for example a steam heated cylinder, such as a Yankee drying cylinder or the like. When in operation, the fibrous web supported by a fabric, such as felt, is arranged to run through the nip formed between the heated cylinder and the roll. While supporting the fibrous web, the fabric at the same time protects the roll cover of the roll from the excess heat and moisture. Preferably the protection regions of the roll are arranged on the areas of the fabric edges where the outer mantle surface of the roll body that is uncovered and unprotected by the fabric, i.e. at least on the area between the roll end and the fabric edge. The edge regions with the blind holes are preferably located at the fabric edges.

[0025] The following schematical non-limiting drawings further demonstrates certain aspects of the present invention. The invention may be better understood by reference to the drawings in combination with the detailed description of the embodiments presented herein.

Figure 1 is a side view of a Yankee drying cylinder during tissue paper manufacturing,

Figure 2 is a schematic partial view of an arrangement according to one embodiment of the invention, seen in machine direction.

[0026] Figure 1 shows a Yankee drying cylinder 1, which rotates about an axis A in the direction of arrow R. The Yankee drying cylinder 1 is a large diameter cylinder and has journals 24 and bearings 25 that allow rotation. The Yankee drying cylinder 1 is heated from the inside either by hot steam that may be overpressurized, or by other internal or external heating means such as infrared heaters, hot oil or by induction. A wet fibrous web W travels on a fabric 30 that may be, for example, an endless water absorbing felt that runs in a loop around guide rolls (not shown) or, in some cases, a fabric that does not absorb water but is textured such that it may imprint a three-dimensional structure into the fibrous web W. In Figure 1, the direction of movement of the fabric 30 is indicated by the arrows C.

[0027] A counter roll 31 is placed inside the loop of the fabric 30 and arranged to form a nip with the outer surface of the Yankee drying cylinder 1. The roll 31 can be a

suction roll with perforated surface or a press roll with grooved or non-grooved surface. If the counter roll 31 is a suction roll, a suction box D (schematically represented in Figure 1) is provided inside the roll 31 to improve the dewatering of the web W and to enhance separation of the fabric 30 from the web W in the nip. The roll 31 has an elastic cover on its outer surface. In the nip the fibrous web W and the fabric 30 are sandwiched between the roll 31 and the Yankee drying cylinder 1, and the fibrous web W is transferred to the smooth outer surface of the Yankee drying cylinder 1. The fibrous web W will then travel reliably over the outer surface of the Yankee drying cylinder 1 as the Yankee drying cylinder 1 rotates in the direction of arrow R. As the fibrous web W which initially was relatively wet travels in contact with the very hot outer surface of the Yankee cylinder 1 it is drying during its travel by evaporation and can then be creped off from the Yankee drying cylinder 1 by a doctor 29.

[0028] Nip performance is important for the reliable operation of the manufacturing process and for production of a fibrous web W with desired properties. To ensure that the web W follows the Yankee drying cylinder 1 over its full width instead of remaining totally or partly on the fabric 30, the nip pressure profile between the Yankee drying cylinder 1 and the elastic cover of the roll 31 should be adequate and uniform. Main purpose of the elastic cover of the roll 31 is thus to provide a resilient roll surface which can comply against the surface of the Yankee drying cylinder 1 in given nip load conditions. This can be achieved by the arrangement of the present invention, schematically exemplified in Figure 2.

[0029] Figure 2 is a schematic cross-sectional view of an arrangement according to one embodiment of the invention, seen in machine direction. Figure 2 is a partial view of the arrangement, which means that only a half of the arrangement is seen in Figure 2. The arrangement 40 comprises a heated cylinder 1, which is a Yankee drying cylinder and a roll 31, which is arranged to act as a counter roll to the heated cylinder 1. A nip is formed between the heated cylinder 1 and the roll 31, and a fabric 30 and a fibrous web W are arranged to run through the nip, as a web-fabric sandwich.

[0030] The roll 31 comprises a cylindrical roll body 41 with a hollow inner space S and an outer mantle surface 41'. The hollow inner space S may comprise a suction box, seals for sealing a suction area of the suction box and/or the means for feeding lubricating/cooling water (not shown). The roll 31 further comprises a roll cover comprising at least a base layer 42 and an elastomer layer 43. The base layer is arranged on direct and immediate contact with the outer mantle surface 41' of the roll body 41. The base layer 42 attaches the roll cover to the roll body 41. On top of the base layer 42 is arranged the elastomer layer(s) 43, forming the outer surface of the roll cover.

[0031] It can be seen from Figure 2 that at the end of the roll 31 there is a protection region 44, where the neat-resistant base layer 42 is naked, i.e. uncovered by the heat-sensitive elastomer layer 42, and forms the actual outer surface of the roll 31. Similar protection region is arranged at the other end of the roll 31 (not shown). The protection region minimises the area of the elastomer layer 43 which will be directly exposed for the heat radiating from the heated cylinder 1. Most of the elastomer layer 43 is protected by the fabric 30 and the fibrous web W which carries the heat away. In this manner, the risk for large temperature gradients through the roll cover is decreased and the probability for the failure of elastomer layer 43 through swelling, degradation, debonding, loss of strength and/or wear resistance is reduced.

[0032] Plurality of suction holes, schematically indicated with stripes, extend through the roll cover and roll body 31 from the outer surface of the roll to the hollow inner space S of the roll body 41. Furthermore, the elastomer layer 43 has an edge region 43', which comprise a plurality of blind-drilled holes that extend from the outer surface of the roll only partly within the elastomer layer. The edge region 43' provides a further safety region where the blind-drilled holes further reduce the negative impacts caused by high temperature gradients, temperature and moisture exposure. The solid part of the edge region 43' may have equal width with the blind-drilled part above it, but preferably the solid part of the edge region 43' may be formed slightly longer by reducing the width of the blind-drilled part, for example, by chamfering, rounding or sloping the edge of the outermost elastomer layer 43.

[0033] To provide full-width support as well as uniform thickness and moisture profiles for the fibrous web, the fabric needs to be wider than the fibrous web to ensure a uniform pressing of the web-fabric sandwich in the nip also at the web edge areas. The elastomer layer of the roll cover is wider than the maximum width of the fabric so that the fabric edges maintain the contact with the elastomer layer in the nip despite of inaccuracies of the exact location of the fabric edge. The elastomer layer, however, does not extend too far from the fabric edge even when the fabric is at its most narrow in order to survive under the thermal load from the heated cylinder. Optimally, the heat-sensitive elastomer layer extends beyond the fabric edge at maximum from 5 mm to 15 mm. According to one preferred embodiment of the invention the heat-resistant base layer extends beyond the edges of the heat-sensitive elastomer layer at least for a minimum of about 10 mm to protect the elastomer layer and thus the whole cover from the consequences of the excess heat.

[0034] Even if the invention was described with reference to what at present seems to be the most practical and preferred embodiments, it is appreciated that the invention shall not be limited to the embodiments described above, but the invention is intended to cover also different modifications and equivalent technical solutions within the scope of the enclosed claims.

Claims

1. A roll for manufacture of paper, board, tissue or the like, the roll having a first end and a second end, and comprising

   - a cylindrical roll body with a hollow inner space and an outer mantle surface,
   - a roll cover comprising at least a base layer arranged on the outer mantle surface of the roll body, and an elastomer layer arranged on the base layer, the elastomer layer forming an outer surface of the roll cover,

   characterised in that
   the first end and the second end of the roll have a protection region, where the base layer is uncovered by the elastomer layer and forms the outer surface of the roll.

2. Roll according to claim 1, **characterised in that** the roll comprises a plurality of suction holes extending from the outer surface of the roll to the hollow inner space of the roll body.

3. Roll according to claim 1 or 2, **characterised in that** the base layer is less heat-sensitive than the elastomer layer.

4. Roll according to claim 1, 2 or 3, **characterised in that** the elastomer layer have a first edge region and a second edge region, which comprise a plurality of blind holes that extend from the outer surface of the roll only partly within the elastomer layer.

5. Roll according to claim 4, **characterised in that** the blind holes have a depth which is at most 90%, preferably at most 80%, more preferably at most 60%, of the thickness of the elastomer layer.

6. Roll according to any of preceding claims 1 - 5, **characterised in that** the first end and the second end of the roll show a bare region of an uncovered mantle surface between the protection region and the end of the roll.

7. Roll according to any of preceding claims 1 - 6, **characterised in that** the elastomer layer comprises polyurethane.

8. Roll according to any of preceding claims 1 - 7, **characterised in that** the elastomer layer comprises at least two sub-layers.

9. Roll according to any of preceding claims 1 - 8, **characterised in that** the base layer is made of a composite material comprising reinforcement fibres in an epoxy matrix.

10. Roll according to any of preceding claims 1 - 9, **characterised in that** the roll is a suction roll comprising a stationary suction box arranged within the hollow space inside the cylindrical roll body.

11. Roll according to any of preceding claims 1 - 10, **characterised in that** roll comprises means for feeding, circulating and/or transferring cooling and/or lubricating liquid medium, such as water, inside the roll body.

12. An arrangement for manufacture of paper, board, tissue or the like, the arrangement comprising

    - a heated cylinder, such as a Yankee drying cylinder or the like,
    - a roll according to any of claims 1 - 11, arranged to act as a counter roll to the heated cylinder, whereby a nip is formed between the heated cylinder and the roll, and
    - a fabric, arranged to run through the nip and having a first fabric edge and a second fabric edge.

13. Arrangement according to claim 12, **characterised in that** the protection regions of the roll are arranged on the area between the roll ends and the fabric edges.

14. Arrangement according to claim 12 or 13, **characterised in that** the roll has a roll cover having an elastomer layer comprising a first and a second edge region with blind holes, wherein the edge regions are located at the fabric edges.

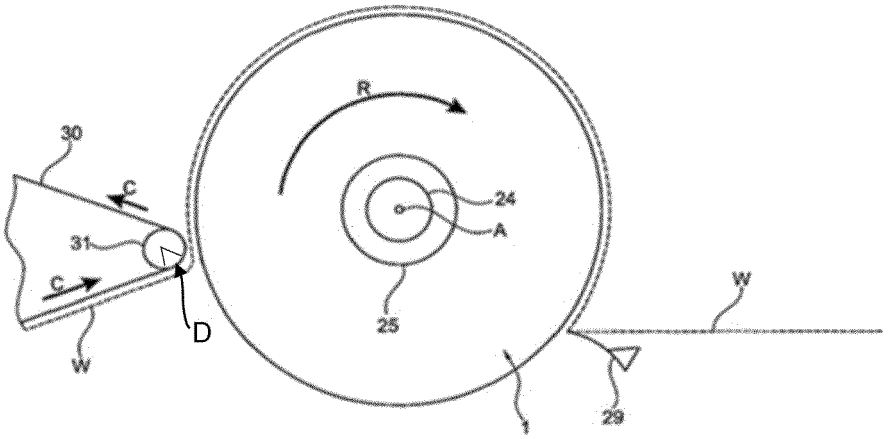

Figure 1

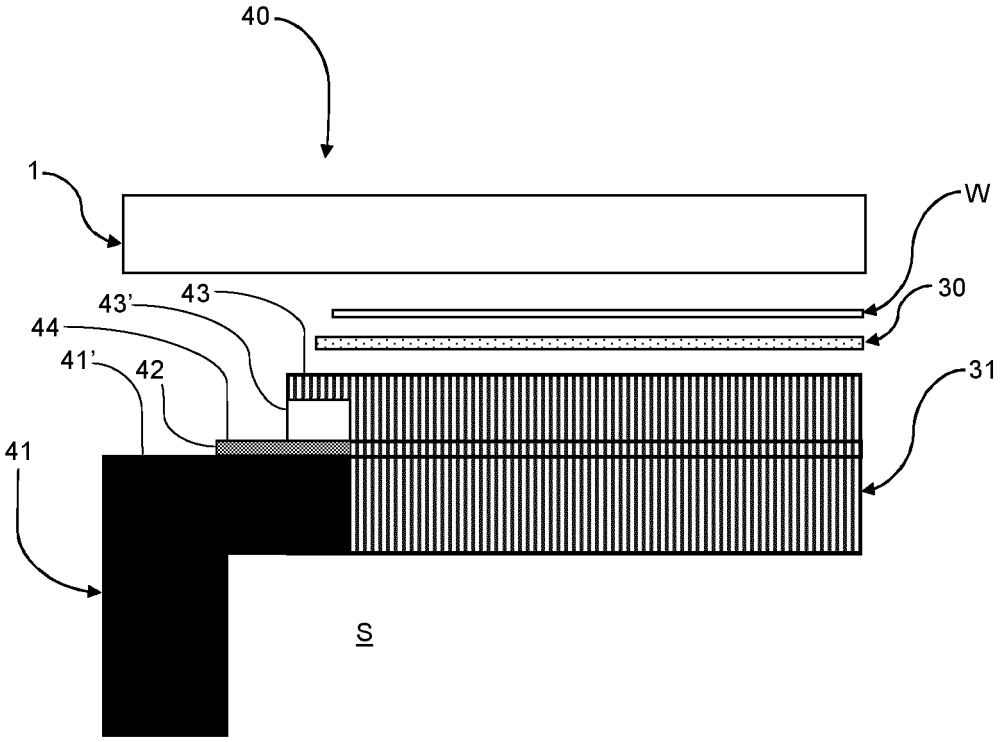

Figure 2

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 4988

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC) D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	1 June 2021	Pregetter, Mario

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 21 4988

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82