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(54) **Title**: WINDOWED SECURITY DEVICE

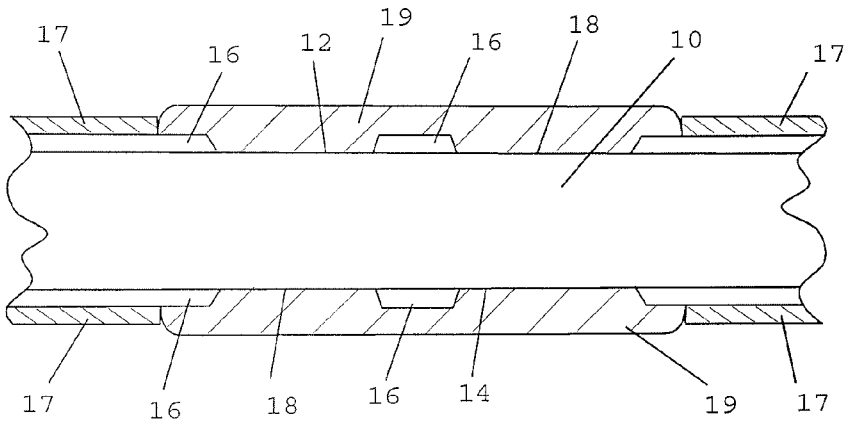

Figure 1a

(57) **Abstract**: A security device for inclusion in pulp from which a security paper is manufactured, and a method of making such a security device. The device is arranged so as to form a windowed security thread in a security paper and comprises flexible substrate (10) having two surfaces (12, 14); a bonding layer (17) on at least part of one or both surfaces and a reflective or diffractive layer (16) on at least part of one or both surfaces, between the substrate and the bonding layer; wherein at least one surface of the device has one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present.

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Windowed security device

Background of the Invention

The present invention concerns security features for inclusion in security papers. More particularly, the invention concerns a security device for inclusion in pulp from which a security paper is manufactured, a security paper including such a security device, and a method of manufacturing a security paper including such a security device.

Counterfeiters are becoming increasingly sophisticated in their efforts to reproduce security documents. Reprographic equipment available to counterfeiters becomes more effective with each passing year, and counterfeiters show considerable ingenuity when simulating security features that have been included in genuine security documents. Consequently, there is a continuing demand for innovative security features that can be produced at relatively low cost, but which, when included in a security document, produce an effect that cannot be reproduced using technologies available to counterfeiters, or likely to be available to them in the near future. Examples of security documents include banknotes, passports, driving licences, bank cards, and certificates of various kinds. Examples of security features included in such documents include chips containing biometric or other data, printed features, such as patterns of lines that create interference patterns when copied, and various features incorporated into the security paper from which the security document is made. Examples of

security features included in security papers are holograms, foils, planchettes, watermarks, microdots, and metallic threads.

Metallic security threads are typically made from a transparent film coated with a metal layer, such as vacuum deposited aluminium on polyester. When such threads are embedded in a security paper the thread is not visible in reflected light but is immediately apparent as a dark line when the security document is viewed in transmitted light. This optically variable effect cannot be simulated by printing a line on the paper, so a security thread provides a simple but effective anti-counterfeiting measure.

It is common practice to incorporate threads into a security paper such that some portions of the thread are embedded shallowly enough that they are visible at a surface of the paper whilst other portions are embedded deeply enough within the paper that they are not visible. Thus the thread appears as a broken line when the security document is viewed in reflected light, and as a complete unbroken dark line when the document is viewed in transmitted light. Such partially embedded security threads are known in the art as windowed threads.

At present security paper incorporating windowed threads must be made using a special cylinder mould (or vat) papermaking machine having a dandy roll with raised regions. The raised regions create areas on the partially formed paper that have less fibre than surrounding areas. A thread is inserted into the pulp so that it lines up with the raised regions on the dandy roll and comes to the surface of the paper in the areas that have less fibre, creating

windows in the finished paper. It is not possible to preselect which regions of the thread will be visible at the surface of the paper, so if it is desired to provide a design on the visible portions of the thread this design must be present on the entire thread. Cylinder mould machines are also significantly more expensive and slower to run than the standard fourdrinier papermaking machines usually used to make banknotes, and as such they are not very common.

A further disadvantage of threads inserted using a cylinder mould machine is that the metallised thread does not bond to the paper fibres. It is therefore possible for the thread to be pulled out of the security document into which it is embedded, or to become at least partially dislodged through general wear and tear. Bonding between the thread and the paper can be improved by using a heat seal adhesive coating on the thread, but the heat required to activate the coating can damage the paper.

The requirement that at least some of the thread be completely embedded within the paper means that the whole thread can never be visible on the security document.

The present invention seeks to address the aforementioned disadvantages. Alternatively or additionally the present invention seeks to provide an improved security device for incorporation into a security paper, as well as an improved method of manufacturing a security paper.

Summary of the Invention

The present invention provides, according to a first aspect, a device for forming a windowed security thread in a security paper, the device comprising

a flexible substrate having two surfaces,

a bonding layer on at least part of one or both surfaces, and

a reflective or diffractive layer on at least part of one or both surfaces, between the substrate and the bonding layer,

wherein at least one surface of the device has one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present.

The device may be a security thread. The bonding layer may be arranged such that hydrogen bonds form between the bonding layer and the security paper during a process of forming the security paper. The bonding layer may be a fibrous layer. Advantageously, providing a bonding layer which forms hydrogen bonds with the paper substrate enables the device to adhere strongly to the security paper in which it is embedded without the need for an adhesive coating on the device.

Preferably the bonding layer is opaque. The bonding layer may be translucent. The bonding layer may be transparent. Preferably the bonding layer is invisible when the device is incorporated into a security paper. The bonding layer may be a textile fabric layer. Preferably the

bonding layer is a paper layer. The bonding layer may comprise tissue paper.

The bonding layer may comprise paper having a basis weight of between 10 and 45 grams per square metre. Preferably the bonding layer comprises paper having a basis weight of between 20 and 30 grams per square metre. The bonding layer may comprise paper having a basis weight of 25 grams per square metre. The bonding layer may comprise paper having a high wet tensile strength. Preferably the bonding layer comprises paper having a wet tensile strength of at least 4 Newtons per 15mm. It may comprise paper having a wet tensile strength of at least 5 Newtons per 15mm. The bonding layer may comprise paper having high porosity. It may comprise paper having a porosity of at least 20/mn/100cm^3. Preferably it comprises paper having a porosity of at least 25/mn/100cm^3. It may comprise paper may having a porosity of greater than 30/mn/100cm^3.The reflective or diffractive layer may be a foil layer. The reflective or diffractive layer may comprise any thin laminar material. The reflective or diffractive layer may be metallic. Equally, the reflective or diffractive layer may be non-metallic. For example, the reflective or diffractive layer may be a polymer film. Regions where the reflective or diffractive layer is not present may be referred to as "metal-free" regions regardless of whether or not the reflective or diffractive layer is a metallic layer. There may be one or more metal-free regions.

The device may further comprise an adhesive layer between the substrate and the bonding layer.

The one or more second regions may be configured to form one or more shaped windows in the thread. The one or more second regions may be any shape or size. The one or more second regions may, but need not, be rectangular, in which case an apparently conventional windowed thread effect will result when the device is incorporated into a security paper. The one or more second regions may be circular. They may be star-shaped. They may be of an irregular shape. Advantageously, the location of the second regions may be chosen to correspond with any designs present on the device.

The substrate may be transparent. If the substrate is transparent, metal-free regions of the substrate that are in register on both surfaces of the substrate will stand out clearly against the regions covered by the reflective or diffractive layer when the security device is viewed in transmitted light.

The reflective or diffractive layer may have been applied to the substrate by a cold foil process. If such a process is used, it creates a possibility that the reflective or diffractive layer need not be a plain reflective or diffractive layer. For example, the reflective or diffractive layer may include a plurality of regions, each of the regions being a different colour to adjacent regions. The plurality of regions may form a geometric pattern. The plurality of regions may form text. Alternatively or additionally, the reflective or diffractive layer may include a holographic design.

The security device may include at least two light-emitting components and at least one light-absorbing component between two of the light-emitting components.

Preferably the security device includes exactly two light-emitting components and one light-absorbing component between the two light-emitting components. The light-absorbing component may be incorporated in the substrate. Alternatively the light-absorbing component may be in the form of a coating on at least one face of the substrate. Preferably the light-absorbing component is an ultraviolet-light-absorbing component, in which case preferably the light-emitting components are fluorescent components. Preferably each of the fluorescent components fluoresces in ultraviolet light at a different visible colour. The light absorbent component may be an infrared-absorbent component, in which case preferably the light-emitting components emit light via the anti-Stokes effect. Preferably each of the light emitting components emit light of a different visible colour when illuminated with infrared light.

At least one of the light-emitting components may include a plurality of parts, each of the plurality of parts emitting light of different visible colours to adjacent parts. The plurality of parts may form a geometric pattern. The plurality of parts may form text.

The security device may be arranged such that both surfaces of the substrate include metal-free regions not covered by the reflective or diffractive layer, said regions being in register. If the substrate is transparent, these metal-free regions will stand out clearly when the device is viewed in transmitted light, even when it is incorporated into a security paper. The reflective or diffractive layer may be opaque. If the device includes light-emitting components and the reflective or diffractive layer is

opaque, visible light will only be emitted from the light-emitting components in the metal-free regions. The metal-free regions will therefore appear to glow when the device is viewed in the correct type of light (for example ultraviolet) and will stand out clearly against the regions covered by the reflective or diffractive layer. The metal-free regions may be in the form of text.

The second regions (where the bonding layer is not present) may encompass the metal-free regions. Any visual effect created by the metal-free regions will therefore not be obscured by the bonding layer. When the device is incorporated in a security paper, the second regions will remain at the surface of the security paper, ensuring that any visual effect created by the metal-free regions is apparent when the security paper is viewed in the appropriate sort of incident light. Alternatively, the second regions may coincide with areas of the substrate that are covered by the reflective or diffractive layer. In this case the reflective or diffractive layer will be directly visible in these regions when the device is viewed in reflected visible light.

The reflective or diffractive layer may be translucent. The reflective or diffractive layer, if translucent, may be located directly over at least part of at least one of the light emitting components. This means that light emitted by the at least one light emitting component may pass through the reflective or diffractive layer. The reflective or diffractive layer, if translucent, may correspond to a first part of the at least one light emitting component. One or more of the metal-free regions may correspond to one or more

second parts of the light emitting component. The first and second parts of the at least one light emitting component preferably emit light of different visible colours. This creates the effect that, when viewed in the appropriate incident light to activate the at least one light emitting component, the regions covered by the reflective or diffractive layer and the metal-free regions appear different colours.

The width of the bonding layer or layers may be greater than the width of the substrate. Advantageously, this creates a significantly stronger bond between the security device and a security paper into which it is embedded than if the paper layer and the substrate are the same width. It is believed that the greater surface area of the bonding layer allows more hydrogen bonds to form between the bonding layer and the security paper. This results in the further advantage that a wider substrate may be used.

The security device may comprise a hydrophobic coating. The coating may cover one or more third regions, the one or more third regions being within or substantially the same as the one or more second regions. The hydrophobic coating may be a varnish. Alternatively the hydrophobic coating may be a gel. Preferably the hydrophobic coating is a UV varnish. If the one or more second regions carry a hydrophobic coating, they can be expected to remain exposed at the surface of the security paper when the device is incorporated into such a security paper. This ensures that the designs on the device will, if desired, be visible at the surface of the security paper rather than hidden within it.

The invention further provides, according to a second aspect, a method of making a security device for incorporation into a security paper, the method comprising at least the steps of

providing a flexible substrate having two surfaces and a reflective or diffractive layer on at least part of one or both surfaces, and

applying a bonding layer to one or both surfaces such that at least one surface of the device has one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present.

The step of applying a bonding layer may comprise gluing the bonding layer to the at least one surface of the device. The step of applying a bonding layer may comprise coating the at least one surface of the device with an adhesive layer. Alternatively the step of applying a bonding layer may comprise coating a surface of the bonding layer with an adhesive layer.

The method may be performed such that the bonding layer is a paper layer. The method may further comprise the step of providing windows in the bonding layer before it is applied to the substrate. The method may further comprise the step of applying a hydrophobic coating such that the coating covers one or more third regions, said one or more third regions being within or substantially the same as the one or more second regions.

The invention further provides, according to a third aspect, a security paper including a security device as described above.

The invention further provides, according to a fourth aspect, a method of making a security paper incorporating a security device, the method comprising the steps of

pre-selecting one or more first regions of the security device and one or more second regions of the security device,

forming a pulp,

including in the pulp a security device, and

forming the security paper from pulp,

wherein the one or more first regions of the security device form part of at least one surface of the security paper and the one or more second regions of the security device are embedded within the security paper. The step of pre-selecting one or more first regions of the security device and one or more second regions of the security device may include the step of applying a strip having pre-cut windows to at least one surface of the device such that the windows correspond to the second regions. The strip may be a paper strip. The step of applying a strip may comprise gluing the strip to the at least one surface of the device. The step of applying a strip may comprise coating the at least one surface of the device with an adhesive layer. Alternatively the step of applying a strip may comprise coating a surface of the strip with an adhesive layer.

The step of pre-selecting one or more first regions of the security device and one or more second regions of the security device may include the step of applying a hydrophobic coating to the second regions of the security device. The step of forming the security paper from pulp may comprise forming hydrogen bonds between the security device

and the security paper. The step of forming the security paper from pulp may comprise forming hydrogen bonds between the one or more second regions and the security paper. The step of forming the security paper from pulp may comprise forming hydrogen bonds between the strip and the security paper. The method may be performed such that the security device is a security device as described above.

The invention further provides, according to a fifth aspect, a security device for incorporation into a security paper, the device comprising

a flexible substrate having two surfaces and at least two edges, and

a bonding layer,

wherein the bonding layer has a first portion that is attached to the flexible substrate on at least part of one or both of the surfaces.

The bonding layer may have a second portion that extends from the first portion beyond at least one of the edges.

It may be that the bonding layer has a width and the substrate has a width that is less than the width of the bonding layer.

It may be that the substrate is a rectangular strip. The first portion may be coterminous with the strip. It may be that the second portion extends beyond a long edge of the strip (for example forming an elongate wing portion beyond one or both edges of the rectangular strip).

Providing portions of the device which comprise only the bonding layer ensures that strong adhesion is achieved between the device and paper into which it is embedded. The

degree of adhesion achievable means that devices according to the present invention can be significantly wider than prior art devices, a feature which helps to ensure that the device remains in the correct orientation during the papermaking process.

It may be that there is a bonding layer on only one of the surfaces. Alternatively there may be a bonding layer on both surfaces. If a bonding layer is provided on only one surface, the device can be inserted into a security document during the papermaking process in an orientation such that the entire surface of the device which does not have a bonding layer forms part of the surface of the security document and is therefore visible. Alternatively, if a bonding layer is provided on only one surface, the device can be inserted in to a security document during the papermaking process in upside-down orientation which results in the device being completely embedded within the paper, and it may therefore be not visible. If a bonding layer is provided on both surfaces of the device, areas of the device surfaces where the bonding layer is present will be completely embedded when the device is inserted into a security paper during the papermaking process. Various different visual effects can therefore be created in the final security document depending on the arrangement of bonding layers on the device.

At least one surface of the security device may have one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present. If the security device has one or more second regions, the security device may further comprise a

hydrophobic coating. The security device may comprise a reflective or diffractive layer on at least part of one or both surfaces, between the substrate and the bonding layer. The device may further comprise an adhesive layer between the substrate and the bonding layer. The reflective or diffractive layer may be a foil layer. The reflective or diffractive layer may comprise any thin laminar material.

The reflective or diffractive layer may be metallic. Equally, the reflective or diffractive layer may be non-metallic. For example, the reflective or diffractive layer may be a polymer film. The reflective or diffractive layer may be a metallic layer. (Regions where the reflective or diffractive layer is not present may be referred to herein as "metal-free" regions regardless of whether or not the reflective or diffractive layer is a metallic layer.) There may be one or more metal-free regions.

The reflective or diffractive layer may have been applied to the substrate by a cold foil process. If such a process is used, it creates a possibility that the reflective or diffractive layer need not be a plain reflective or diffractive layer. For example, the reflective or diffractive layer may include a plurality of regions, each of the regions being a different colour to adjacent regions. The plurality of regions may form a geometric pattern. The plurality of regions may form text. Alternatively or additionally, the reflective or diffractive layer may include a holographic design.

The substrate may be transparent. If the substrate is transparent, metal-free regions of the substrate that are in register on both surfaces of the substrate will stand out

clearly against the regions covered by the reflective or diffractive layer when the security device is viewed in transmitted light.

It may be that the security device includes at least two light-emitting components and at least one light-absorbing component between two of the light-emitting components. Preferably the security device includes exactly two light-emitting components and one light-absorbing component between the two light-emitting components. The light-absorbing component may be incorporated in the substrate. Alternatively the light-absorbing component may be in the form of a coating on at least one face of the substrate. Preferably the light-absorbing component is an ultraviolet light-absorbing component, in which case preferably the light-emitting components are fluorescent components. Preferably each of the fluorescent components fluoresces in ultraviolet light at different visible colours. The light-absorbing component may be an infrared-absorbing component, in which case preferably the light-emitting components emit light via the anti-Stokes effect. Preferably each of the light-emitting components emit light of different visible colours when illuminated with infrared light.

At least one of the light-emitting components may include a plurality of parts, each of the plurality of parts emitting light of different visible colours to adjacent parts. The plurality of parts may form a geometric pattern. The plurality of parts may form text.

Both surfaces of the subtrate may include metal-free regions not covered by the reflective or diffractive layer,

said regions being in register. If the substrate is transparent, these metal-free regions will be clearly visible when the device is viewed in transmitted light, even when it is incorporated into a security paper. The reflective or diffractive layer may be opaque. If the device includes light-emitting components and the reflective or diffractive layer is opaque, visible light will only be emitted from the light-emitting components in the metal-free regions. The metal-free regions will therefore appear to glow when the device is viewed in the correct type of light (for example ultraviolet) and will stand out clearly against the regions covered by the reflective or diffractive layer. The metal-free regions may be in the form of text.

If the device comprises second regions (where the bonding layer is not present), the second regions may encompass the metal-free regions. Alternatively, the second regions may coincide with areas of the substrate that are covered by the reflective or diffractive layer. The reflective or diffractive layer may be translucent. The reflective or diffractive layer, if translucent, may be located directly over at least part of at least one of the light emitting components. The reflective or diffractive layer, if translucent, may correspond to a first part of the at least one light-emitting component. One or more of the metal-free regions may correspond to one or more second parts of the light-emitting component. The first and second parts of the at least one light-emitting component preferably emit light of different visible colours.

The invention further provides, according to a sixth aspect, a method of making a security device for

incorporation into a security paper, the method comprising at least the steps of

providing a flexible substrate having two surfaces and at least two edges, and

applying a bonding layer to one or both surfaces so as to form a first portion of the bonding layer that is attached to the flexible substrate.

The bonding layer may be applied to one or both surfaces so as to form a second portion that extends from the first portion beyond at least one of the edges.

The method may be performed such that the bonding layer is a paper layer. The method may further comprise the step of providing windows in the bonding layer before it is applied to the substrate. The windows may be pre-cut so that they correspond with any designs present on the substrate. If the method includes the step of providing windows in the bonding layer, the method may further comprise the step of applying a hydrophobic coating to one or more regions of the device, said one or more regions corresponding to the windows in the bonding layer.

The invention further provides, according to a seventh aspect, a security paper including a security device according to the fifth aspect of the invention

It may be that the second surface of the device does not have a bonding layer. If the second surface of the device does not have a bonding layer it may be that the second surface of the device forms part of the surface of the security paper. Alternatively the security device may be completely embedded within the security paper.

The first surface of the device may have one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present. In this case the security paper may be arranged such that the first regions of the security device are embedded within the paper and the second regions of the security device form part of the surface of the security paper. The security device may be a security device as described above in relation to the first or fifth aspects of the invention.

The invention further provides, according to an eighth aspect, a method of making a security paper incorporating a security device, the method comprising the steps of

providing a security device according to the first aspect of the invention,

forming a pulp,

including the security device in the pulp, and

forming the security paper from the pulp.

The method may further comprise the step of pre-selecting one or more first regions of the security device and one or more second region of the security device, wherein the one or more first regions of the security device form part of at least one surface of the security paper and the one or more second regions of the security device are embedded within the security paper.

It may be that the security paper is formed from the pulp using a Fourdrinier machine.

The present invention provides, according to a ninth aspect, a security device for incorporation into a security paper, the device comprising

a flexible substrate having two surfaces, and

a bonding layer on at least part of one or both surfaces,

wherein the bonding layer and the substrate are arranged such that the device comprises a first portion where the bonding layer and the substrate are both present and a second portion where the bonding layer is present but the substrate is not present.

It will of course be appreciated that features described in relation to one aspect of the present invention may be incorporated into other aspects of the present invention. For example, the method of the invention may incorporate any of the features described with reference to the device of the invention and *vice versa*.

Description of the Drawings

Embodiments of the present invention will now be described by way of example only with reference to the accompanying schematic drawings of which:

Figure 1a is a cross section of an example security device according to a first embodiment of the invention;

Figure 1b is a plan view of an example security device according to a first embodiment of the invention;

Figure 2 is a schematic view of an example security device according to a second embodiment of the invention;

Figure 3a is a cross section of an example security device according to a third embodiment of the invention;

Figure 3b is a plan view of an example security device according to a third embodiment of the invention;

Figure 4a is a cross section of an example security device according to a fifth embodiment of the invention;

Figure 4b is a plan view of an example security device according to the fifth embodiment of the invention;

Figure 5a is a transverse cross-section through a security device according to a sixth example embodiment of the invention;

Figure 5b is a plan view of a first example security paper incorporating a security device according to the sixth embodiment of the invention; and

Figure 5c is a plan view of a second example security paper incorporating a security device according to the sixth embodiment of the invention.

Detailed Description

Figs. 1a and 1b show an example of a security device according to a first example embodiment of the invention, in the form of a security thread. The thread is composed of a thin strip of transparent polyester substrate 10, in this example 2 mm x 100 mm. Any other polymer could also be used. The substrate 10 has two surfaces 12 and 14. Each face includes a region 16 where an opaque metallic foil has been applied by a cold foil stamping process, and several regions 18 that have been left free of foil. The foil-free regions are in the form of text, and the text on each face is in register. Consequently, when the thread is viewed in transmitted visible light the text stands out clearly against the opaque foil covered region.

A strip of opaque tissue paper 17 slightly wider than the substrate has been glued to each surface. The optimum paper is a high porosity, high wet strength tissue paper with a nominal basis weight of 25 grams per square metre. The properties of the paper are listed below. These properties have been developed with the intention of providing a device that works well but are only one example. Other papers could be used.

Properties	**Units**	**Minimum**	**Maximum**	**Average**
Substance	g/m^2	15	45	24.8
Lemm capillary climb md	mm	16	17	16.6
Wet tensile strength	N/15mm	4.5	5.9	5.14
Bulk	Cm^3/g	2.4	2.5	2.46
High porosity	$1/mn/100cm^2$	24	31.2	27.9
Humidity	%	4.9	7.0	4.98
pH of aqueous extract				6.8

Before being applied to the substrate, several rectangular windows were cut into the paper strips 17 in locations corresponding to the locations of the foil-free regions 18 such that when the paper strips 17 are applied to the substrate 10 the foil-free regions 18 are not covered by the paper layer. The presence of the paper layers 17 significantly improves the adhesion between the security thread and the base paper into which it is embedded when it is incorporated into a security document as compared with

prior art threads not having paper layers because hydrogen bonds form between the fibres in the paper layers 17 and the fibres in the base paper during the papermaking process.

Fig. 1b shows that when a surface of the device is viewed in plan, there is a first region indicated by closely spaced hatching which is covered by the paper strip 17, and a second region, indicated by widely spaced hatching, which is not covered by the paper strip 17 because this second region corresponds with one of the pre-cut windows in the paper strip. Although only the surface 12 is shown, clearly the opposite surface 14 will be the same. The paper layers 17 are wider than the substrate 10, which results in the creation of two edge regions 15 which are composed entirely of paper. The presence of these edge regions 15 further improves the adhesion between the security thread and the base paper.

After the paper strip has been applied, a transparent coating 19 is printed or coated onto to the second, paper-free, regions. This coating is a UV varnish with a low surface energy and has properties that prevent paper fibres from forming on its surface. The presence of the coating in these regions means that when the security thread is incorporated into a security paper using a fourdriner papermaking machine, no paper fibres can form in the second regions and so these regions form part of the surface of the finished security paper. When the second regions are in register as is the case in the example shown in figs. 1a and 1b this ensures that the foil-free regions of the transparent substrate are exposed so that the text will be clearly visible.

Fig. 2 shows an example security device in the form of a security thread according to a second example embodiment of the invention. As with the thread of the first embodiment, the thread of the second embodiment is composed of a transparent polyester substrate 20 having two faces (only one face, 22, is shown). Each face includes a region 26 where an opaque metallic foil has been applied by a cold foil stamping process, several foil-free regions 28 (only one is shown) that are in the form of text. The metallic foil also bears a design 25. In the example thread shown in fig. 2 the design takes the form of currency symbols and numbers. The numbers and symbols appear red, whereas the rest of the foil appears green when viewed in visible light. The design can, if desired, be holographic. Foils bearing holographic and/or coloured designs are readily commercially available, for example from API Group.

As with the thread of the first embodiment, the thread of the second embodiment has an opaque paper strip 27, which is slightly wider than the substrate, applied to each face, over the foil. The paper-covered region of the thread is indicated by the closely spaced hatching. Edge regions 23 are composed only of paper. In this case the pre-cut windows (only one window shown, indicated by widely spaced hatching) in the strips are diamond shaped. The paper-free region encompasses both the text formed by the foil-free region 28 and the foil design 25. A hydrophobic coating 29 is applied to the paper free regions of the thread, ensuring that these remain at the surface of the security paper when the thread is incorporated into such a paper so that the designs remain visible.

Figs. 3a and 3b show an example security device in the form of a security thread according to a third example embodiment of the invention. The thread is composed of a thin strip of transparent polyester substrate 30. The substrate 30 contains an ultraviolet light absorber, such as titanium dioxide, which is introduced into the polyester during manufacture of the substrate. The presence of the absorber causes the substrate to absorb significantly more light in the ultraviolet spectral region than it would if it did not contain the absorber.

One face 32 of the substrate is coated with a fluorescent coating 33 which fluoresces under UV illumination. The coating 33 consists of a fluorescent pigment or dye incorporated into a binder material and is applied to the substrate by a contact printing process. The second face 34 of the substrate is coated with a second fluorescent coating 35 of a similar composition to the first coating 33, but it fluoresces at a different wavelength to the wavelength at which the first coating 33 fluoresces. This means that the coatings 33, 35 appear different colours in UV light, for example red and green respectively. The coatings 33, 35 are substantially transparent in visible light.

Each face 32, 34 includes a region 36 where an opaque metallic foil has been applied by a cold foil stamping process, and several regions 38 that have been left free of foil. The foil-free regions are in the form of text, and the text on each face is in register.

UV light which is incident on the foil-free regions 38 on face 32 causes the coating 33 to fluoresce. The

ultraviolet absorber in the substrate 30 prevents the UV light from reaching coating 35. The visible red light produced by coating 33 is emitted in all directions meaning that the foil-free regions on face 32 appear red in reflected UV light and the foil-free regions on face 34 appear red in transmitted UV light. UV light which is incident on the foil-free regions 38 on face 34 causes the coating 35 to fluoresce, producing visible green light. The ultraviolet absorber in the substrate 30 prevents the UV light from reaching coating 33. This has the effect that the foil-free regions on face 34 appear green in reflected UV light and the foil-free regions on face 32 appear green in transmitted UV light. Thus if a viewer looks at the same face of the thread in reflected and then in transmitted UV light, the colour of the text will change.

As with previously described embodiments, the thread of the third embodiment has an opaque paper strip 37 applied to each surface, over the foil. The paper-covered region of the thread is indicated in fig. 3b by the closely spaced hatching. In this case the pre-cut windows (only one window shown, indicated by widely spaced hatching) in the strips are rectangular. The paper-free region encompasses the text formed by the foil-free regions 38. A hydrophobic coating 39 is applied to the paper free regions of the thread, ensuring that these remain at the surface of the security paper when the thread is incorporated into such a paper. This ensures that the design remains visible in reflected light, and that the fluorescent colour switch effect is as clear as possible.

A fourth example security device (not illustrated) is identical to the third example security device, except that the metallic foil is translucent rather than opaque, and the fluorescent coatings 33, 35 are not uniform. Instead, the fluorescent coatings are printed so that areas of coating that are covered by foil contain a fluorescent pigment or dye that emits visible blue (coating 33) or pink (coating 35) light when illuminated with UV light, whilst the areas of coating that are not covered by foil contain a fluorescent pigment or dye that emits visible red (coating 33) or green (coating 35) light when illuminated with UV light.

Because the metallic foil used in this embodiment is semi-transparent rather than completely opaque, UV light can pass through it to reach the fluorescent coatings 33, 35 and visible light emitted by the coatings 33, 35 can pass through it to reach the eyes of a viewer. The effect of the semi-transparent foil and multi-coloured coatings is that when face 32 of the thread is viewed in reflected UV light the text appears red and the surrounding thread appears blue. When the same face 32 is viewed in transmitted UV light the text appears green and the surrounding thread appears pink. The colour switch effect is reversed for face 34. The semi-transparent metallic foil may appear an entirely different colour, such as gold, in visible light. Such semi-transparent foils are readily commercially available.

The regions of the thread not covered by paper strip 37 and treated with the hydrophobic coating (i.e. the rectangular windows such as that denoted by the widely

spaced hatching) are sufficiently large that a significant proportion of the foil will be visible at the surface of any security paper into which the thread is incorporated. This ensures that the contrasting colour switch effects created by the foil covered region 36 and the foil-free regions 38 are easily apparent.

Figs. 4a and 4b show an example security device in the form of a security thread according to a fifth example embodiment of the invention. The thread is composed of a thin strip of transparent polyester substrate 40. One face 42 of the substrate is coated with a first fluorescent coating 43, a second fluorescent coating 45, and an ultraviolet light absorbing coating 47 between the first and second fluoresent coatings. The first and second fluorescent coatings fluoresce under UV illumination and are of a standard composition similar to that described above in relation to the third embodiment. The first and second fluorescent coatings 43, 45 fluoresce at different wavelengths, so that the first fluorescent coating 43 appears green in UV light whereas the second fluorescent coating 45 appears red in UV light. The coatings 43, 45 are substantially transparent in visible light.

The opposite face 44 of the substrate, shown by fig. 4b, includes a region 46 where an opaque metallic foil has been applied by a cold foil stamping process, and several regions 48 that have been left free of foil. The foil-free regions are of irregular quadrilateral shape when the thread is viewed from above face 44.

The thread of the fifth embodiment has a translucent paper strip 47 applied to the face 44 of the substrate, over

the foil. The paper-covered region of the thread is indicated in fig. 4b by hatching. The paper strip is slightly wider than the substrate, creating edge regions 52 which are composed only of paper. As with the third embodiment, the paper strip includes pre-cut windows 50, which in this case are of irregular quadrilateral shape. The paper-free regions created by the windows 50 are arranged such that they correspond with the metal-covered region 46.

UV light which is incident on face 42 causes the coating 45 to fluoresce. The ultraviolet absorber in the coating 47 prevents the UV light from reaching coating 43. The visible red light produced by coating 45 is emitted in all directions meaning that all of face 42 appears red in reflected UV light, while the foil-free regions on face 44 appear red in transmitted UV light. The metal foil used in this embodiment is opaque, so the foil-covered regions on face 44 appear dark in transmitted UV light.

UV light which is incident on the foil-free regions 48 on face 44 passes through the translucent paper layer and the substrate and causes the coating 43 to fluoresce, producing visible green light. The ultraviolet absorber in the coating 47 prevents the UV light from reaching coating 45. This has the effect that the foil-free regions on face 44 appear green in reflected UV light (while the foil-covered regions remain dark) and the areas on face 42 that correspond to the foil-free regions on face 44 appear green in transmitted UV light. Thus if a viewer looks at the same face of the thread in reflected and then in transmitted UV light, the colour of the face (or at least the foil-free regions on the face) will change.

Fig. 5a shows a cross section through the width of an example of a security device according to a sixth example embodiment of the invention, in the form of a security thread. As with the threads of the previous embodiments, the thread 70 is composed of a thin strip of transparent polyester substrate 60 having two surfaces 62 and 64. A layer of opaque metallic foil 66 has been applied to each surface 62, 64 by a cold foil stamping process.

As with the threads of the previous embodiments, a strip of opaque tissue paper 67 slightly wider than the substrate has been glued to surface 62, on top of the foil layer 66. The arrangement of the substrate 60 and paper layer 67 results in the device having two edge portions 65 which are composed entirely of paper, and a central portion 63 which is composed of substrate, foil and paper. The edge portions 65 bond particularly strongly with the base paper when the security thread is embedded into a security paper through the formation of hydrogen bonds between the fibres in the base paper and the fibres in the paper layer 67.

The security thread can be embedded into a security document using a standard fourdrinier papermaking machine. Figure 5b shows a first example security document 68 comprising base paper 61 and the security thread 70 of figure 5a. The thread 70 has been inserted into the pulp during the papermaking process so that surface 64 is at the surface of the pulp. This face does not have a paper layer, and the paper fibres in the pulp cannot readily bind to the polyester substrate 60 or the metallic foil layer 66. The paper fibres do, however, readily bind to the paper layer 67 through the formation of hydrogen bonds as, and so this

layer becomes embedded within the base paper 61. The result is that when the security paper 68 is viewed in plan from a first side (as shown in fig. 5b) the central portion 63 of surface 64 is visible in reflected light, whereas edge portions 65 are not visible. When the security paper 68 is viewed in plan from a second side (not shown), the thread 70 is not visible at all in reflected light.

Fig. 5c shows a second example security document 69 comprising base paper 61 and the security thread 70 of figure 5a. The thread 70 has been inserted into the pulp during the papermaking process the opposite way up to when security document 68 was made, i.e. so that surface 62 with its paper layer 67 is at the surface of the pulp. The paper fibres in the pulp bind readily to the paper layer 67 through the formation of hydrogen bonds, leading to the substrate 60 becoming completely embedded within the base paper 61. The result is that the thread 70 is not visible at all in reflected light when the security document 69 is viewed in plan from either side. In both security document 68 and security document 69 the embedded thread 70 will be visible in transmitted light, since the metallic foil 66 is more opaque than the base paper 61.

A security device according to the present invention, such as any of the security threads described above, can be incorporated into a security paper, for example a banknote, using a standard fourdrinier papermaking machine by simply adding the thread from a bobbin to the pulp in the appropriate location and then running the machine in a normal manner as well known in the art. The combination of the paper layer and the hydrophobic coating ensures that

certain regions of the thread (i.e. those having the hydrophobic coating) will end up at the surface of the finished security paper, whilst certain other regions (i.e. those having a paper layer) will be firmly embedded within the finished security paper.

The process of applying the metallic layer to the substrate by cold foil stamping will now be explained in more detail. In traditional hot foil stamping, a thin, pigmented or metallic foil is supplied on a special film backing. The foil is placed over a sheet of paper in the appropriate location, and then a heated die is pressed onto the backing film. The heat and pressure makes the foil adhere to the paper, so foiled area in the shape of the die is left on the paper when the die and backing film are removed. This process cannot be used to transfer a foil to a polyester substrate because the heat causes the polymer to deform.

Cold foil stamping is a process that has several similarities to hot foil stamping, but does not require the use of heat. Cold foils, after application, generally consist of a lacquered layer which determines the colour of the foil, a layer of vacuum deposited aluminium, and a UV light activated adhesive layer. They are applied by first printing the adhesive onto the substrate in an appropriate design. The foil is then placed against the adhesive, and the whole "sandwich" is illuminated with UV light to cure the adhesive. Areas of the foil in contact with the adhesive will then remain on the substrate when the backing is removed.

This process is relatively fast, and the necessary equipment can be placed in series with the equipment used to manufacture the substrate and/or apply other coatings to it. Foils bearing different colours and designs are manufactured by altering the lacquer layer, and are readily commercially available.

In the description above, several particlar examples have been described, but it should be understood that many other variations and modifications are also possible. For example, all of the above examples describe security devices in the form of threads. However, the invention may also be applied to other security devices suitable for inclusion in a pulp from which a security paper is to be made, for example planchettes. The security device may be used on or in security papers other than banknotes, for example it may be used on or in cheques, ID cards, passports, vouchers, security labels and the like.

A paper strip need not be applied to both surfaces of the security device. For example, a paper strip may be applied to both surfaces of the security device, but it may be that only one of the strips has pre-cut windows.

The "metallic" layer need not be a metallic foil, and indeed need not actually be metallic. The metallic layer need not have been applied by a cold foil stamping process. For example the metallic layer may have been applied by vacuum depositing a metal coating onto the substrate and then using a chemical resist and etch process to demetallise specific areas. The metal-free regions need not be in the form of text, and indeed there need not be any metal-free regions at all. Any number and combination of fluorescent

pigments may be used. The fluorescent coatings may be activated by incident light other than UV light. For example the flourescent coatings may be replaced by coatings which emit light via the anti-Stokes effect when illuminated with infrared light. In this case it will be understood that the substrate needs to contain an infrared absorber rather than an ultraviolet absorber. The absorber need not be incorporated within the substrate, instead it could be a separate coating applied to one face of the substrate, between the substrate and the fluorescent coating.

Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or features of the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims. Moreover, it is to be understood that such optional integers or features, whilst of possible benefit in some embodiments of the invention, may not be desirable, and may therefore be absent, in other embodiments.

Claims

1. A security device for forming a windowed security thread in a security paper, the device comprising

a flexible substrate having two surfaces,

a bonding layer on at least part of one or both surfaces, and

a reflective or diffractive layer on at least part of one or both surfaces, between the substrate and the bonding layer,

wherein at least one surface of the device has one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present, and wherein the one or more second regions are configured to form one or more shaped windows in the thread.

2. A security device as claimed in claim 1, in which the bonding layer is arranged such that hydrogen bonds form between the bonding layer and the security paper during a process of forming the security paper.

3. A security device as claimed in claim 1 or claim 2, in which the bonding layer is a paper layer.

4. A security device as claimed in any preceding claim, in which the bonding layer is glued to the one or both surfaces.

5. A security device as claimed in any preceding claim, in which the device includes at least two light-emitting components and at least one light-absorbing component between two of the light-emitting components.

6. A security device according to any preceding claim, in which both surfaces of the subtrate include metal-free regions not covered by the reflective or diffractive layer, said regions being in register.

7. A security device according to claim 6, in which the second regions encompass the metal-free regions.

8. A security device as claimed in any preceding claim, in which the width of the bonding layer is greater than the width of the substrate.

9. A security device as claimed in any preceding claim, in which at least one surface of the device comprises at least one region which appears a first colour when viewed with transmitted ultraviolet light and a second colour when viewed with reflected ultraviolet light, wherein the second colour is different to the first colour.

10. A security device as claimed in any preceding claim, in which the security device comprises a hydrophobic coating which covers one or more third regions, the one or more third regions being within or substantially the same as the one or more second regions.

11. A method of making a security device for incorporation into a security paper, the method comprising at least the steps of

providing a flexible substrate having two surfaces and a reflective or diffractive layer on at least part of one or both surfaces, and

applying a bonding layer to one or both surfaces such that at least one surface of the device has one or more first regions in which the bonding layer is present and one or more second regions in which the bonding layer is not present.

12. A method as claimed in claim 10, wherein the step of applying a bonding layer comprises gluing the bonding layer to the at least one surface of the device.

13. A method as claimed in claim 11 or claim 12, wherein the method further comprises the step of applying a hydrophobic coating such that the coating covers one or more third regions, said one or more third regions being within or substantially the same as the one or more second regions.

14. A security paper including a security device as claimed in any of claims 1-10.

15. A security paper as claimed in claim 14, in which the security paper has two surfaces, wherein the first regions of the security device are embedded within the paper and the second regions of the security device form part of at least one surface of the security paper.

16. A method of making a security paper incorporating a security device, the method comprising the steps of

pre-selecting one or more first regions of the security device and one or more second regions of the security device by applying a strip having pre-cut windows to at least one surface of the device such that the windows correspond to the second regions,

forming a pulp,

including in the pulp a security device, and

forming the security paper from the pulp,

wherein the one or more first regions of the security device form part of at least one surface of the security paper and the one or more second regions of the security device are embedded within the security paper.

17. A method as claimed in claim 16, in which the security device is a security device according to any of claims 1-9.

18. A security device for incorporation into a security paper, the device comprising

a flexible substrate having two surfaces and at least two edges, and

a bonding layer,

wherein the bonding layer has a first portion that is attached to the flexible substrate on at least part of one or both of the surfaces and a second portion that extends from the first portion beyond at least one of the edges.

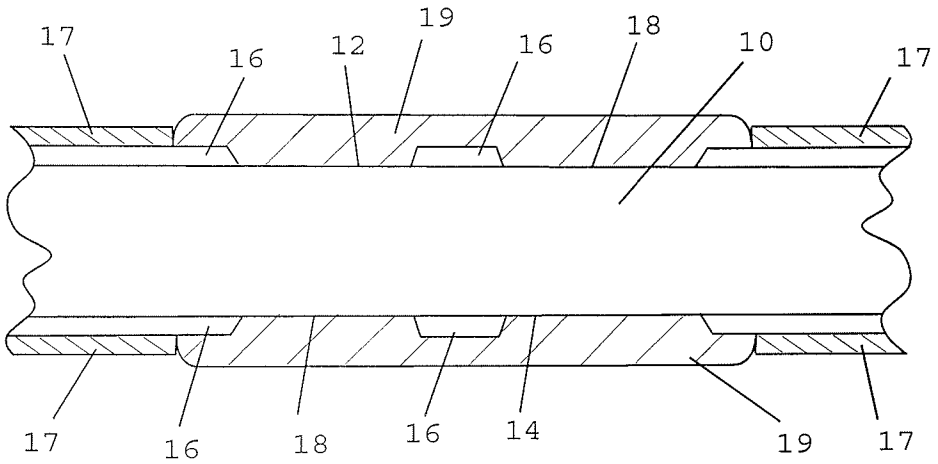

Figure 1a

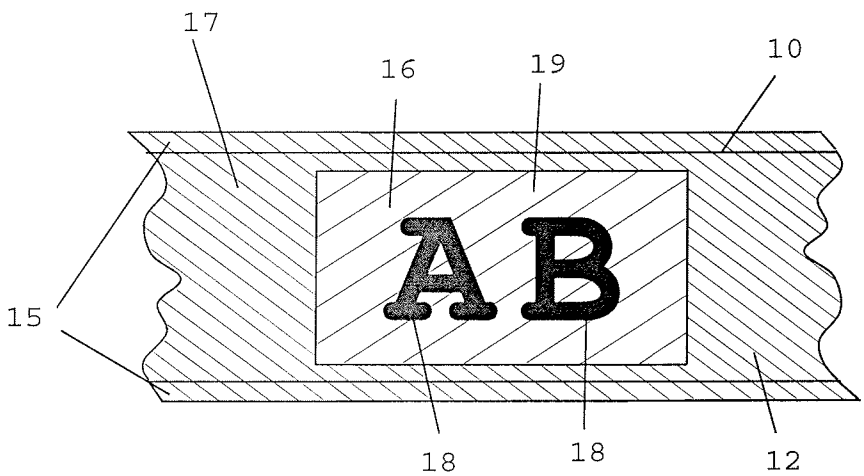

Figure 1b

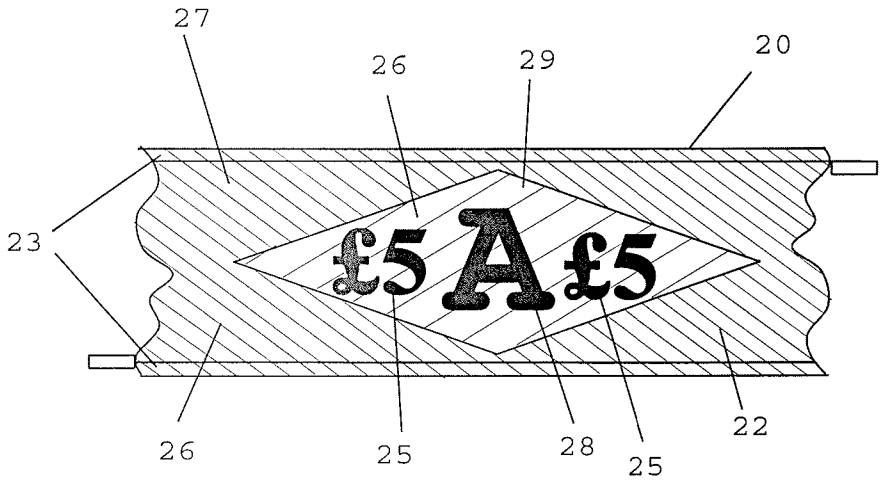

Figure 2

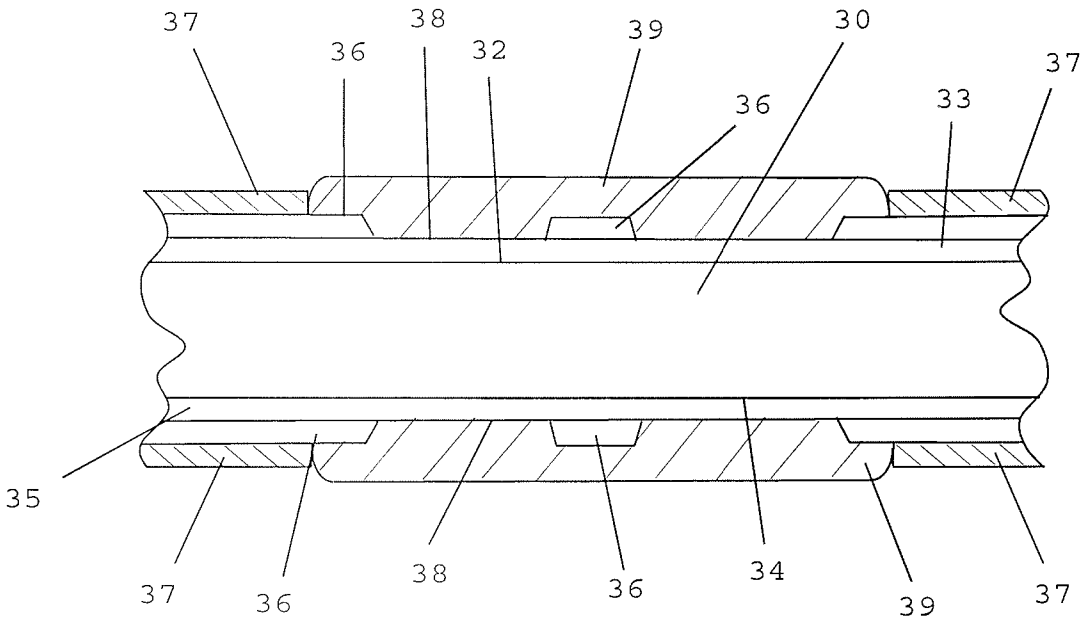

Figure 3a

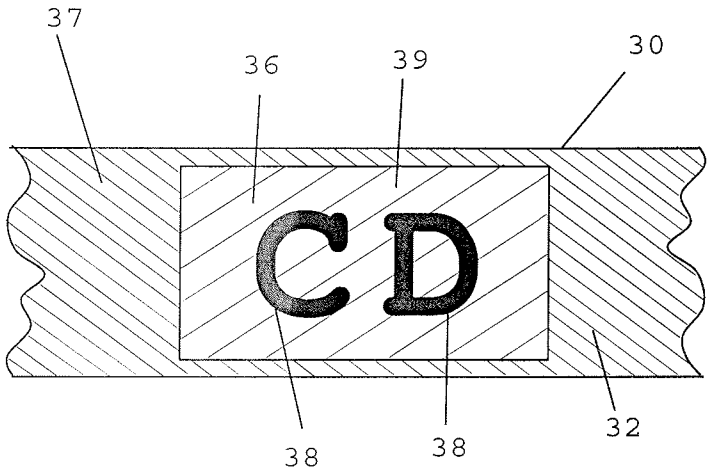

Figure 3b

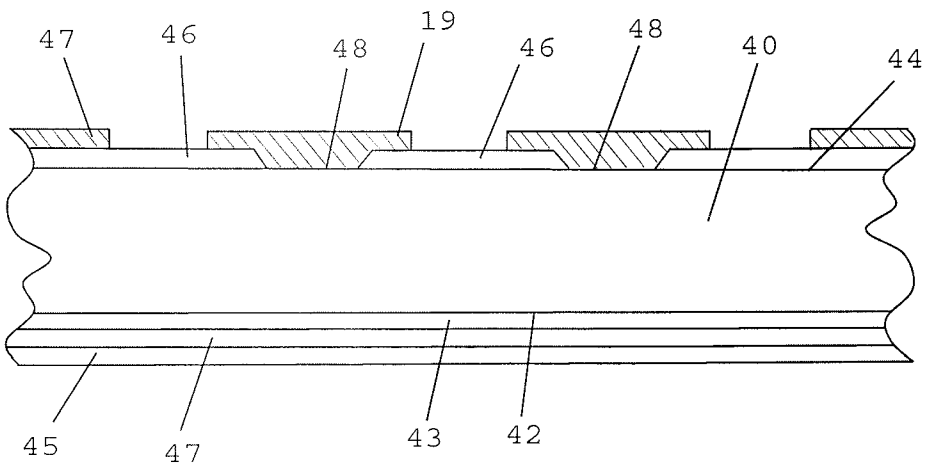

Figure 4a

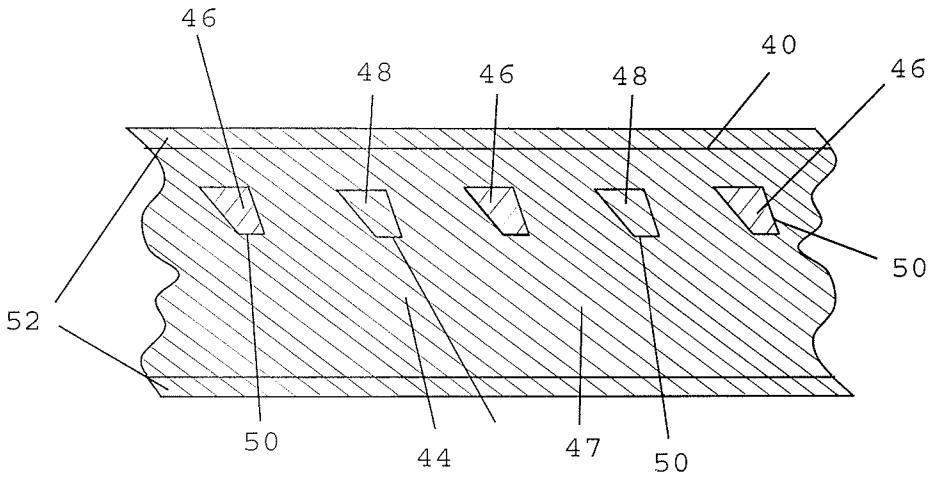

Figure 4b

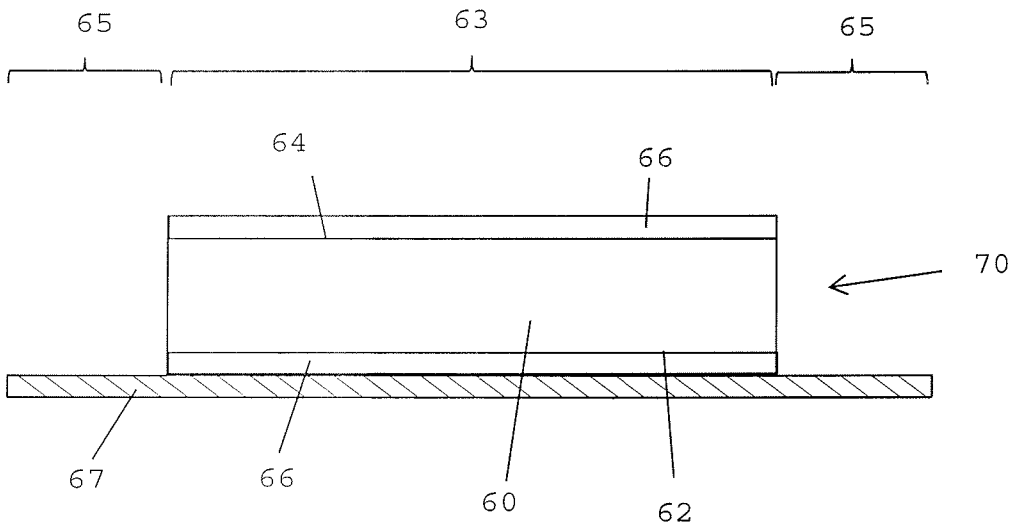

Figure 5a

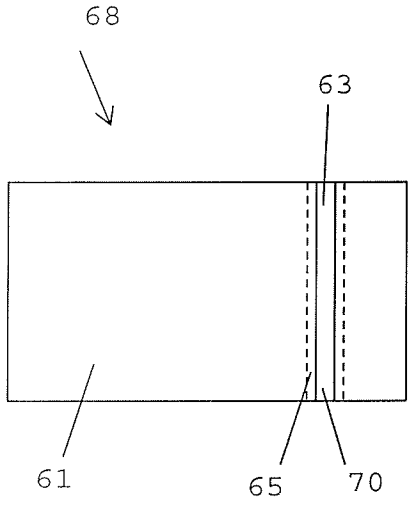

Figure 5b

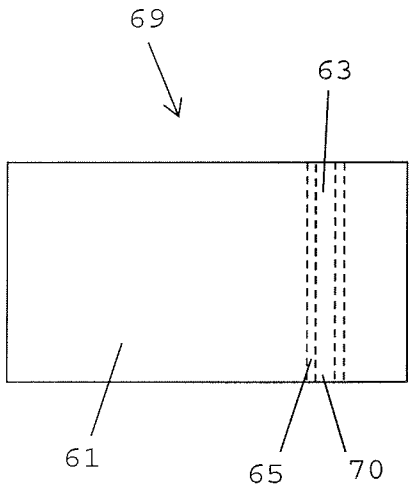

Figure 5c

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/050994

A. CLASSIFICATION OF SUBJECT MATTER
INV. B42D15/00 D21H21/42 D21H21/48
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21H B42D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/050951 A2 (GIESECKE & DEVRIENT GMBH [DE]; SCHNEIDER WALTER [DE]) 17 June 2004 (2004-06-17) page 11, line 20 - page 13, line 11; claims 1-42; figures 1-4	1-18
X	EP 1 291 463 A1 (HUECK FOLIEN GMBH [AT]) 12 March 2003 (2003-03-12) the whole document	1-18
X	GB 2 250 474 A (PORTALS LTD [GB]) 10 June 1992 (1992-06-10) claims 1-17; figures 1-7; examples 1-9	1-18
X	EP 1 903 144 A1 (TOPPAN PRINTING CO LTD [JP]) 26 March 2008 (2008-03-26) the whole document	1-18

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2012	14/06/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Chindia, Evangelia

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/050994

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 400 902 A2 (PORTALS LTD [GB]) 5 December 1990 (1990-12-05) paragraphs [0046] - [0090]; claims 1-19; figures 1-18; examples 1-6	1-18
X	EP 1 857 295 A2 (GIESECKE & DEVRIENT GMBH [DE]) 21 November 2007 (2007-11-21) the whole document	1-18
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Information on patent family members

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