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1. Field of the invention

The present invention concerns an improved panel, in particular a wall, ceiling or floor panel, based on a hard PVC (PVC-U) carrier plate, and a method for its manufacture.

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2. Background of the invention

Polyvinyl chloride has long been used in the manufacture of floor coverings. Polyvinyl chloride (PVC) is a thermoplastic material that is hard and brittle without the addition of additives. However, the mechanical properties of PVC can be adjusted over a wide range by adding suitable auxiliary materials such as plasticizers, fillers, colorants, stabilizers, etc. For this reason, the term "PVC" in this document does not refer to pure polyvinyl chloride, but to PVC with the additives normally added and necessary for practical use, unless otherwise specified.

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A typical example from the state of the art is described in the document DE 10 2006 058 655 A1. This document discloses a floor panel in the form of a multi-layer rectangular laminate with a carrier plate made of a soft polyvinyl chloride and a décor paper layer arranged on top of the polyvinyl chloride layer. The application of a décor paper sheet is technically elaborate and involves considerable costs.

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From DE 10 2006 029 963 A1 a floor covering made of polyvinyl chloride is known, which is coated with a hard-wearing lacquer layer in order to improve the durability of the PVC floor covering. The lacquer layer is based on an acrylate resin and is to be cured by means of radiation. The core of this document lies in the addition of electrically conductive substances to the acrylate resin to provide the finished floor covering with antistatic and/or electrically conductive properties.

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The WO 2008/061791 A1 of the same applicant represents a further development of a lacquer coating. The content of this document is hereby incorporated in its entirety by reference. The core of the improvement of this document lies in the fact that two liquid, different polymer layers are applied wet-on-wet to the surface of a panel, so that a partial

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mixing of the coating agents takes place. These two wet-on-wet coatings are then cured together, with the cured resulting coating having a hardness gradient due to partial mixing, with the hardness of the coating decreasing with increasing depth as seen from the surface of the resulting coating.

5

In the light of these well-known PVC coverings, the present invention has the task of providing a panel, in particular a wall, ceiling or floor panel, comprising a carrier plate made of (in particular) hard PVC, which is to be produced in a cheaper and simpler way than is known, for example, from DE 10 2006 058 655 A1. Another task is to provide such
10 a panel that has improved durability and high quality decorative patterns.

15

The document DE 10 2010 011 602 A1 discloses a method in which the carrier plate is first laminated on one side or both sides with a plastic film. The laminated carrier plate is then fed to a printer and the plate is printed with images or graphic patterns, whereby the ink is
15 then cured by means of UV radiation. The printed plate is then removed from the printer and temporarily stored in shelves for further processing. The printed carrier plate is then coated with a single- or multi-layer UV-curable lacquer.

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These and other tasks, which are still mentioned when reading this description or can be identified by the skilled person, are solved by a panel according to Claim 1 and a method for its manufacture according to Claim 18.

3. Detailed description of the invention

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According to the present invention, a panel is provided comprising a carrier plate based on polyvinyl chloride and a film attached thereon, wherein the film is a PVC film having a thickness of 0.04 to 0.2 mm and comprising a decorative pattern directly printed thereon, and a cured polymer layer is provided over the PVC film. Herein, the polymer layer is generally preferably based on a polymerizable resin, in particular an acrylate resin.

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Generally preferred, the cured polymer layer has a hardness gradient according to the WO 2008/061791 of the same applicant described at the beginning.

The carrier plate based on polyvinyl chloride consists in general preferably of hard PVC (also referred to as PVC-U), i.e. it comprises essentially no or no plasticizers.

5 In contrast to the state of the art DE 10 2006 058 655 A1 mentioned at the beginning the present invention provides a panel according to claim 1 that does not require a separate décor paper, as the decorative pattern is printed directly onto the PVC film. The PVC film has the advantage that it is possible to dispense with expensive pre-treatment of the carrier plate (although pre-treatment is of course possible, should this be desired). In particular, it can be dispensed with, extensive grinding the surface of the carrier plate, and
10 the application of filler mass and primers, as it is typically necessary in the state of the art, can also be advantageously omitted when using a PVC film in the thickness in accordance with the invention.

In a preferred embodiment, the polymer layer has a hardness gradient, so that the
15 hardness of the polymer layer decreases essentially continuously with increasing depth as seen from the surface of the polymer layer. Such a layer with a hardness gradient is advantageous in combination with the relatively soft PVC film and, among other things, achieves good sound insulation.

20 The printing ink used for printing the decorative pattern is solvent-containing and is a UV printing ink. Such printing inks slightly dissolve the surface of the PVC film, resulting in a firm anchorage of the printing ink on the film. The use of UV inks also results in very good cross-linking of the ink with the surface of the PVC film. UV inks are used because they contain reactive solvents that are chemically incorporated into the later network.

25 According the present invention the printing ink contains a polymerizable acrylate and N-vinylcaprolactam.

For printing the decorative pattern a polymerizable printing ink (ink) based on polymerizable acrylic resins and/or N-vinylcaprolactam (a liquid reactive diluent) as
30 offered by the company BASF is therefore used. The applicants have surprisingly found that improved adhesion properties of the layer system can be achieved by using polymerizable printing inks instead of the common water-based dispersion inks. This applies in particular to the preferred application with a polymer layer, in particular with a

hardness gradient. Suitable weight proportions for the amount of polymerizable acrylate and N-vinylcaprolactam in the printing ink have been proven to be 2 to 50, more preferred 5 to 40 and most preferred 10 to 30 %. These specifications refer to the sum of acrylate and N-vinylcaprolactam. The proportion by weight of N-vinylcaprolactam in the printing ink, for example, is 3 to 12 %.

The positive effect is particularly noticeable if the printing ink of the décor layer (i.e. the decorative pattern) and the polymer layer are cured or polymerized together (if the décor layer is printed directly on, as in digital printing, the décor layer virtually consists of the printing ink). Curing of a polymer layer or a polymerizable printing ink (such as polymerizable acrylates or UV-reactive inks in general) is herein understood to mean the chemical reaction that takes place during polymerization. Due to curing (polymerization) of the polymerizable components (acrylate systems and/or N-vinylcaprolactam) of the printing ink and polymer layer together, a chemical crosslinking occurs at the interface of the two layers, which is assumed to be responsible for the improved adhesion of the layers.

Polymerizable components comprise acrylates as main components, in particular acrylate monomers, oligomers and optional photoinitiators, but also N-vinylcaprolactam as a liquid reactive diluent. N-vinylcaprolactam can be added to the printing ink as a diluent in addition to the acrylates and polymerizes together with these. Alternatively, it is also possible to dispense with the acrylates and provide a correspondingly larger amount of N-vinylcaprolactam, since the N-vinylcaprolactam itself can be polymerized. Details on this are known to the skilled person from the German publication DE 197 02 476 A1. However, this alternative is not part of the claimed invention. In not claimed, preferred embodiments, the polymerizable components therefore essentially consist of N-vinylcaprolactam. The photoinitiators effect a polymerization of the monomers or oligomers under the influence of radiation, whereby the printing ink cures quickly.

Preferably the PVC film has a thickness from 0.05 to 0.15 mm, more preferably from 0.06 to 0.095 mm. Such strengths (thicknesses) can be processed very well and especially applied well with a calender. For example, the PVC film can be applied directly by means of a heated calender so that the film is thermally bonded/welded to the carrier plate. The

use of an additional adhesive to attach the film to the carrier plate is then not necessary, although this is possible alternatively or additionally of course.

5 Preferably the carrier plate based on polyvinyl chloride has a density of 900 to 2,500 kg/m³, preferably 1,000 to 2,200 kg/m³, more preferably 1,300 to 1,950 kg/m³ and most preferably 1,350 to 1,500 kg/m³. Such densities result in very robust and resistant plates, which are particularly advantageous when panels are used as floor coverings. In addition, these plates allow the incorporation of locking or coupling elements at the side edges of the plate, e.g. in order to be able to connect several similar plates with each other in a
10 form-fitting manner.

A thickness (strength) for the carrier plate between 3 and 20 mm, preferably between 4 and 15 mm, more preferably between 3 and 12 mm and most preferably between 4 and 10 mm has proven to be advantageous. It has been found that these areas provide sufficient
15 stability for the thickness of the carrier plate during the manufacturing process and also provide sufficient impact sound absorption (when used as flooring) and dimensional stability of the finished panel.

In a preferred embodiment, a layer comprising a UV primer is provided on the PVC film.
20 This layer preferably has a grammage of 1 to 20 g/m², more preferably 2 to 15 g/m², and most preferably 2 to 5 g/m². Dipropylene glycol diacrylate has proven to be a suitable material, e.g. in an amount of 2 g/m² it achieves a good effect. The primer is preferably applied to the printing ink and thus improves the adhesion between the printing ink, the substrate and the polymer layer. It has been shown that especially in areas with little
25 printing ink the adhesion is improved by using the primer.

The carrier plate is generally preferably an extruded PVC plate.

In a preferred embodiment, abrasion-resistant particles, especially corundum particles,
30 with an average diameter of 10 to 100 µm, preferably 20 to 80 µm, more preferably 25 to 70 µm and especially preferably 30 to 60 µm are embedded in the polymer layer. The abrasion-resistant particles make it possible to considerably increase the lifetime of a panel according to the invention.

In a preferred embodiment, the decorative pattern, which is applied directly to the PVC film by means of a digital printing process, represents the only décor layer of the panel according to the invention, i.e. no further décor papers or décor films are provided.

5 Therefore, there is no need to provide a separate décor paper or the like, which leads to a considerable cost reduction and method simplification of the manufacturing of a panel according to the invention.

10 As mentioned at the beginning, according to a preferred embodiment of the invention, the printing ink of the décor layer (of the decorative pattern) is cured (polymerized) together with the polymer layer applied over it, preferably by irradiating them together. This results in a partial chemical crosslinking of the polymers used at the interface between the printing ink and the polymer layer(s) applied above it. Herein, it has shown that a particularly good adhesion of the polymer layer to the carrier plate can be achieved.

15 According to claim 16 of the present invention a method for manufacturing a panel, in particular a wall, ceiling or floor panel, is further provided. In a first step (step i) of this method, a carrier plate based on polyvinyl chloride with a density of 900 to 2,500 kg/m³ is provided. The carrier plate preferably consists of a hard PVC. A PVC film having a
20 thickness of 0.04 to 0.2 mm is then (ii) applied to this carrier plate by means of a calender and afterwards (iii) a decorative pattern is printed on the PVC film. After the imprint of the decorative pattern on the PVC film, a liquid first polymer layer is applied to the primer layer (iv). In a further step, the polymer layer is cured, preferably together with the printing ink (vi). Optionally, at least a second polymer layer can be applied in liquid form
25 to the still wet first polymer layer (v) so that a partial of the coating agents takes place. The curing of the printing ink and the polymer layer(s) can occur in one method step but also successively in two separate method steps. Hardening or curing of a polymer layer is understood to be the chemical reaction that takes place during polymerization. A distinction must be made between this and the drying of such layers, in which only the
30 water content is reduced or removed.

Preferably the steps (iv) to (vi) are performed such that the cured polymer layer has a hardness gradient, wherein the hardness of the coating decreases with increasing depth as

seen from the surface of the resulting coating. This process is described in more detail in the WO 2008/061791 A1 mentioned at the beginning, so it is dispensed with further details.

- 5 Preferably, a heated calender is used in such a way that the PVC film is thermally welded to the carrier layer. In this way, the application and fastening of the film can occur easily and safely in a single step.

10 Further, the directly printed decorative pattern preferably imitates a wood, stone or tile surface. The PVC film is generally preferred unicoloured or white. This provides a good background colour for most commercially used decors.

In the following, two examples are mentioned:

- 15 **Example 1** (not part of the claimed invention): "Panel with conventional indirect gravure printing".

A PVC carrier plate with a thickness of 4 mm is first provided with a primer on the basis of a commercially available aqueous acrylic dispersion via a roller applicator. In a next step,
20 the smoothing of the PVC carrier plate occurs by roller applicator by means of a filler mass based on a highly filled aqueous acrylate dispersion. Subsequently, a printing primer on the basis of an aqueous acrylate dispersion mixed with fillers and colour pigments is applied by means of casting. After each of these coating steps, intermediate drying occurs at temperatures between 80 and 200 °C. The PVC carriers treated in this way are supplied
25 to a printing machine essentially consisting of an engraving roller and a rubber roller for transferring the print image from the engraving cylinder to the plate. The printing image is produced by 3 downstream printing units, whereby each printing unit applies its own printing ink consisting of ink pigments and an aqueous acrylic dispersion. For example, if a dark walnut wood is imitated, 5 g/m² of printing ink is applied. A commercial UV primer
30 is then applied to the ink layer via a roller applicator. Finally, the application polymer layer occurs as described in WO 2008/061791 to produce a polymer layer with a hardness gradient.

Example 2: "Panels where the pattern is printed on a PVC film".

A 6 mm thick PVC carrier plate made of hard PVC is used and a PVC film with a thickness of 0.03 mm is applied to it by means of a heated calender, so that the film is thermally welded to the carrier plate. On the attached PVC film, the same décor image as in example 1 is produced by means of a digital printer. Herein, however, a solvent-containing, UV-curing digital printing ink that contains polymerizable acrylate and N-vinylcaprolactam is used. For the production of the print image, a quantity of ink of about 2 g/m² is required. The ink is first fixed with 150 mJ/cm² (mercury). Thereon the application of 2 g/m² of a first UV-curing layer occurs, which mainly contains dipropylene glycol diacrylate. On this non-irradiated layer a double bond containing oligomer mixed with photoinitiators is applied. The compound is then irradiated with a UV radiation source and the polymerizable components are cured subsequently. The resulting polymer layer comprises the printing ink and all layers above it.

4. Description of preferred embodiments:

In the following, the invention is explained in more detail using the figure, wherein:

Fig. 1 shows a schematic representation of a panel 10 according to the invention with a polyvinyl chloride carrier plate 12; and

Fig. 2 shows a schematic view of a system for coating.

In Fig. 1 the carrier plate 12 is shown, which has tongue and groove connections at its respective edges, which allow individual panels 10 to be connected with each other. The carrier plate consists of an extruded hard PVC (PVC-U).

Above the carrier plate 12 a PVC film 17 is arranged. A decorative pattern (décor layer) 18 is printed on the top side of film 17, preferably by means of a digital printing process. This decorative pattern can be any pattern, depending on the application. Above the PVC film and the décor layer, a UV-curable polymer layer system 19 is provided. The illustration is not true to scale and the layers are shown here at a distance from each other not present in the real product in order to make them more clearly visible.

In the following, Fig. 2 is used as an example to describe the manufacture of a panel according to the invention or the method according to the invention. Fig. 2 schematically shows a coating system for the coating of plates 12 or for the manufacture of panels 10.

5 The plates 12 consist of hard PVC with a thickness of 4-8 mm. The plates 12 are guided by a roller conveyor 21 through the various stations of the coating system. The coating stations shown are not to be understood conclusively but serve only as examples to explain the method according to the invention and are shown purely schematically. In front of, behind and between the stations shown, further processing stations may be provided, such as further drying stations, stations for applying primers, stations for applying fillers, etc. 10 The first station 30 is intended to be a calender unit with which the PVC film 17 is applied to the top side of the plates 12. The film is unwound from a supply roll 31 and attached to the top of the plates 12 by means of a heated calender roll 32. A cutting of the film occurs by using suitable cutting means known to a person skilled in the art (not shown).

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In Station 60, a decorative décor, in particular a real wood décor, is printed on PVC film 17 by means of digital printing. After printing, a polymer layer is applied in the coating station 70. The polymer layer is applied with a hardness gradient, so that the hardness of the polymer layer decreases essentially continuously with increasing depth as seen from 20 the surface of the polymer layer. For this purpose, a first polymer layer based on a polymerizable acrylate system is applied in a first coating unit 71. A further wet-on-wet polymer layer is applied to this first polymer layer in Station 72. The second polymer layer, for example, has a higher double bond content, as described in detail in the above-mentioned application on the hardness gradient. The two polymer layers are applied wet-on-wet in stations 71 and 72, so that partial mixing takes place at the interface of the two 25 layers. In Station 73, the two polymer layers are cured together under the influence of UV radiation.

Station 60 is preferably a digital printing station and uses a printing ink based on a 30 polymerizable acrylate and N-vinylcaprolactam. In this case, it is preferred that no curing of the printing ink takes place between stations 60 and 70, but at most an intermediate drying step during which some moisture is removed from the polymerizable acrylate of the

printing ink. In the curing station 73, the printing ink and the first and second polymer layers are then cured together, resulting in a particularly resistant surface.

Patentkrav

- 1.** Panel, især et væg-, lofts- eller gulvpanel, omfattende en bærerplade (12) baseret på polyvinylchlorid og en derpå fastgjort film (17), hvor filmen (17) er en PVC-film med en tykkelse på 0,04 til 0,2 mm og omfatter et derpå direkte påtrykt
5 dekorativt mønster (18), og over PVC-filmen er der tilvejebragt et hærdet polymerlag (19), hvor trykfarven anvendt til tryk af det dekorative mønster (18) er opløsningsmiddelholdig og er en UV-trykfarve, **kendetegnet ved, at** trykfarven indeholder en polymeriserbar acrylat og N-vinylcaprolactam.
- 10 **2.** Panel ifølge krav 1, **kendetegnet ved, at** polymerlaget (19) har en hårdhedsgradient, således at hårdheden af polymerlaget i alt væsentligt aftager kontinuerligt med tiltagende dybde set fra overfladen af polymerlaget.
- 3.** Panel ifølge krav 1, **kendetegnet ved, at** trykfarven anvendt til tryk af det
15 dekorative mønster (18) indeholder en polymeriserbar acrylat og N-vinylcaprolactam i en vægtandel (%) på 2 til 50, mere fortrinsvis 5 til 40, og mest fortrinsvis 10 til 30 % i trykfarven.
- 4.** Panel ifølge et af de foregående krav, **kendetegnet ved, at** trykfarven og
20 polymerlaget blev hærdet sammen, fortrinsvis via stråling.
- 5.** Panel ifølge et af de foregående krav, **kendetegnet ved, at** det dekorative mønster (18) blev påført ved hjælp af digitaltryk.
- 25 **6.** Panel ifølge et af de foregående krav, **kendetegnet ved, at** PVC-film har en tykkelse på 0,05 til 0,15 mm, mere fortrinsvis på 0,06 til 0,095 mm.
- 7.** Panel ifølge et af de foregående krav, **kendetegnet ved, at** bærerpladen (12) har en tykkelse mellem 3 og 20 mm, fortrinsvis mellem 4 og 15 mm, mere
30 fortrinsvis mellem 3 og 12 mm, og mest fortrinsvis mellem 4 og 10 mm.
- 8.** Panel ifølge et af de foregående krav, **kendetegnet ved, at** et lag omfattende en UV-primer er tilvejebragt på PVC-filmen (17).

9. Panel ifølge det foregående krav, **kendetegnet ved, at** laget omfattende en UV-primer (14) har en gramvægt mellem 1 og 15 g/m², fortrinsvis en gramvægt mellem 1,5 og 10 g/m², særligt foretrukket en gramvægt mellem 2 og 5 g/m².
- 5 10. Panel ifølge et af de foregående krav, **kendetegnet ved, at** bærerpladen (12) er en ekstruderet PVC-plade.
11. Panel ifølge et af de foregående krav, **kendetegnet ved, at** PVC-filmen (17) er termisk svejset eller klæbet på bærerpladen.
- 10 12. Panel ifølge et af de foregående krav, **kendetegnet ved, at** PVC-filmen (17) er ensfarvet og især hvid.
13. Panel ifølge et af de foregående krav, **kendetegnet ved, at** der er
- 15 tilvejebragt slidbestandige partikler i polymerlaget, hvor de slidbestandige partikler fortrinsvis har en gennemsnitlig diameter på 10 til 150 µm, fortrinsvis 20 til 80 µm, mere fortrinsvis 25 til 70 µm og særligt foretrukket på 30 til 60 µm og yderligere fortrinsvis består af korund.
- 20 14. Panel ifølge et af de foregående krav, **kendetegnet ved, at** polymerlaget (19) er baseret på en eller flere af følgende acrylater: 1,6-hexandioldiacrylat, polyesteracrylat, polyurethanacrylsyreester og dipropylenglycoldiacrylat.
15. Panel ifølge et af de foregående krav, **kendetegnet ved, at** udover det
- 25 dekorative mønster (18) på PVC-filmen (17) er der ikke påført noget yderligere dekorationslag, især intet dekorationspapir eller ingen dekorationsfilm.
16. Fremgangsmåde til fremstilling af et panel, især et væg-, lofts- eller gulvpanel, omfattende følgende trin i den nævnte rækkefølge:
- 30 (i) tilvejebringelse af en bærerplade baseret på polyvinylchlorid med en densitet på 900 til 2.500 kg/m³;
- (ii) påføring af en PVC-film med en tykkelse på 0,04 til 0,2 mm på bærerpladen ved hjælp af en kalender;
- (iii) påtrykning af et dekorativt mønster direkte på PVC-filmen, hvor
- 35 trykfarven anvendt til trykning af det dekorative mønster (18) er

- opløsningsmiddelholdig og en UV-trykfarve, og trykfarven indeholder en polymeriserbar acrylat og N-vinylcaprolactam;
- (iv) påføring af mindst et første polymerlag på PVC-filmen;
- (v) eventuelt: påføring af mindst et andet flydende polymerlag på det
- 5 stadig fugtige første polymerlag, således at der sker en delvis blanding af polymerlagene; og
- (vi) hærdning af polymerlaget/lagene.

17. Fremgangsmåde ifølge krav 16, **kendetegnet ved, at** trin (iv) til (vi) udføres

10 således, at det hærde polymerlag har en hårdhedsgradient, hvor hårdheden af belægningen aftager med tiltagende dybde set fra overfladen af den resulterende belægning.

18. Fremgangsmåde ifølge et af de foregående fremgangsmådekrav,

15 **kendetegnet ved, at** bærerpladen fremstilles via ekstrudering.

19. Fremgangsmåde ifølge et af de foregående fremgangsmådekrav, **kendetegnet ved, at** i trin (ii) anvendes en opvarmet kalender på en sådan måde, at PVC-filmen svejses termisk på bærerpladen.

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20. Fremgangsmåde ifølge et af de foregående fremgangsmådekrav, **kendetegnet ved, at** det dekorative mønster trykkes direkte på PVC-filmen ved hjælp af digitaltryk.

25 **21.** Fremgangsmåde ifølge et af de foregående fremgangsmådekrav, **kendetegnet ved, at** PVC-filmen har en tykkelse på 0,05 til 0,15 mm, mere fortrinsvis på 0,06 til 0,095 mm.

22. Panel eller fremgangsmåde ifølge et af de foregående krav, **kendetegnet**

30 **ved, at** bærerpladen (12) baseret på polyvinylchlorid har en densitet på 900 til 2.500 kg/m³, fortrinsvis 1.000 til 2.200 kg/m³, mere fortrinsvis 1.300 til 1.950 kg/m³ og mest fortrinsvis 1.350 til 1.500 kg/m³.

23. Panel eller fremgangsmåde ifølge et af de foregående krav, **kendetegnet**

35 **ved, at** det direkte påtrykte dekorative mønster efterligner en træ-, sten eller

fliseoverflade.

24. Panel eller fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved, at** bærerpladen (12) baseret på polyvinylchlorid ikke indeholder
5 blødgøringsmidler.

25. Panel eller fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved, at** bærerpladen (12) baseret på polyvinylchlorid består af hårdt PVC (PVC-U).

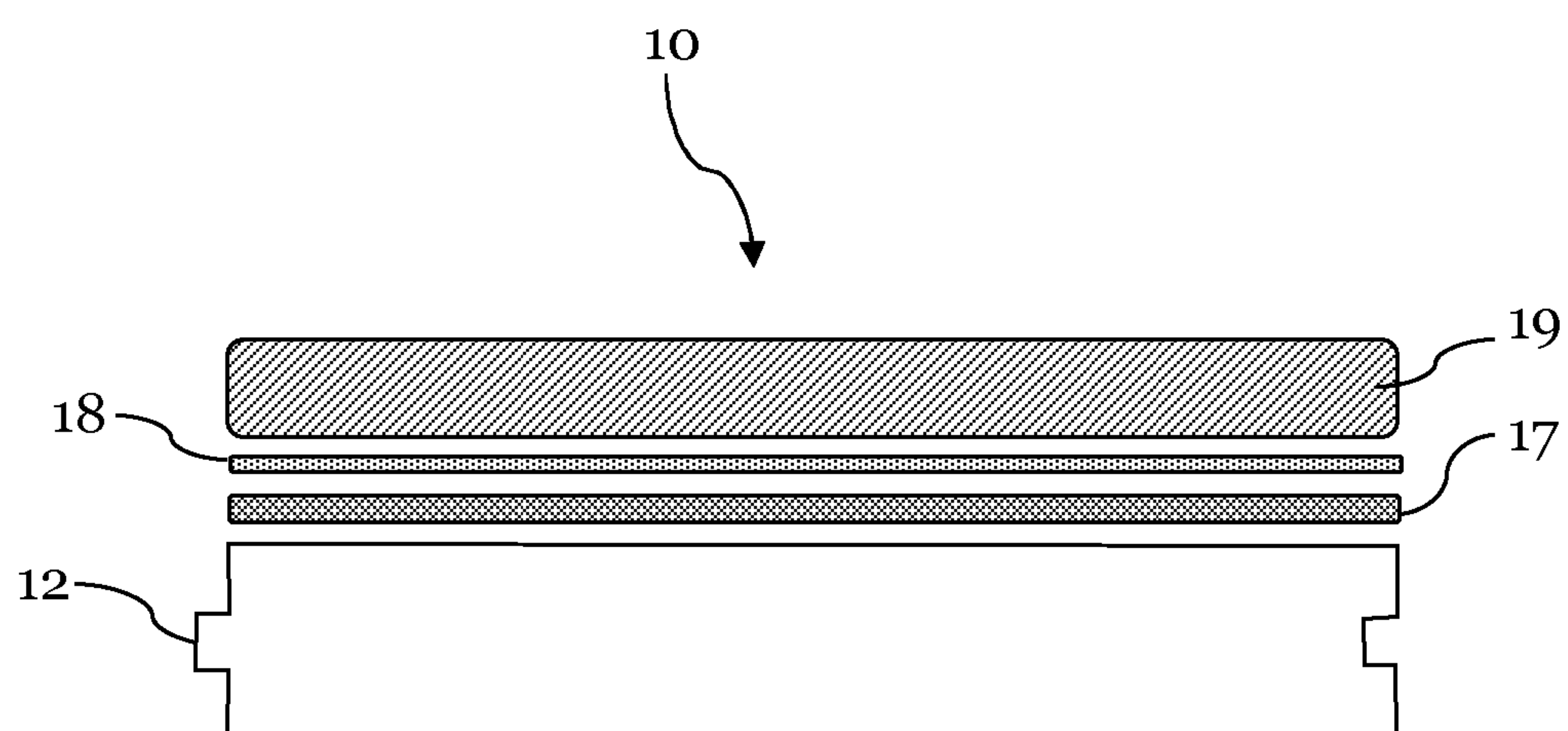


Fig. 1

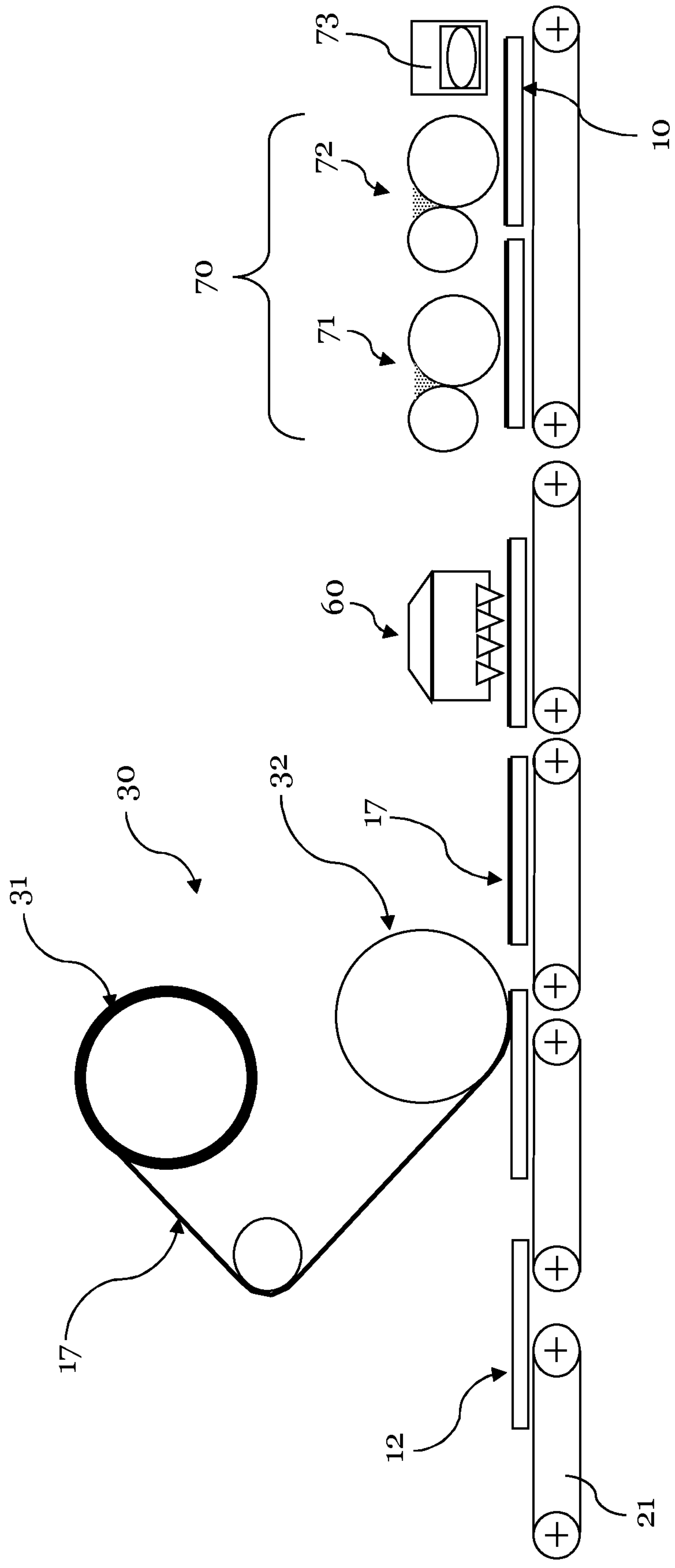


Fig. 2