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A METHOD FOR MANUFACTURING A SECURITY SUBSTRATE

The present invention is directed towards a method for manufacturing a security substrate for displaying personal data. The present invention is further directed towards a security
5 substrate and a security document made from the security substrate.

Security documents and booklets, such as passports, passbooks, identification documents, certificates, licences, cheque books and the like, commonly comprise one or more pages on which information is provided, which have security features to prevent counterfeiting.
10 For example, a passport booklet typically comprises a cover and a plurality of internal visa pages therebetween. Typically the visa pages are made from paper having a grammage of around 85 gsm and are sewn together along a stitch line. The cover is adhered to the outside of the visa pages and thereby protects the stitch line. The booklet usually has at least on one data page with security features (hereinafter referred to as at security sheet)
15 which is usually the second or the penultimate page, typically located between one of the visa pages and the cover. The security sheet usually contains personal data and is generally overlaid by a layer of polymer laminate, usually applied as a film or lacquer. This layer helps protect the data and prevent counterfeiting and fraudulent alteration. The security sheet is formed from a security substrate, which may comprise a fibrous substrate,
20 such as paper, and security features, such as watermarks, laser perforations, security fibres, security threads, security print and the like.

Alternatively, the security substrate may be a plastic substrate, which is typically polycarbonate. Plastic security substrates are more durable than fibrous security substrates
25 and are more resistant to delamination by a counterfeiter. Such plastic security substrates are typically formed from a number of thin plastic layers, which are laid over one another and fused together to form a thicker plastic substrate. The most common method of fusing the thinner plastic layers together involves placing them between a "sandwich" of steel or brass laminating plates and applying pressure. A number of such sandwiches are stacked
30 on top of each other and heat is applied to the top and bottom of the stack. The heat is transferred through the laminating plates thinner to the thinner plastic layers such that the thinner plastic layers fuse together, thereby forming a plastic sheet within each sandwich. A low temperature is then applied to the top and bottom of the stack to cool and harden the plastic sheets. However, such a method is relatively time inefficient as each heating and
35 cooling cycle lasts for around thirty minutes. Furthermore, it can lead to uneven fusing and

quality of the plastic substrate due to varying temperature and pressure distribution throughout the stack. This is caused by the laminating plates closer to the top and bottom of the stack usually being hotter (during heating) or colder (during cooling) than those in the middle of the stack.

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An alternative, semi-continuous, method of manufacturing plastic security substrates for security documents is disclosed in US-B-6669813. The thin plastic layers are brought together before being incrementally conveyed between two opposing continuous belts through a series of heating and cooling devices. A section of the thin plastic layers is initially kept stationary by the continuous belts and the layers are heated and pressed together under pressure by the heating devices such that they fuse into a plastic sheet. After a certain amount of time, typically less than a minute, the continuous belts move the section to between the cooling devices where it is cooled and pressure is again applied, typically for less than a minute. The resulting plastic substrate is substantially uniform in quality.

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Plastic security substrates may comprise various security features, such as UV responsive arrangements, optically variable features, windowed or transparent features, laser-perforations, laser markings and tactile features. However, it is not usually possible to include some of the security features in a plastic security substrate which can be included in a fibrous substrate security substrate (such as watermarks). Furthermore, the manufacture of plastic security substrates using the semi-continuous method described above presents challenges when attempting to incorporate security features.

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WO-A-2015/104011 discloses a method of forming a window in a plastic security substrate by punching a transparent filler material from a strip and inserting the filler material into an aperture punched through several thin plastic layers. During lamination the filler material and thin plastic layers fuse together to form the plastic substrate with a transparent window therein.

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WO-A-2017/060688 discloses a method of manufacturing a security substrate for displaying personal data. The security substrate is formed from a plurality of layers, in at least one of which is formed an aperture, for example by a punching process. An insert substrate is inserted into the aperture. A security element is located within and/or on the insert substrate. Further plastic layers are arranged over opposing surfaces of the insert

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substrate and the insert substrate and further plastic layers are fused together to form a plastic substrate.

However, some of the layers used in these security substrates are very thin (in the order of 30µm), especially where the layer has an aperture, in order to prevent air bubbles from forming in the finished laminate. It can be very difficult to form apertures in such thin layers. Punching can cause tearing of such thin layers. Whilst laser cutting may prevent tearing, this can cause the layers to turn brown if oxygen is present. Carrying out such operation in an oxygen-free environment is very costly.

An object of the present invention is to provide a method of manufacturing such a security substrate having improved security features and a security substrate having improved security features.

According to the invention, there is provided a method of manufacturing a security substrate comprising at least a first layer having at least one aperture, the method comprising the steps of:-

applying an adhesive in at least one first adhesive region to either the first layer or a contact layer, the at least one first adhesive region having a substantially similar shape to the at least one aperture;

applying the contact layer to the first layer with the at least one first adhesive region therebetween;

forming at least one first cut in the first layer defining at least one first cut portion of the first layer to be removed from the first layer; and

separating the contact layer and the first layer, wherein the at least one first cut portion of the first layer is adhered to the contact layer by means of the at least one first adhesive region and is removed from the first layer to form the at least one aperture; wherein the steps of applying the contact layer to the first layer and forming the at least one first cut in the first layer are carried out in either order.

Preferably the first layer is formed from a plastic material, preferably a thermoplastic material.

The first layer is preferably at least partially opaque, transparent and/or translucent and may be coloured.

The first layer is preferably laminated between a plurality of additional layers to form a unitary structure.

5 The method may further comprise the steps of:-

applying an adhesive in at least one second adhesive region to a second layer, the at least one adhesive region having a substantially similar shape to at least one second cut portion to be removed from the first layer;

10 applying the first layer to the second layer with the at least one second adhesive region therebetween;

forming the at least one cut in the first layer and at least one second cut in the first layer defining at least one second cut portion to be removed from the first layer;

applying the contact layer to the first layer with the at least one first adhesive region therebetween;

15 separating the contact layer and the first layer, wherein the at least one first cut portion of the first layer is adhered to the contact layer by means of the at least one first adhesive region and is removed from the first layer to form the at least one aperture and the at least one second cut portion remains adhered to the second layer by means of the at least one second adhesive region.

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Preferably the first layer is at least partially opaque, and the second layer is at least partially transparent and/or translucent and the at least one first and second cuts are made in an opaque area of the first layer, which overlies a transparent or translucent area of the second layer.

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The first and/or second layers are preferably coloured.

The second layer is preferably formed from a plastic material, preferably a thermoplastic material, which is the same as or different to the material from which the first layer is
30 formed.

Preferably the first and second layers are laminated between a plurality of additional layers to form a unitary structure.

Preferably one or more of the additional layers is at least partially opaque, transparent and/or translucent.

5 The steps of applying the adhesive, applying the contact layer, forming the at least one cuts and separating the contact and first layer are preferably carried out as a continuous process.

Preferably the at least one cut is made by a laser or a die cutting tool.

10 The security substrate is preferably manufactured in the form of a web, which is slit to form a plurality of security sheets.

15 The invention further provides a security substrate comprising at least a first layer and a second layer, said first and second layers being formed from the same or different plastic materials and being laminated together, said first layer comprising an aperture formed by the removal of a first portion cut from the first layer, wherein a second portion cut from the first layer is adhered to the second layer by an adhesive and is positioned within the aperture in the first layer.

20 Preferably the first layer is at least partially opaque, and the second layer is at least partially transparent and/or translucent and the first and second portions are cut from an opaque area of the first layer, such that the aperture overlies a transparent or translucent area of the second layer.

25 The first and/or second layers are preferably coloured.

The first and second layers are preferably from the same or different thermoplastic materials.

30 Preferably the first and second layers are laminated between a plurality of additional layers to form a unitary structure.

Preferably one or more of the additional layers is at least partially opaque, transparent and/or translucent.

The adhesive is preferably coloured and/or comprises a security feature.

The present invention is now described, by way of example only, with reference to, and as shown in, the accompanying drawings, in which:

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Figure 1 is a plan view of a passport opened between a security sheet and a visa page;

Figure 2 is a cross-sectional side elevation of the security sheet of Figure 1 through section A-A;

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Figure 3 is an isometric view of a stack of layers used to form the security substrate from which the security sheet of Figure 1 is formed;

Figure 4 is a cross-sectional side elevation of an alternative a stack of layers used to form the security substrate;

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Figure 5 is a cross-sectional side elevation of lamination apparatus for manufacturing the security substrate;

Figure 6 is a schematic cross-sectional side elevation of a portion of the security sheet of Figure 1 through section A-A showing the internal structure of the security substrate;

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Figures 7A to 7D illustrate the formation of a cut out in a core layer of the stack of layers of Figure 3;

Figures 8A to 8F illustrate the formation of a cut out in one of two core layers of the stack of layers of Figure 4;

Figure 9 is a cross-sectional side elevation of apparatus for manufacturing a core layer of the security substrate; and

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Figures 10A and 10B, 11A and 11B, 12A and 12B, 13A and 13 B, 14A and 14B, 15A and 15B, 16A and 16B and 17A and 17 B are front and rear views of a section of various embodiments of the security substrate illustrating the effect of windows formed in the core layer thereof.

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Figure 1 illustrates a security document 10, in this case a passport, comprising a security sheet 11, in this case a data page, sewn along a stitch line 12 to a plurality of visa pages 13 and a cover (not shown). The visa pages 13 are typically made from a fibrous substrate, such as paper, and may include a number of security features, such as security fibres and watermarks.

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The security sheet 11 is formed from a plastic security substrate 14 and, as shown in Figure 2, has a first surface 15 and an opposing second surface 16. Each of the first and second surfaces 15, 16 is preferably substantially flat and planar. The security substrate 14 may be substantially rigid or at least semi-rigid, by virtue of its thickness. The thickness of the security substrate 14, which is the distance between the first and second surfaces 15, 16, is preferably at least 150 μm and more preferably at least 300 μm . More preferably still, the security substrate 14 may have a thickness between 300 μm and 1000 μm thick. One suitable thickness is 800 μm .

- 10 The security substrate 14 preferably comprises at least one substantially opaque region 17 within its thickness which is preferably separated from the first and second outer surfaces 15, 16 by first and second substantially transparent regions 18, 19, such that the at least one opaque region 17 is visible there through. The security substrate 14 further comprises at least one gap 20 adjacent to or within the at least one substantially opaque region 17.
- 15 The gap 20 may be substantially transparent, such that visible light can pass through it. The first and second transparent regions 18, 19, and therefore the at least one gap 20, may be clear and/or coloured by suitable selection of the properties of the first and second transparent regions 18, 19. However the gap 20 may extend only partially through the at least one opaque region 17 and may therefor also be opaque. The combination of the at least one opaque region 17 and the at least one gap 20 may form a design, pattern, image, alphanumerics or any other type of indicia.
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- A series of laser markings 21 may be located within the security substrate 14, for example in the first transparent region 18 between the opaque region 17 and the first outer surface 15. The series of laser markings 21 may be used to provide personal data of the holder of the security document 10. Such personal data is known as "variable data" or "biographical data" and is provided in the security sheet 11 to identify the specific holder of the security document 10. The Seventh Edition (2015) of Document 9303 ("Machine Readable Travel Documents") issued by the International Civil Aviation Organization (ICAO) describes such biographical data and its contents are incorporated herein by reference. Typically, no two security documents 10 issued by an issuing authority contain the same variable data. The personal data includes, for example, text 22 providing the holder's name, nationality and date of birth, a machine readable zone 23 containing machine readable data and the holder's portrait 24. The personal data may be applied to the security substrate 14 by any
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suitable method, such as printing, as an alternative to, or in addition to, the series of laser markings 21.

A hologram 25 may also be located within the security substrate 14, for example within the first transparent region 18. The hologram 25 may be in the form of non-variable data, in that it represents generic information which is typically present in a number of security documents 10 issued by an issuing authority. For example, the hologram 25 may indicate the issuing authority of the security document 10 or it may be in the form of a pattern or image.

The series of laser markings 21 and hologram 25 are preferably visible when the first surface 15 is viewed in reflected light incident upon the first surface 15 by virtue of the first transparent region 18 in which they are located. The security substrate 14 may also comprise one or more other suitable security features, such as UV responsive features, optically variable features, windowed or transparent features, antenna, electronic chips, microprint and laser-perforations.

The security substrate 14 is formed from a plurality of layers 29, as shown in Figure 3, which are fused together to form the substantially non-laminar or unitary structure shown in Figures 5 and 6. The layers 29 are formed from plastic materials, preferably thermoplastic polymers, such as polycarbonate, polyester, polyethylene, polyethylene terephthalate, polypropylene or polyvinyl chloride. Polycarbonate is particularly suitable due to its high durability, its ease of manufacture and the ease with which security features can be incorporated within it. However, the layers 29 need not all be made from the same plastic material and some or all of the layers 29 may be made from different materials.

In a preferred embodiment, the layers 29 comprises a plurality of overlay layers 30, 36, a plurality of intermediate layers 31, 32, 34, 36 and at least one core layer 33. In the embodiment shown in Figure 3, the layers 29 comprise a first overlay layer 30, a first intermediate layer 31, a second intermediate layer 32, a core layer 33, a third intermediate layer 34, a fourth intermediate layer 35 and a second overlay layer 36.

The overlay layers 30, 36 are preferably substantially transparent and form the first and second outer surfaces 15, 16 of the security substrate 14.

The core layer 33 preferably has at least one opaque area 39, which may be white or coloured, and which provides the at least one opaque region 17 in the security substrate 14. The core layer 33 also preferably has at least one aperture 37, which provides the at least one gap 20 in the security substrate 14. In the illustrated embodiment the core layer 33 is made from an opaque material, or a material which has been rendered opaque for example by printing, and the at least one aperture 37 is provided by at least one cut out (i.e. a region cut from the core layer 33 to provide an aperture 37 through the otherwise opaque core layer 33). In another embodiment, the core layer 33 may be made from a transparent or translucent material, and at least one opaque area 39 may be formed on the core layer 33 by applying material cut from another opaque substrate to the core layer 33. The rest of the transparent or translucent core layer 33 therefore provides the at least one aperture 37. The transparent or translucent material may be clear or coloured. The core layer 33, whether partially or wholly opaque, translucent or transparent, may include a fluorescent additive or a fluorescent coating, which is detectable only under certain lighting conditions, such as ultraviolet light. In yet another embodiment, the core layer 33 has no opaque areas 39 and is transparent or translucent. In this embodiment, the core layer 33 is also provided with at least one aperture 37 provided by at least one cut out. However, the opaque region 17 of the security substrate is formed as a result of one or more of the intermediate layers 31, 32, 33, 34, for example the second intermediate layer 32, being at least partially opaque.

In another embodiment the layers 29 may include a plurality of core layers 33a, 33b, as shown in Figure 4. Where there are a plurality of core layers 33a, 33b, the at least one aperture 37a, 37b in each core layer 33a, 33b may be the same dimension and shape as, and in register with, the at least one aperture 37a, 37b in the other core layer 33a, 33b. Alternatively the apertures 37a, 37b may be of different shapes or dimensions and may be in register with each other, out of register or not registered at all. In such an embodiment an inlay layer 38 may be located between two core layers 33a, 33b, so that the inlay layer 38 can be seen through the at least one gap 20 in the security substrate 14 formed by the at least one aperture 37a, 37b in the core layers 33a, 33b. The inlay layer 38 may be opaque, and may be white or coloured, or it may be transparent or translucent and either clear or coloured. The inlay layer 38 may comprise or support an electronic device and antenna. Graphical information, colours, images and/or patterns may be printed on one or more surfaces of the core layer(s) 33a, 33b and or the inlay layer 38 by any suitable method, such as screen printing, ink jet printing or gravure, and using any suitable inks. Any suitable

apparatus may be used for printing. A flexographic printing machine is a particularly suitable apparatus.

The second and third intermediate layers 32, 34, which are located on either side of the core layer(s) 33, and at least one of the second and third intermediate layers 32, 34 are preferably at least partially opaque and may be arranged to be laser engraved through the first outer surface 15 of the security substrate 14 to form the laser markings 21 providing the personal data. For example, at least one of the second and third intermediate layers 32, 34 may comprise a laser markable additive, such as by being carbon enriched. One of the second and third intermediate layers 32, 34 may be wholly opaque and the other of second and third intermediate layers 32, 34 may be partially opaque, having both opaque regions and transparent or translucent regions, with at least one of the transparent or translucent regions being arranged to overlie the at least one aperture 37 in the core layer 33.

Alternatively both of the second and third intermediate layers 32, 34 may be partially opaque or both of the second and third intermediate layers 32, 34 may be transparent or translucent. The opaque, transparent and/or translucent regions of the second and third intermediate layers 32, 34 may be coloured. Graphical information, colours, images and/or patterns may be printed on one or more surfaces of one or both of the second and third intermediate layers 32, 34 by any suitable method, such as screen printing, ink jet printing or gravure, using any suitable inks.

The first and fourth intermediate layers 31, 35, which are located on either side of the second and third intermediate layers 32, 34, are preferably substantially transparent and at least one of first and fourth intermediate layers 31, 35 may include the hologram 25 therein or on one of its surfaces.

In other embodiments any number of intermediate layers 31, 32, 34, 35 may be used on either or both sides of the one or more core layers 33, having different characteristics to provide different security features or effects.

Figure 5 illustrates an embodiment of lamination apparatus 40 suitable for manufacturing a continuous web of the security substrate 14, which may then be slit to form a plurality of security sheets 11. The lamination apparatus 40 is similar to the device disclosed in US-B-6669813. The layers 29 are provided as continuous webs and the apparatus 40 comprises a suitable feed arrangement 41 for supplying and arranging the webs, so that the layers 29

are stacked in the desired order as they are fed into a laminator 42. For simplicity, Figure 4 only shows three of the layers 31, 33 and 36. The laminator 42 fuses the layers 29 together by the application of heat and pressure to form a continuous web of the security substrate 14.

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The laminator 42 comprises first and second continuous belts 43, 44 which rotate in opposite directions. The first continuous belt 43 comprises a first support surface 45 extending around first inlet and outlet drums 46, 47 and the second continuous belt 44 comprises a second support surface 48 extending around second inlet and outlet drums 49, 50. The first and second support surfaces 45, 48 are substantially adjacent to one another over an elongate laminating region 51 for receiving and pressurising the layers 29 therebetween. Opposing heating devices 52 are located adjacent to the first and second inlet drums 46, 49 within each of the first and second continuous belts 43, 44. Opposing cooling devices 53 are located between the heating devices 52 and the first and second outlet drums 47, 50. The heating and cooling devices 52, 53 are operable to move towards and away from the first and second support surfaces 45, 48 and to apply pressure to the layers 29 between them. A plurality of alternating heating and cooling devices 52, 53 may be provided along the length of the laminator 42.

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At least one of the first and second continuous belts 43, 44 is intermittently driven to draw the webs into the laminator 42 through a nip 55 between the first and second inlet drums 46, 49. Initially a section of the stacked webs is moved between the heating devices 52. The heating devices 52 move towards the first and second support surfaces 45, 48 to heat and pressurise the section of the stacked webs to form the security substrate 14. After a set period of time, typically less than a minute, the heating devices 52 move away from the first and second support surfaces 45, 48 and the first and/or second continuous belt 43, 44 is driven to move the section to between the cooling devices 53. The cooling devices 53 move towards the first and second support surfaces 45, 48 and cool and apply pressure to the security substrate 14 in order to maintain its structure. This heating, cooling and pressure application process is repeated along the plurality of alternating heating and cooling devices 52, 53 until the fully formed security substrate 14 exits the laminator 42.

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During the heating process each of the layers 29 become at least softened or semi-molten (i.e. a liquid of relatively high viscosity) so that the plastic flows and mixes together across the interfaces between them. Figure 6 is a schematic of the security substrate 14

illustrating this after fusion of the layers 29. The first overlay layer 30 and first intermediate layer 31 form the second transparent region 19. The opaque area 38 of the core layer 33 forms the opaque region 17, with the at least one aperture 37 forming the at least one gap 20. The second overlay layer 36 and the fourth intermediate layer 35 form the second
5 transparent region 19. The security substrate 14 comprises mixed regions 60 formed at positions that correspond to the interfaces between the adjacent layers 29. The mixed regions 60 comprise varying concentrations of plastic from the adjacent layers 29.

In order to achieve such fusion, the heating devices 52 may be suitably controlled to raise
10 the temperature and pressure applied to the layers 29 to reach the softening point of the plastic. A temperature at which deformation and therefore fusion is possible at a certain pressure can be ascertained using the Vicat softening point test of any of the methods of the ASTM D 1525 and ISO 306 standards. The Vicat softening point may be the
15 temperature at which a specimen is penetrated to a depth of 1 mm by a flat-ended needle with a 1 mm² circular or square cross-section. In a particular example, the Vicat softening point for polycarbonate can be determined using a heating rate of 50°C/hr and a load rate of 50 N. In a further example for polycarbonate, the heating devices 52 may apply a temperature of approximately 186°C at approximately 10MPa to the layers 29 and the cooling devices 53 may apply a temperature of approximately 16°C to 30°C and a pressure
20 of 10MPa to the layers 29. In yet a further example for polycarbonate, the heating devices 52 may apply a temperature of approximately 180°C at approximately 1.6N/mm² and the cooling devices 53 may apply a temperature of approximately 20°C to 30°C at a pressure of 3.2N/mm². This latter example is particularly appropriate where the section of the stacked webs between the heating or cooling devices 52, 53 has a surface area of 130mm
25 by 190mm.

After the web of security substrate 14 has exited the laminator 42 it may be subjected to further processing, such as the addition of further security features to the first and/or second outer surfaces 15, 16. The web of security substrate 14 may then be slit to form a
30 plurality of security sheets 11. The web may initially be slit into a number of narrower webs, and the narrower webs may be cut into security sheets 11. Each security sheet 11 may then be bound with the visa pages 13 and cover to form a passport as shown in Figure 1 or may be used to form another security document 10. The security document 10 comprising the security sheet 11 may be of any other suitable type, such as a driving

licence or identity card. The personal data relating to the holder of the security document 10 may also be laser marked into each security sheet 11.

Prior to the lamination of the layers 29, the at least one aperture 37, which forms the at
5 least one gap 20 in the security substrate 14, is formed in the core layer(s) 33. A simple
example is illustrated in Figures 7A to 7D, in which an aperture 37 is a cut out in the form of
a circular disc which is removed from the core layer 33. An adhesive is applied to a one
side of the core layer 33, which is opaque, to form an adhesive region 61 in the shape of
the desired aperture 37 (Figure 7A). A contact layer 62 is applied to the core layer 33 so
10 that it adheres to the adhesive regions 61 (Figure 7B). At least one cut 63 is made in the
core layer 33 (from its second side) in exact registration with the boundary of the adhesive
region 61 (Figure 7C). The at least one cut 63 is also in the shape of the intended at least
one aperture 37 and the depth of the at least one cut 63 must be carefully controlled so as
not to cut into the contact layer 62. The contact layer 62 is then separated from the core
15 layer 33 (Figure 7D). As this happens, the cut portion 64 of the core layer 33, i.e. the disc
which is bounded by the at least one cut 63, remains adhered to the at least one adhesive
region 61 on the contact layer 62 and is removed with the contact layer 62 leaving the
aperture 37 in the core layer 33. In an alternative embodiment, the adhesive is applied to
form an adhesive region 61 on the contact layer 62 before it is applied to the core layer 33.
20 In a further alternative embodiment, the at least one cut 63 is made in the core layer 33
prior to the application of the contact layer 62 to the core layer 33.

The contact layer 62 is made of a flexible plastic material. Preferably the material is
polyethylene terephthalate (PET), although polycarbonate (PC) or another plastic material
25 may be used. The contact layer 62 is preferably transparent and clear. The thickness of the
contact layer 62 is preferably in the region of 10 - 30µm, and more preferably 19µm or
23µm.

The core layer 33 is also made of a flexible plastic material, preferably polycarbonate for
30 the reasons indicated previously. The thickness of the core layer 33 is preferably in the
region of 10 - 300µm, more preferably 30 – 50µm and most preferably has a thickness of
30µm. As indicated above, whilst the core layer 33 is preferably at least partially opaque
(prior to the removal of the at least one cut portion 64), it may also be translucent or
transparent. Essentially what is required is that, when the core layer 33 is combined with
35 the other of the layers 29 to form the security substrate 14, a visible contrast is provided in

the gap 20 (formed by the at least one aperture 37) and the remaining part of the security substrate 14. It is not necessary that the contrast can be seen in visible light. For example, the core layer 33 may be transparent and include a fluorescent coating or additive which is only visible under certain lighting conditions, such as UV light. Alternatively, the core layer
5 33 may comprise a metallised plastic material.

Preferably, the dimensions of the at least one adhesive region 61 are slightly smaller than those of the at least one aperture 37, for example by 1mm all round. This is in case the adhesive spreads when the contact layer 62 is applied to the core layer 33. This may be
10 undesirable in some embodiments, as it could result in adhesive being left on the core 33 layer. In other embodiments, the dimensions of the at least one adhesive region 61 may be deliberately selected to leave some adhesive on the core layer 33 after removal of the contact layer 62, and for the adhesive to be provided with a security feature. Such security
15 features may include a fluorescent pigment, an optically variable device or material, a colour shift pigment or the like. The adhesive may be translucent or light transmissive and it may be clear or coloured. If it is not intended to leave any of the adhesive on the core layer 33, it may be beneficial to use a coloured adhesive, so that any undesirable traces of adhesive remaining on the core layer 33 can be seen easily. A further benefit of using a
20 coloured adhesive is that it may be used as a machine pick up point during the manufacturing process.

The adhesive used for the at least one adhesive region 61 is preferably a low tack pressure sensitive adhesive. It may be a UV curable adhesive, a thermally activated adhesive or the like. If the adhesive requires a curing process, the contact layer 62 is only removed after
25 the adhesive is cured. Some suitable adhesives would be MQL 45410 Quartz Pre-Cure Adhesive (Fast), MQL 34237/1 Quartz Cold Foil Adhesive (Slow) and Quick Dry Solvent Based Adhesive, all from Mirage Inks. The strength of the adhesive is selected to ensure that the cut portions 64 adhere to it and are safely removed. Where the adhesive is a UV
30 curable adhesive, such as the Quartz Adhesives, the contact layer 62 is preferably UV transparent. This enables the adhesive to be cured through the contact layer 62.

The at least one cut 63 may be continuous or may be in the form of a continuous line of perforations.

The dimensions of the at least one aperture 37, where in the form of a cut out, may be restricted by the parameters of the tools used to make the at least one cut 63. One advantage of laser cutting is that it forms very sharp clean edges and the at least one cut out may have finer dimensions as a result. The preferred minimum dimension of any area in the at least one aperture 37 is 250µm and the preferred maximum dimension is 5mm aperture 37.

A more complex aperture 37 can be produced using two core layers 33a, 33b as illustrated in Figures 8A to 8F. In this example, inner and outer adhesive regions 61a, 61b are formed on a first side of one of the core layers 33a, 33b, which is at least partially transparent or translucent (Figure 8A). It should, however, be noted that only a single adhesive region could be used, e.g. corresponding to inner adhesive region 61a. Alternatively, more than two adhesive regions 61a, 61b may be used. The use of two or more adhesive regions 61a, 61b enable a more complex design to be achieved, which may be more aesthetically pleasing and is more difficult to counterfeit. In this example, adhesive region 61b is used to aid the manufacturing process, to stabilise the structure during the cutting and design steps, and is not necessary for the design.

In the illustrated example, the inner and outer adhesive regions 61a, 61b are formed on a first side of the second core layer 33b. The inner adhesive region 61a is in the form of a square and the outer adhesive region 61b is a square frame which frames the inner adhesive region 61a, leaving a gap between the inner and outer adhesive regions 61a, 61b. A first side of a first core layer 33a, which is at least partially opaque, is applied to the first side of the second core layer 33b, so that it adheres to the inner and outer adhesive regions 61a, 61b. Inner and outer cuts 63a, 63b are made in the first core layer 33a (from its second side), which correspond respectively to the outer boundary of inner adhesive region 61a and the inner boundary of outer adhesive region 61b (Figure 8C). The depth of the inner and outer cuts 63a, 63b are controlled so as not to cut into the second core layer 33b. The inner and outer cuts 63a, 63b are made in an opaque area of the first core layer 33a, which overlies a transparent or translucent area of the second core layer 33b.

An adhesive region 61c is applied to a first side of the contact layer 62 in the shape of the desired aperture 37a, which corresponds to the region between the inner and outer cuts 63a, 63b. The first side of the contact layer 62 is applied to the second side of the first core layer 33a, with the adhesive region 61c registered so as to lie within the inner and outer

cuts 63a, 63b. When the contact layer 62 is separated from the first core layer 33a (Figure 8F), a first cut portion 64b of the first core layer 33a, i.e. the area between the inner and outer cuts 63a, 63b, remains adhered to the adhesive region 61c on the contact layer 62 and is removed with the contact layer 62 leaving the aperture 37a in the opaque area 39a of the first core layer 33a. A second cut portion 64a, i.e. the area of the first core layer 33a which is bounded by the inner cut 63a, remains adhered to the inner adhesive region 61a on the second core layer 33b. The cut portion 64a from the first core layer 33a becomes the opaque area 39b of the second core layer 33b. The area of the first core layer 33a which lies outside the outer cut 63b remains adhered to the outer adhesive region 61b. The use of two core layers 33a, 33b in this manner enables the formation of an aperture 37a, which is in the form of a transparent frame which is exactly registered to, and surrounds, the "island" of opaque area 39b provided by the second cut portion 64a.

The manufacture of the core layer 33, i.e. the application of the adhesive and the cutting process, may be carried out as a continuous in line process, as illustrated in Figure 9. A continuous web of the core layer 33 is fed to a print station 65 by means of a suitable feed arrangement 41. At the print station 65, the adhesive is applied to the core layer 33 to form the adhesive regions 61 using any suitable method, such as screen printing, ink jet printing or gravure. Subsequently, a continuous web of the contact layer 62, again supplied by a suitable feed arrangement 41, is applied to the printed web of core layer 33. If an adhesive is used which requires curing, the combined web of core layer 33 and contact layer 62 passes through a curing station 66, to ensure that the adhesive is fully cured.

The combined web of core layer 33 and contact layer 62 subsequently passes to a cutting station 67, for the formation of the at least one cut 63. The at least one cut 63 is preferably made using a die cutting tool, which may be a solid or flexible tool, and more preferably a rotary die cutter (illustrated in Figure 9). Typically a rotary die cutter comprises a cylindrical rotating die cutting tool 68 and a cylindrical rotating anvil 69 mounted so that the material to be cut passes therebetween as they rotate against each other. In this arrangement, the die cutting tool 68 is arranged on the same side as the core layer 33 and the anvil 69 is located on the same side as the contact layer 62. The pressure and gap between the die cutting tool 68 and the anvil 69 determines the depth of the cut and are selected so that the die cutting tool 68 only penetrates the core layer 33 and not the contact layer 62. Alternatively another mechanical cutting process may be used, which may be another rotary process or

a flatbed process, such as stamping. As a further alternative, the at least one cut 63 may be cut by means of a laser cutting tool or a plotter cutter.

Where the manufacture of the core layer 33, in terms of the application of the adhesive and the cutting process, is a continuous in line process, it is especially important to ensure registration between the at least one aperture 37 and the at least one adhesive region 61. The die cutting tool 68, or other cutting device used in the cutting station 67, therefore needs to be synchronised with the printing device used in the print station 65. The use of rotary printing devices and rotary cutting tools is particularly convenient to enable this to be achieved.

As the combined web of core layer 33 and contact layer 62 leaves the cutting station 67, a separator 70 is used to separate the core layer 33 and contact layer 62, with the at least one cut portion 64 of the core layer 33 still adhered to contact layer 62. As the contact layer 62 is removed, it is reeled by means of suitable reeling apparatus 71 and discarded. The core layer 33 may also be separately reeled by means of suitable reeling apparatus 71, before being transferred to the lamination apparatus 40 of Figure 4 and subsequently unreeled by the as a part of the lamination process described above. Alternatively, the web of core layer 33 may be fed directly to the lamination apparatus 40, by a suitable arrangement.

In another embodiment, the core layer 33 and contact layer 62 may initially be reeled together after leaving the cutting station, and only separated when fed to the lamination apparatus 40. It may also be advantageous to keep the core layer 33 and contact layer 62 together if the web is to be slit into narrower webs before being fed to the lamination apparatus 40, as the contact layer 62 provides additional support to the core layer 33.

Additional stations, such as printing stations, may be added enable one or more of the layers 29 to be printed prior to lamination.

Although the manufacturing process illustrated is an in-line process for producing a web of core layer 33, this is not essential to the method of manufacturing the core layer 33. The same method may also be carried out in a plurality of discrete individual stages to form individual sheets of the security substrate 14.

Although the contact layer 62 may be discarded after reeling, in another embodiment, the contact layer 62 together with the cut portion 64, may be used as one of the layers 29. In a further alternative, the roles of the core layer 33 and contact layer 62 are reversed and the aforementioned method used to form a transparent core layer 33 with discrete opaque cut portions adhered thereto. In such an embodiment, the core layer 33 will therefore include the adhesive regions 61 and it may be advantageous for the adhesive used for the adhesive regions 61 to be coloured or include fluorescent pigments, which may then be used as security features in the security substrate 14.

This method may be used to form complex images, designs, patterns, alphanumerics or any other type of indicia in the security substrate 14, by providing some or all of the layers 29 with different characteristics (e.g. print, security features, opacity, transparency, colour etc.) which are visible through the gaps 20 between the opaque regions 17. Some examples of the effects that can be achieved in the security substrate 14 are given below, noting that the different features described can be varied and combined to provide different effects. Figures 10 to 17 are sections of the security substrate 14 illustrating, for simplicity, one (or two in the case of Figure 16) aperture 37. However, as the security substrate 14 is formed as a web, the web may comprise multiple apertures 37 along the length and/or width of the web. These multiple apertures 37 may all be identical such that when the web is slit to form individual security sheets 11, each security sheet 11 is identical with the aperture(s) 37 on each security sheet 11 being of the same configuration and positioned in the same place on each security sheet 11. Alternatively, all of the windows 37 may be different along the length and/or width of the web, which would enable a series of unique security sheets 11 to be produced from each web, i.e. each security sheet 11 having one or more apertures 37 which are of a different shape to those in the other security sheets 11.

Example 1

In a first example, the layers 29 used to form the security substrate 14 include a core layer 33, which is opaque and coloured white and all the intermediate layers 31, 32, 34, 35 and the overlay layers 30, 31 are transparent and clear. The core layer 33 has a circular aperture 37 formed by cut outs, for example, as shown in Figure 7A to 7D. When either the first surface 15 of the security substrate 14 is viewed from direction A or the second surface 16 is viewed from direction B (as shown in Figure 6), the gap 20 (formed by the aperture 37) provides a transparent circular aperture 37 in the white opaque region 17 (formed by

the rest of the opaque core layer 33) which spreads across the rest of the security substrate 14. Such an aperture 37 is especially visible in transmitted light.

Example 2

- 5 In a modification of this Example 1, the second intermediate layer 32 is tinted, for example green, whilst still being transparent. In the security substrate 14, the gap 20 provided by the circular aperture 37 is still light transmissive, but coloured green.

Example 3

- 10 In this example, the layers are similar to those used in Example 1, with the exception that the second intermediate layer 32 is opaque and coloured red. All the other intermediate layers 31, 34, 35 and the overlay layers 30, 31 are still transparent and clear. When the first surface 15 of the security substrate 14 is viewed from direction A (i.e. with the second intermediate layer 32 behind the core layer 33), the colour of the second intermediate layer 32 shows through the gap 20 (formed by the aperture 37) in the white opaque region 17 (formed by the rest of the core layer 33) as a red circle in an otherwise white opaque security substrate 14 (Figure 10A). When the second surface 16 of the security substrate 14 is viewed from direction B, the whole security substrate 14 appears red (Figure 10B) as the colour of the second intermediate layer 32 shows through the overlying transparent layers.
- 20

Example 4

- In a modification of this Example 3, the second intermediate layer 32 is made from a transparent material, but is printed with an image or pattern which renders it partially opaque. When the first surface 15 of the security substrate 14 is viewed from direction A, a portion of the pattern printed on the second intermediate layer 32 can be seen through the gap 20 in an otherwise white opaque background. When the second surface 16 of the security substrate 14 is viewed from direction B, the full pattern printed on the second intermediate layer 32 can be seen against a white opaque background.

30

Example 5

- In this example, the layers 29 used to form the security substrate 14 are similar to those of Example 3. However, the opaque red second intermediate layer 32 also has a clear transparent portion in the form of a triangle 80. The third intermediate layer 34 is transparent and tinted blue, and further comprises a printed black opaque region in the
- 35

form of a square 81. When the layers 29 are stacked, the square 81 is located within the triangle 80, which in turn is located within the circular aperture 37 of the core layer 33.

When the first surface 15 of the security substrate 14 is viewed from direction A (Figure 11A), except for the gap 20, the security substrate 14 appears to be blue and opaque (i.e.

5 from the white opaque part of the core layer 33 overlaid by the blue tinted transparent part of the third intermediate layer 34). In the centre of the gap 20 is the opaque black square 81 framed by a transparent blue triangle 80 (i.e. the colour of the third intermediate layer 34 only as the second intermediate layer 32 is clear and transparent in this region). The blue triangle 80 in turn is framed by the gap 20, forming a purple circular frame (i.e. where
10 the blue tinted transparent part of the third intermediate layer 34 overlies the opaque red of the second intermediate layer 32). When the second surface 16 of the security substrate 14 is viewed from direction B (Figure 11B), most of the security substrate 14 appears opaque red with the opaque black square 81 framed by a transparent blue triangle 80 in the centre.

15 **Example 6**

In this example, the layers 29 are similar to those of Example 1. At the cutting station 67, a laser cutting tool makes the cuts 63 in an opaque white core layer 33. The cuts 63 are made in the form of a series of laser perforations, to provide a plurality of circular apertures 37, which together form an identifier. The identifier may be a code (for example a bar code
20 or a QR barcode) or a serial number (for example an ID number) or the like. The laser cutting tool is programmed to change the identifier each time, so that each one of a series of security sheets 11 (whether formed individually, or cut from a web of the security substrate 14) will each bear a unique identifier. The gaps 20 in the security substrate 14 thus provide transparent apertures 37 (when either the first or second surfaces 15, 16 are
25 viewed from the respective side) in the form of the identifier through the otherwise white opaque security substrate 14 (Figures 12A and 12B).

If an opaque green second intermediate layer 32 is used, as in Example 3, the unique identifier would be seen in green when the first surface 15 of the security substrate 14 is
30 viewed from direction A. When the second surface 16 of the security substrate 14 is viewed from direction B, the whole security substrate 14 appears green.

In a modification of this example, one or more apertures 37 are in the form of a geometric or other shape (e.g. as in Example 1), so that each security sheet 11 in a series bears a
35 different shaped gap 20.

Example 7

In this example, the layers 29 are similar to those of Example 3, but the core layer 33 is made from a material which is transparent and includes a UV detectable additive, which
5 glows yellow under UV light. The core layer 33 again has a circular aperture 37 formed by a cut out. The second intermediate layer 32 is white and opaque. When the first surface 15 of the security substrate 14 is viewed from direction A under normal lighting conditions, the gap 20 (formed by the aperture 37) is not visible. The whole or the security substrate 14 appears white and opaque as the second intermediate layer 20 is visible through all the
10 overlying layers. However, when viewed under UV light, the gap 20 becomes visible, as the rest of the core layer 33 glows yellow and the white of the second intermediate layer 32 is only visible in the gap 20 as a white circle. When viewed from direction B, the security substrate will appear white under both normal and UV lighting conditions.

Example 8

In this example, the layers 29 include two core layers 33a, 33b and an inlay layer 38 (e.g. as illustrated in the stack of layers shown in Figure 4). The core layers 33a, 33b are white and opaque, and the inlay layer 38 is transparent and coloured orange. All the intermediate layers 31, 32, 34, 35 and the overlay layers 30, 31 are transparent and clear. An identical
20 aperture 37 is formed in each core layer 33. When the security substrate 14 is viewed from either side 15, 16 the orange of the inlay layer 38 is visible in the gap 20 (Figures 13A and 13B). As mentioned previously, the web of security substrate 14 may be slit to form a plurality of security sheets 11. Depending on the positioning of the aperture 37 relative to one or more edges of the security sheet 11, the aperture 37 in the security sheet 11 may
25 appear as an “edge cut”. If a security sheet 11 cut from such a web corresponds to the section of security substrate 14 illustrated in Figures 13A and 13B, this is how the edge cut would appear.

Example 9

In a modification of Example 8, the apertures 37a, 37b in the core layers 33a, 33b are again provided by edge cuts, but are of a different size and shape. In this example, the first core layer 33a (which is on the side of the first surface 15 of the security substrate 14) has an aperture 37a in the form of a square shaped edge cut. The second core layer 33b (which is on the side of the second surface 16 of the security substrate 14) has an aperture
35 37b in the form of a smaller triangular edge cut. When the security substrate 14 is viewed

from direction A (Figure 14A), an orange square (resulting from the orange of the inlay layer 28 showing through the gap 20 in the first core layer 33a) is visible in an otherwise white background. However, in an overlap region 82 (which is the shape and size of the aperture 37b in the second core layer 33b) where the apertures 37a and 37b overlap, the gap 20 is transparent and coloured orange. In a non-overlap region 83 (which is the shape and size of the aperture 37a in the first core layer 33a less the aperture 37b in the second core layer 33b), the gap 20 is opaque and coloured orange where the orange transparent inlay layer 38 overlies the opaque white second core layer 33b. When the security substrate 14 is viewed from direction B (Figure 14B), the gap 20 is only in the form of the smaller triangular edge cut in the second core layer 33b and is transparent and coloured orange.

Example 10

In this example, the layers 29 include two core layers 33a, 33b produced using the method described above and illustrated in Figures 8A to 8F. In this example the first core layer 33a is opaque and white and the second core layer 33b is transparent and coloured blue. All the intermediate layers 31, 32, 34, 35 and the overlay layers 30, 31 are transparent and clear. When the first surface 15 of the security substrate 14 is viewed from direction A (Figure 15A), the gap 20 comprises a transparent blue frame, which is aperture 37a, which is surrounded by the white opaque area 39b of the second core layer 33b, and which in turn surrounds a white opaque square provided by the opaque area 39a of the first core layer 33a (which is formed by the cut portion 64b from the second core layer 33b which remains adhered to the first core layer 33a). When the second surface 16 of the security substrate 14 is viewed from direction B (Figure 15B), the gap 20 comprises a transparent blue frame surrounded by a blue opaque area and lying within the transparent blue frame is an opaque blue square, which is provided by the white cut portion 64b from the first core layer 33a adhered to the side of the second core layer 33b which faces away from the second surface 16 of the security substrate 14 and is therefore covered by the blue transparent material of the first core layer 33b.

Example 11

In a modification of Example 1, in which the layers 29 are the same, except in that the transparent clear second intermediate layer 32 includes, on one side, a yellow printed opaque area on which are printed in black the letters ABC. In addition, the white opaque core layer 33 includes a first aperture 37 in the form of a star and a second aperture 37 in

the form of a rectangle. The layers 29 are positioned prior to lamination so that the second aperture 37 overlies the printed area, with the printed side of the second intermediate layer 32 adjacent to the core layer 33. When the first surface 15 of the security substrate 14 is viewed from direction A, a first gap 20a (provided by the first aperture 37 in the core layer 33) extends through the opaque region 17 provided by the rest of the core layer 33 is in the form of a transparent star. However the second gap 20b (provided by the second aperture 37 in the core layer) is an opaque yellow rectangle (provided by the yellow printed opaque area on the second intermediate layer 32) on which the black letters ABC are visible (Figure 16A) . When the second surface 16 of the security substrate 14 is viewed from direction B, the first gap 20a is also a transparent star, whereas the second gap 20a is obscured by a solid yellow printed rectangle (Figure 16B).

Example 12

In this example, the layers 29 include two core layers 33a, 33b and an inlay layer 38 (e.g. as illustrated in the stack of layers shown in Figure 4). The core layers 33a, 33b are white and opaque, and the inlay layer 38 is transparent and bears a hologram 25. All of the intermediate layers 31, 32, 34, 35 and the overlay layers 30, 31 are transparent and clear. Identical apertures 37 are formed in each core layer 33 by cut outs. When the layers 29 are stacked prior to lamination, the core layers 33a, 33b and inlay layer 38 are positioned to ensure that the apertures 37 of the core layers 33a, 33b are exactly registered to each other and with respect to the hologram 25. When the first side 15 of the security substrate 14 is viewed from direction A, the hologram 25 is visible in the gap 20 created by the aperture 37. When the second surface 16 of the security substrate 14 is viewed from direction B, the back of the hologram 25 can be seen.

Depending on the desired effect of the security substrate 14, the various features of all these examples can be modified and/or combined with features of different examples. All references to specific colours are purely exemplary. As previously mentioned, the number of layers 29 can be varied and some or all of these can be wholly or partially opaque, transparent and/or translucent and wholly or partially clear and/or coloured. As also indicated previously, one or more of the layers 29 may also be printed and the printing may be combined with the one or more gaps 20 to provide the desired effect. The number, size and shape of the gaps 20 may also be varied to provide different effects. Other security features (as in Example 12) can also be used on one or more of the layers 29 and combined with the one or more gaps 20.

CLAIMS:

1. A method of manufacturing a security substrate comprising at least a first layer having at least one aperture, the method comprising the steps of:-

5 applying an adhesive in at least one first adhesive region to either the first layer or a contact layer, the at least one first adhesive region having a substantially similar shape to the at least one aperture;

applying the contact layer to the first layer with the at least one first adhesive region therebetween;

10 forming at least one first cut in the first layer defining at least one first cut portion of the first layer to be removed from the first layer; and

separating the contact layer and the first layer, wherein the at least one first cut portion of the first layer is adhered to the contact layer by means of the at least one first adhesive region and is removed from the first layer to form the at least one aperture;

15 wherein the steps of applying the contact layer to the first layer and forming the at least one first cut in the first layer are carried out in either order.

2. The method as claimed in claim 1, wherein the first layer is formed from a plastic material, preferably a thermoplastic material.

20

3. The method as claimed in claim 1 or claim 2, wherein the first layer is at least partially opaque, transparent and/or translucent.

4. The method as claimed in any one of the preceding claims, wherein the first layer is
25 coloured.

5. The method as claimed in any one of the preceding claims, wherein the first layer is laminated between a plurality of additional layers to form a unitary structure.

30 6. The method as claimed in claim 1 or claim 2, further comprising the steps of:-

applying an adhesive in at least one second adhesive region to a second layer, the at least one adhesive region having a substantially similar shape to at least one second cut portion to be removed from the first layer;

35 applying the first layer to the second layer with the at least one second adhesive region therebetween;

forming the at least one cut in the first layer and at least one second cut in the first layer defining at least one second cut portion to be removed from the first layer;

applying the contact layer to the first layer with the at least one first adhesive region therebetween;

5 separating the contact layer and the first layer, wherein the at least one first cut portion of the first layer is adhered to the contact layer by means of the at least one first adhesive region and is removed from the first layer to form the at least one aperture and the at least one second cut portion remains adhered to the second layer by means of the at least one second adhesive region.

10

7. The method as claimed in claim 6, wherein the first layer is at least partially opaque, and the second layer is at least partially transparent and/or translucent and the at least one first and second cuts are made in an opaque area of the first layer, which overlies a transparent or translucent area of the second layer.

15

8. The method as claimed in claim 6 or claim 7, wherein the first and/or second layers are coloured.

9. The method as claimed in any one of claims 6 to 8, wherein the second layer is
20 formed from a plastic material, preferably a thermoplastic material, which is the same as or different to the material from which the first layer is formed.

25

10. The method as claimed in any one of claims 6 to 9, wherein the first and second layers are laminated between a plurality of additional layers to form a unitary structure.

11. The method as claimed in any one of the preceding claims, wherein one or more of the additional layers is at least partially opaque, transparent and/or translucent.

30

12. The method as claimed in any one of the preceding claims, wherein the steps of applying the adhesive, applying the contact layer, forming the at least one cuts and separating the contact and first layer are carried out as a continuous process.

13. The method as claimed in any one of the preceding claims wherein the at least one cut is made by a laser or a die cutting tool.

35

14. The method as claimed in any one of the preceding claims, wherein the security substrate is manufactured in the form of a web, which is slit to form a plurality of security sheets.

5 15. A security substrate comprising at least a first layer and a second layer, said first and second layers being formed from the same or different plastic materials and being laminated together, said first layer comprising an aperture formed by the removal of a first portion cut from the first layer, wherein a second portion cut from the first layer is adhered to the second layer by an adhesive and is positioned within the aperture in the first layer.

10

16. The security substrate as claimed in claim 15, wherein the first layer is at least partially opaque, and the second layer is at least partially transparent and/or translucent and the first and second portions are cut from an opaque area of the first layer, such that the aperture overlies a transparent or translucent area of the second layer.

15

17. The security substrate as claimed in claim 15 or claim 16, wherein the first and/or second layers are coloured.

20

18. The security substrate as claimed in any of claims 15 to 17, wherein the first and second layers are from the same or different thermoplastic materials.

25

19. The security substrate as claimed in any one of claims 15 to 18, wherein the first and second layers are laminated between a plurality of additional layers to form a unitary structure.

20. The security substrate as claimed in claim 19, wherein one or more of the additional layers is at least partially opaque, transparent and/or translucent.

30

21. The security substrate as claimed in any one of claims 15 to 20, wherein the adhesive is coloured and/or comprises a security feature.

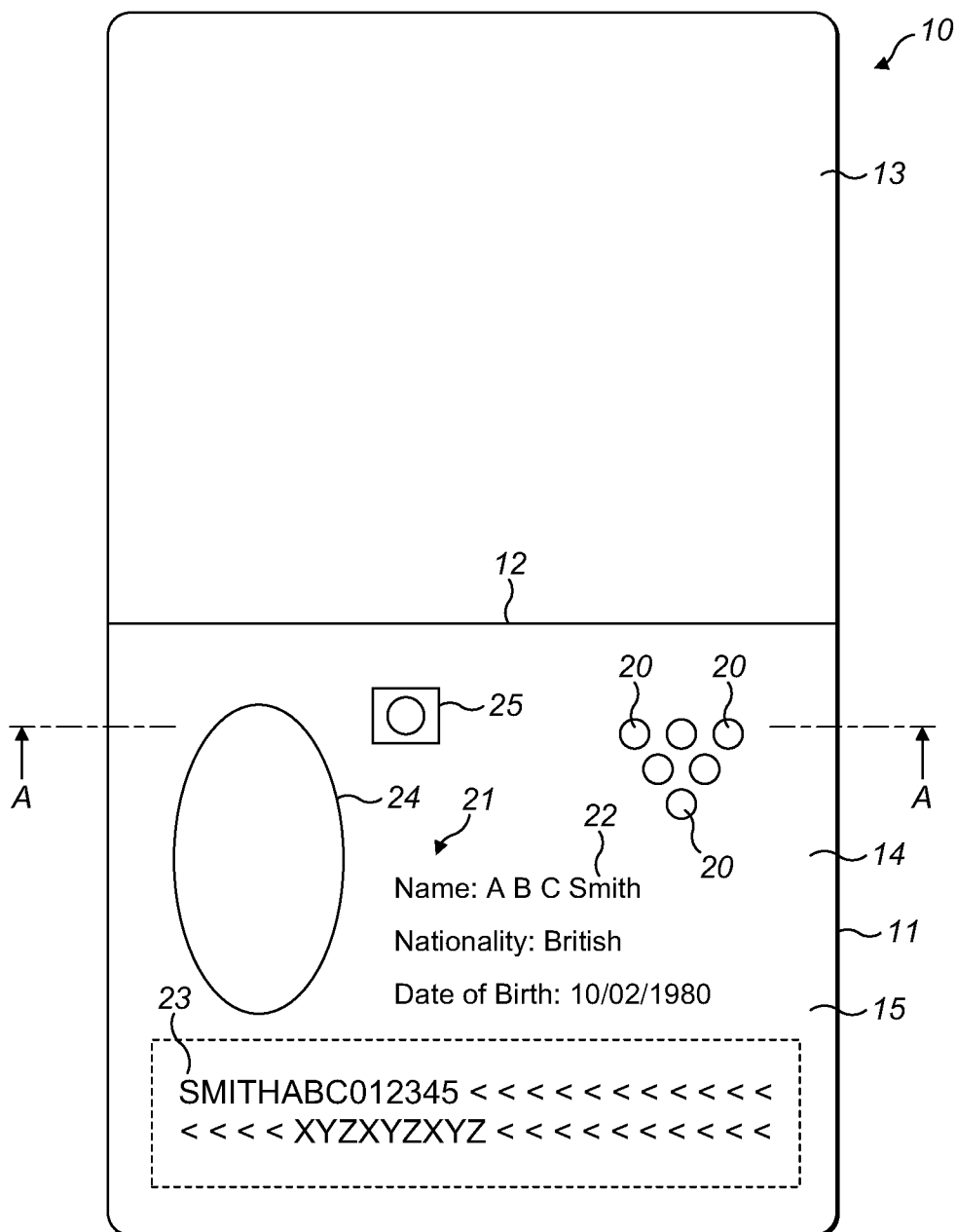


FIG. 1

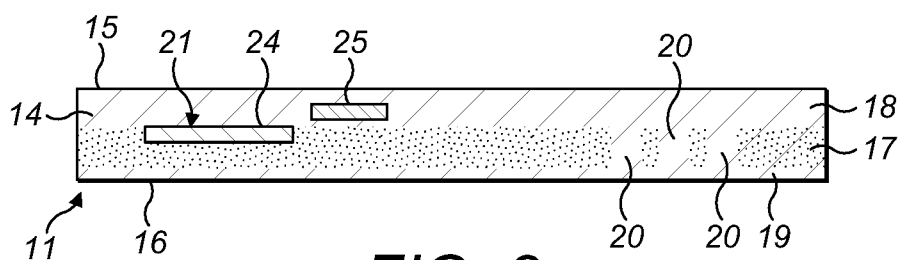


FIG. 2

2 / 11

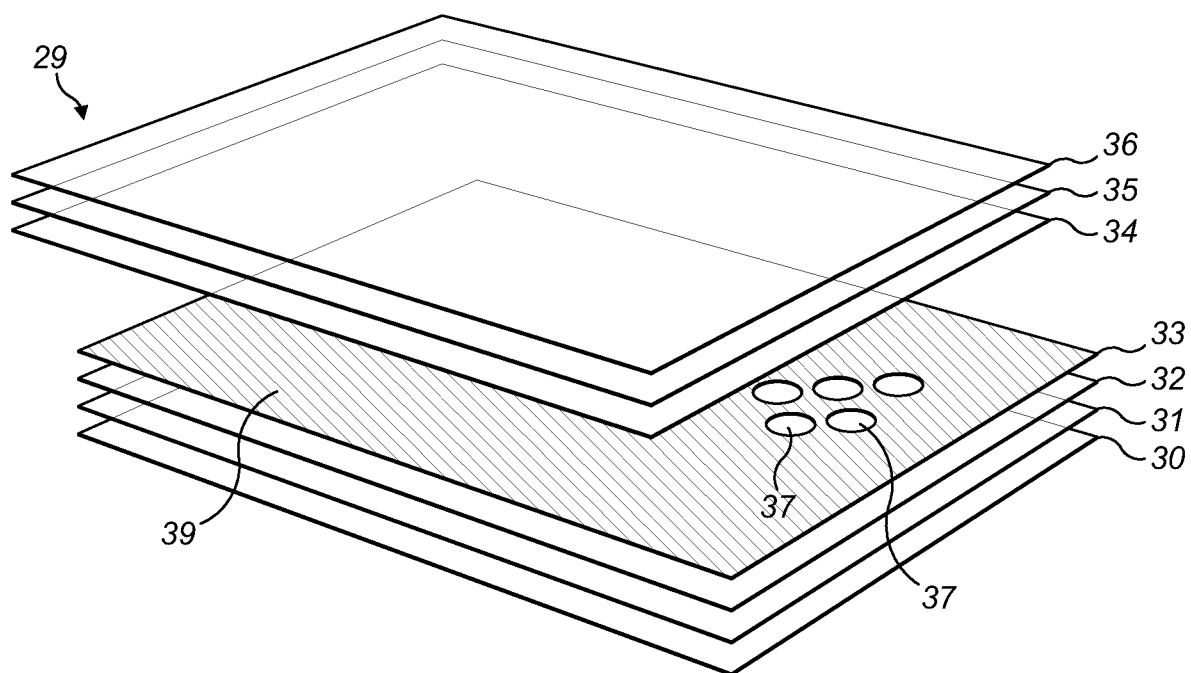


FIG. 3

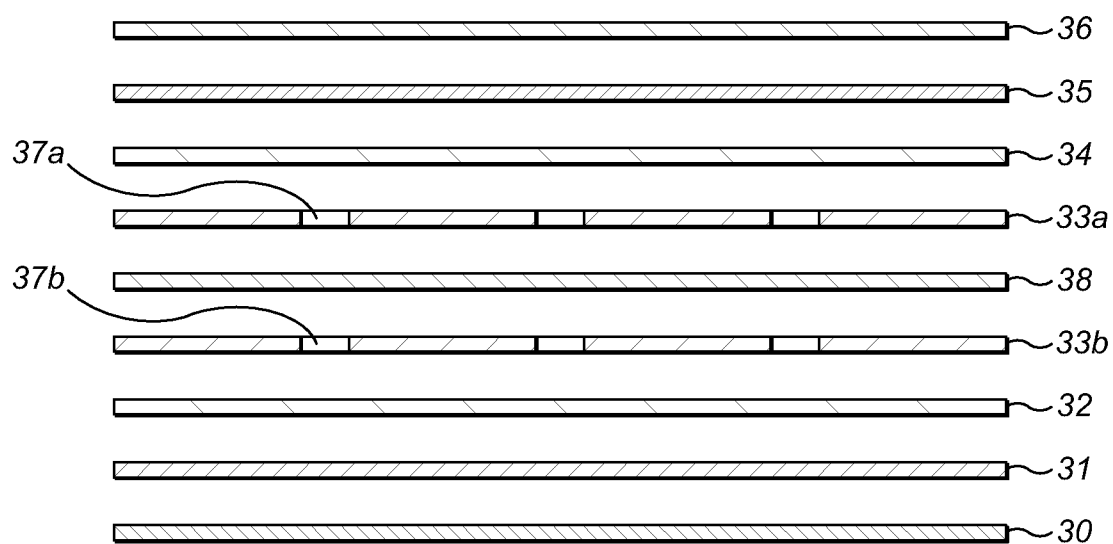


FIG. 4

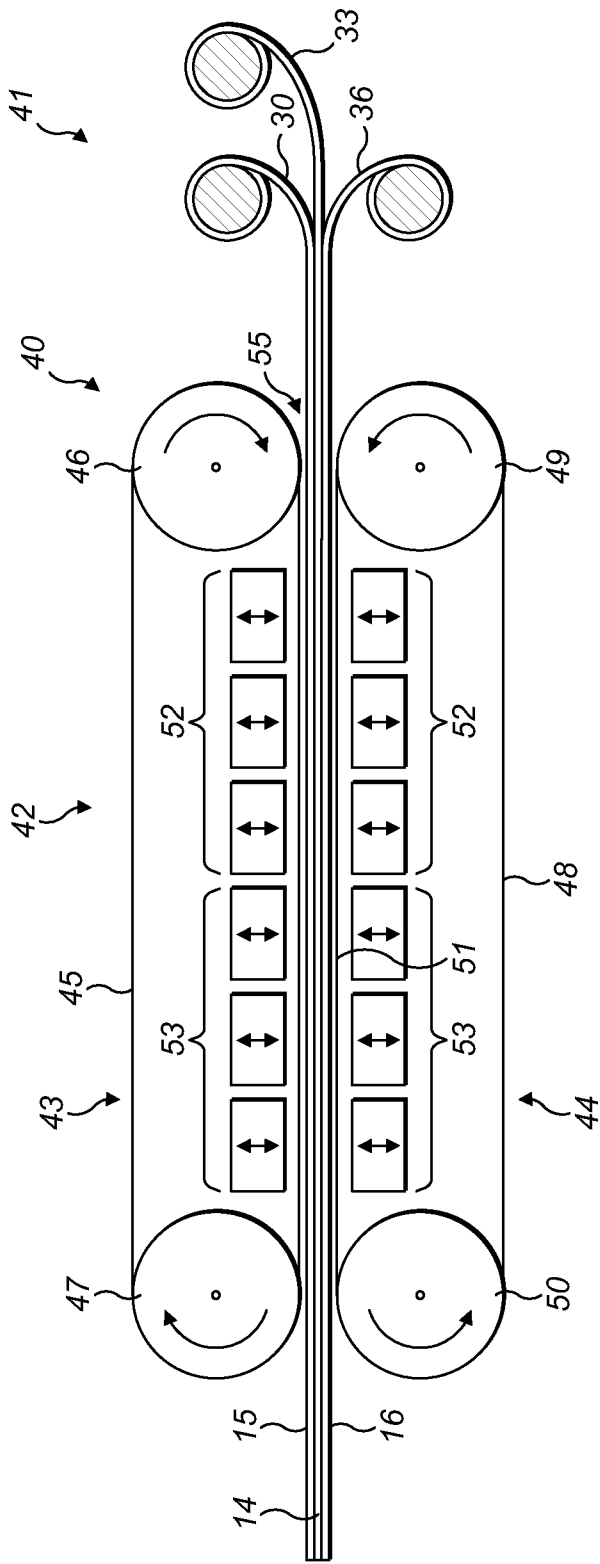


FIG. 5

4 / 11

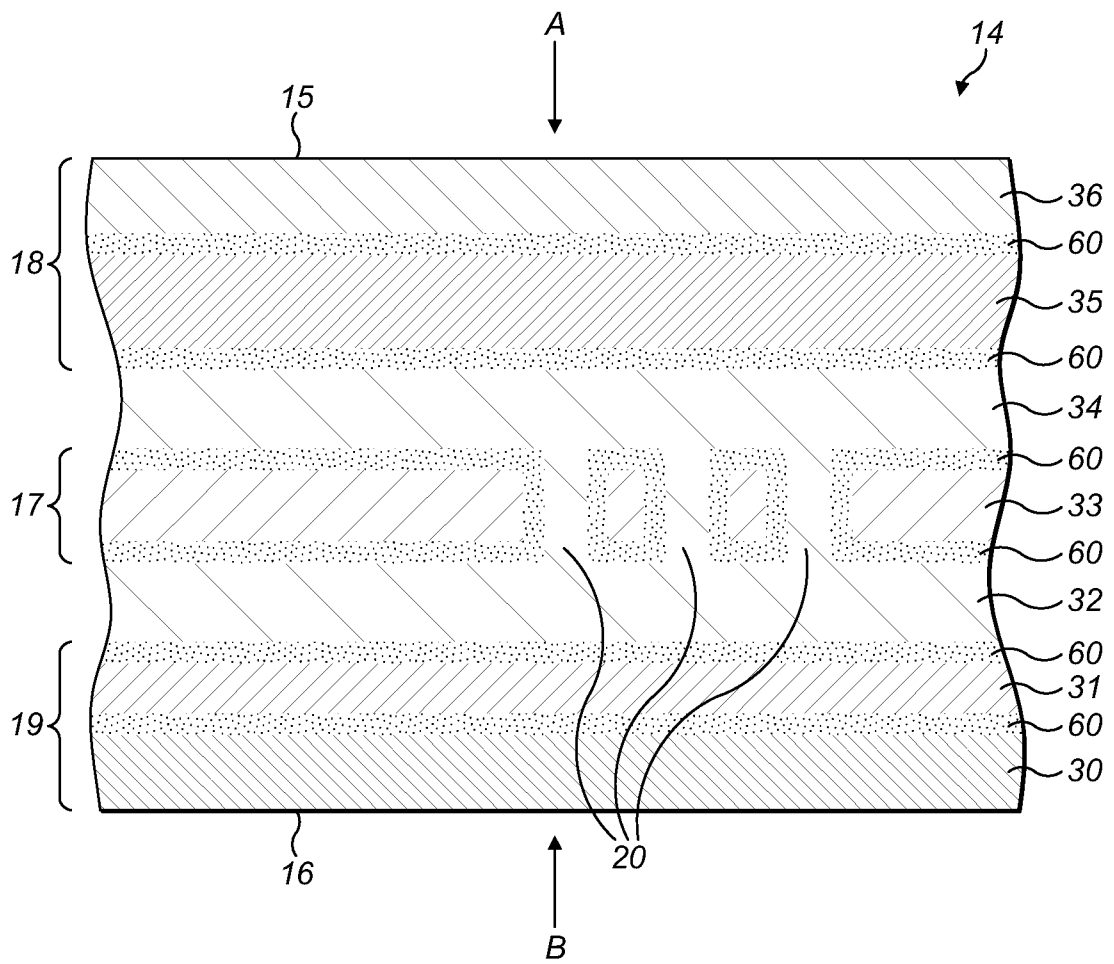
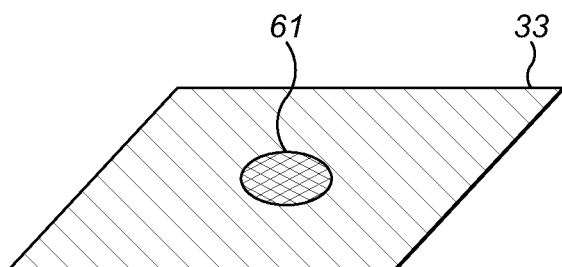
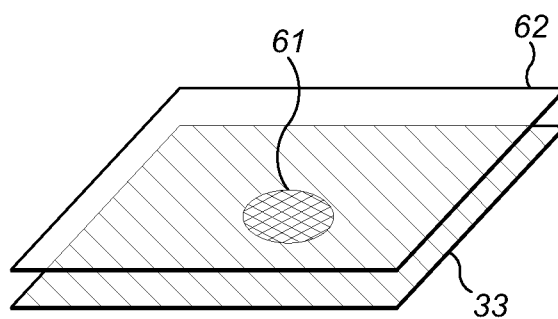
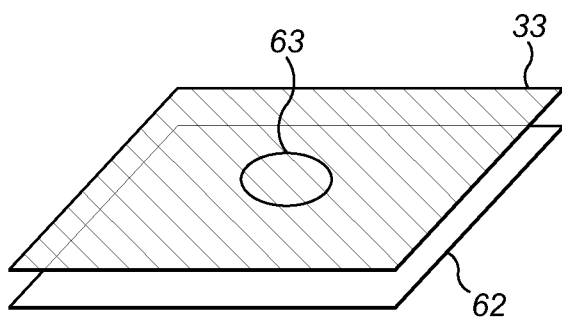
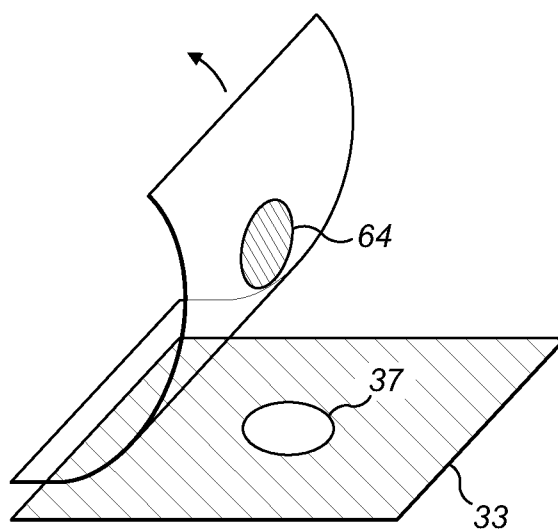


FIG. 6

*FIG. 7A**FIG. 7B**FIG. 7C**FIG. 7D*

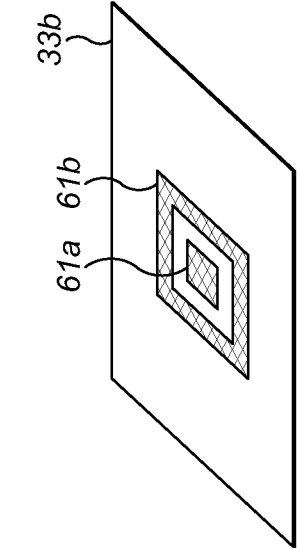


FIG. 8A

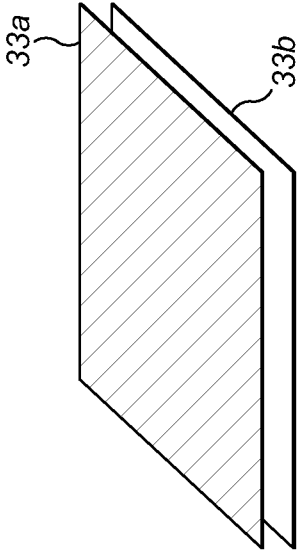


FIG. 8B

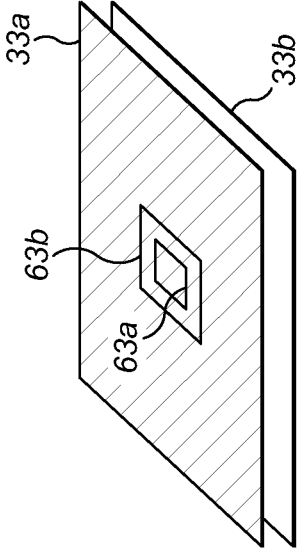


FIG. 8C

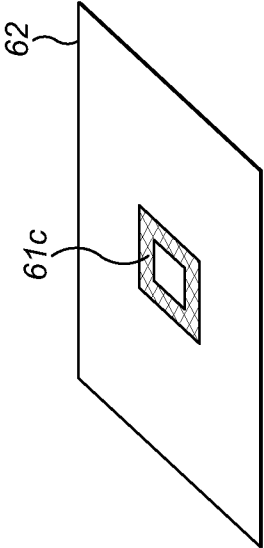


FIG. 8D

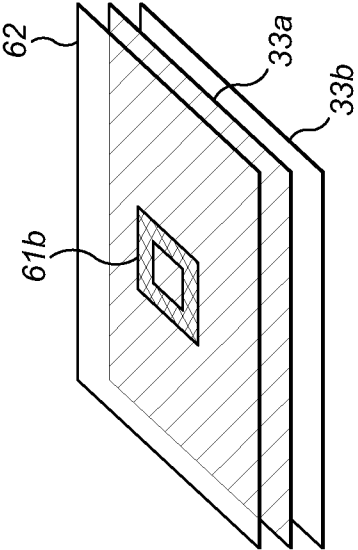


FIG. 8E

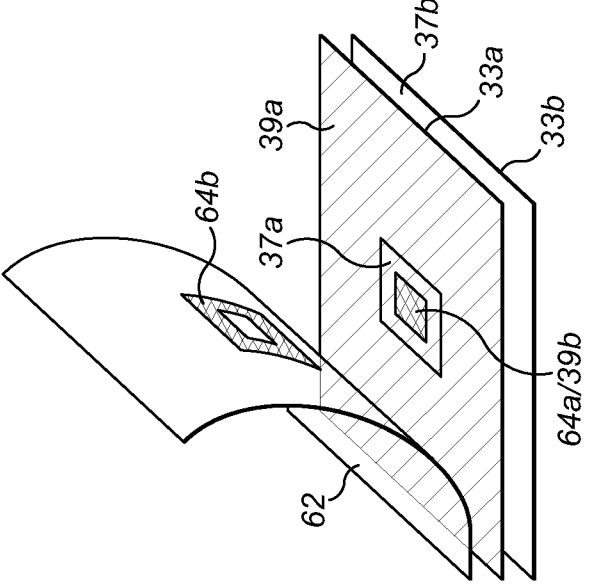
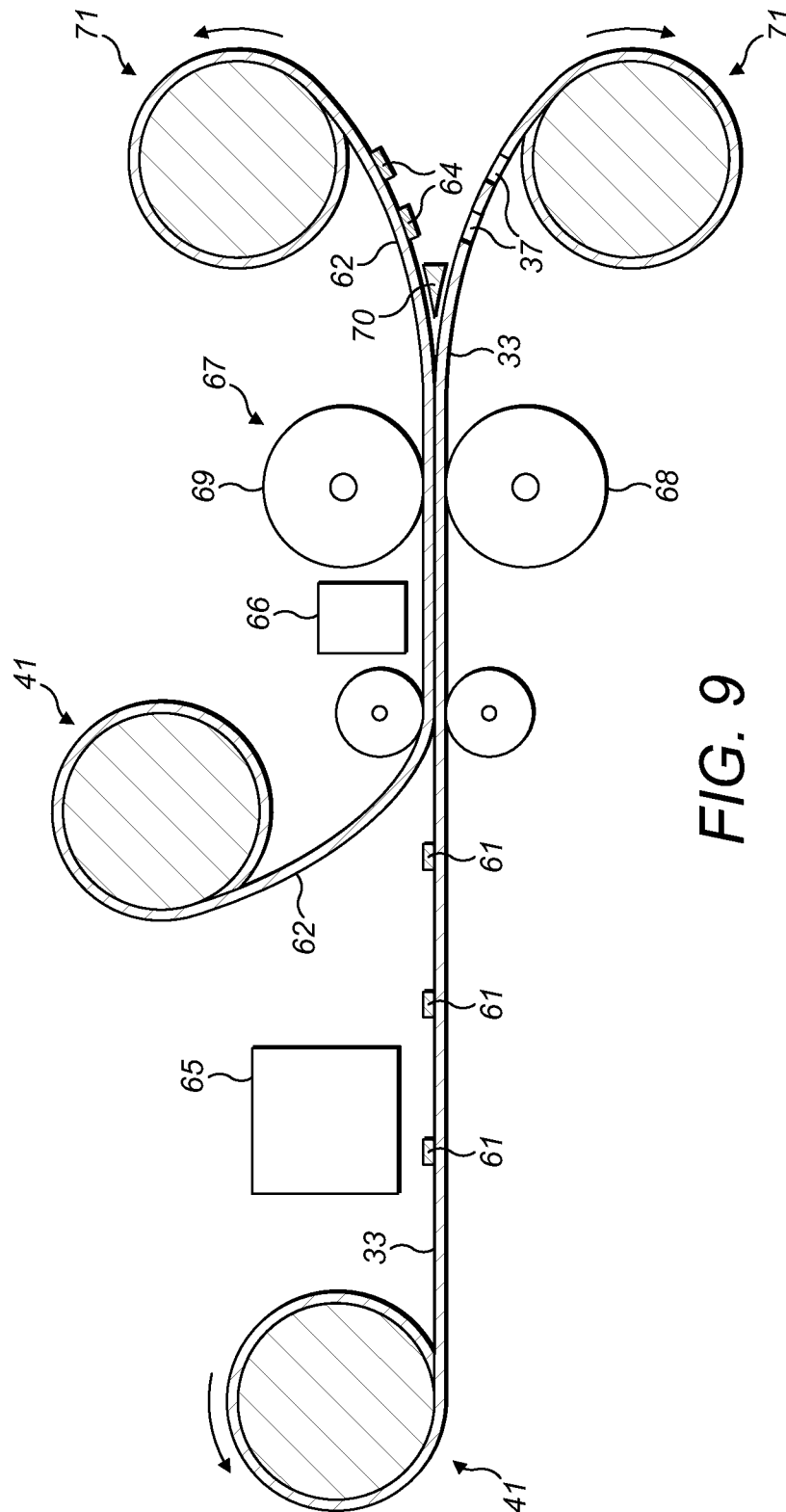
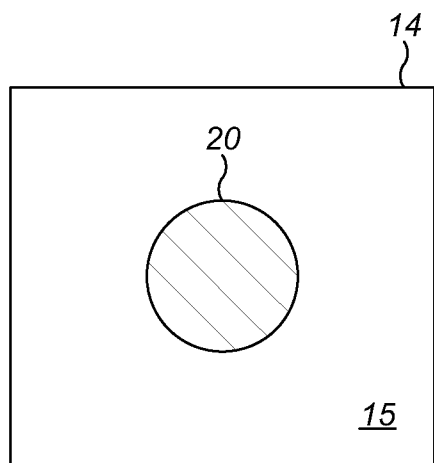
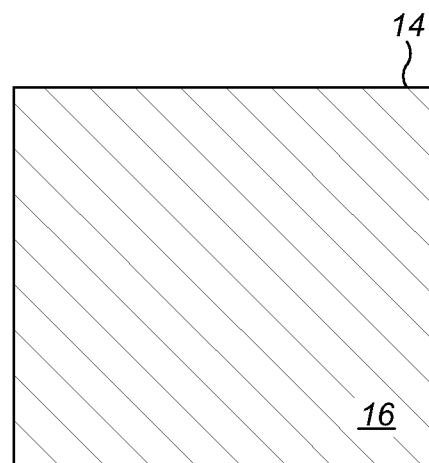
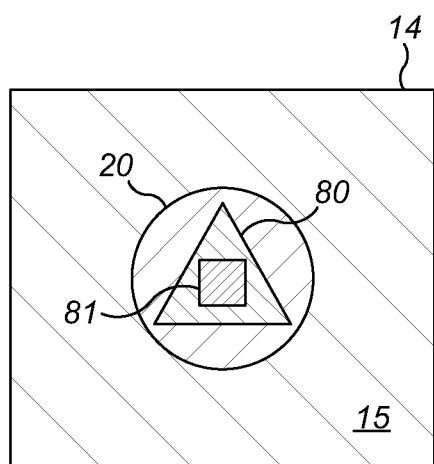
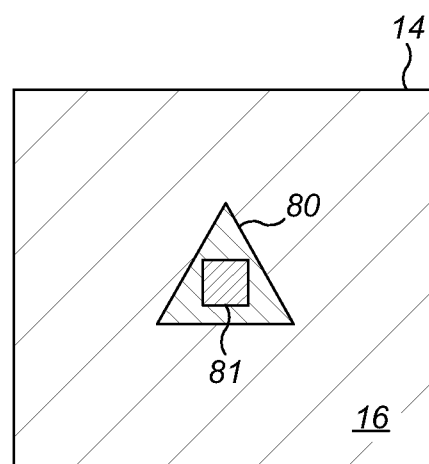
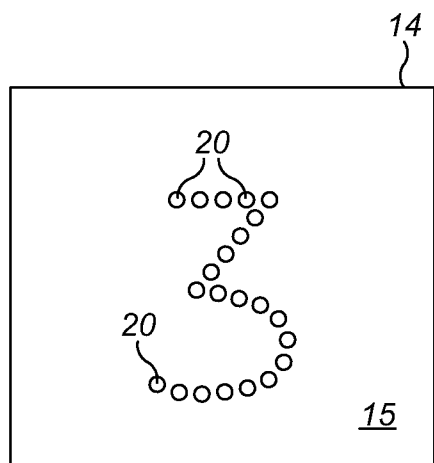
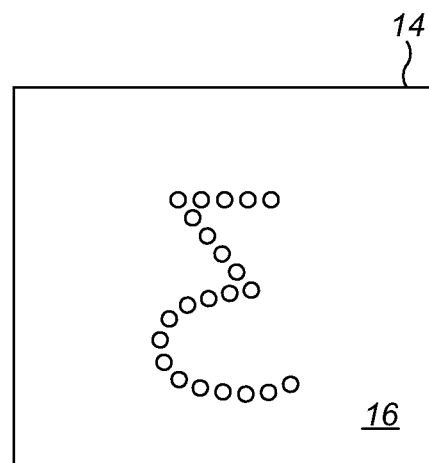
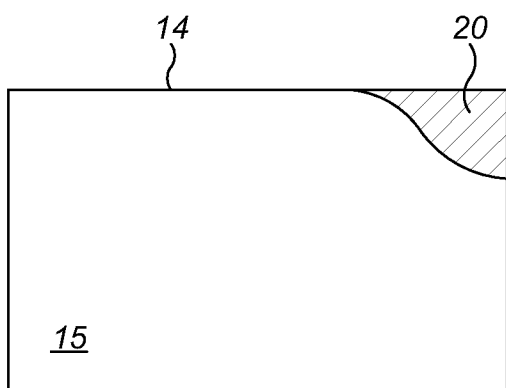
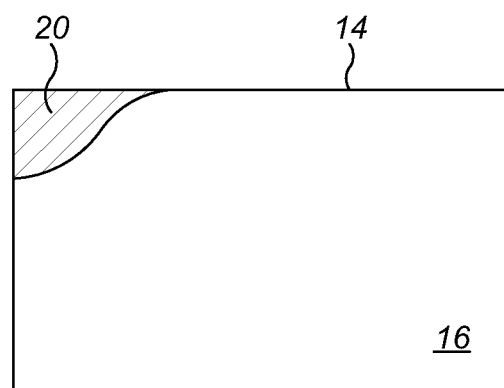


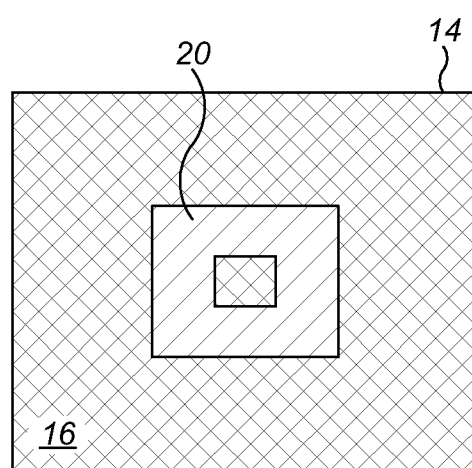
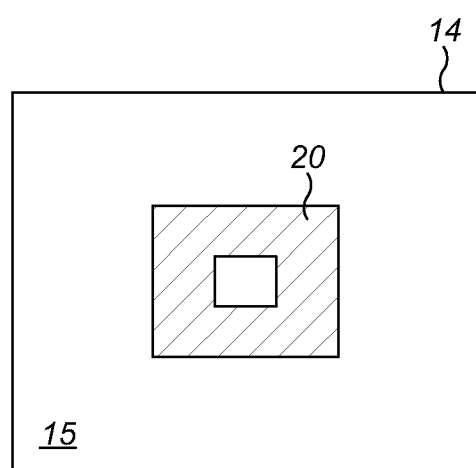
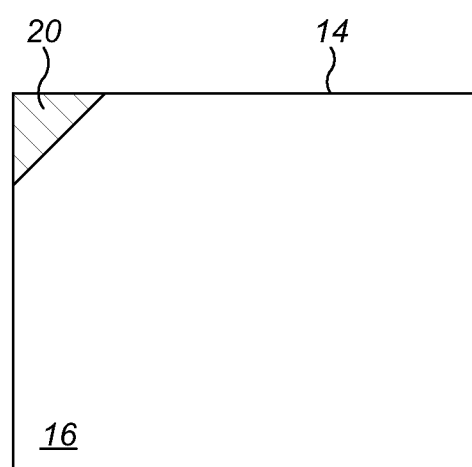
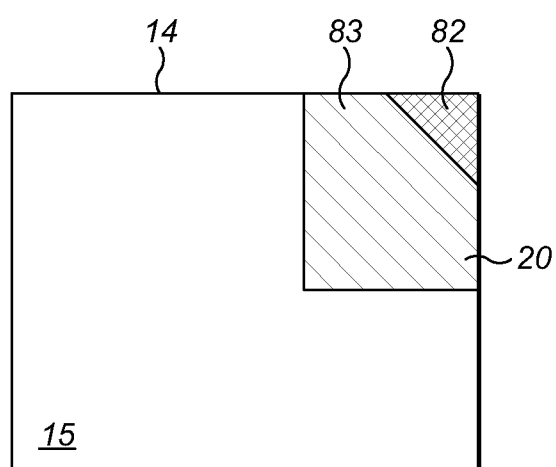
FIG. 8F

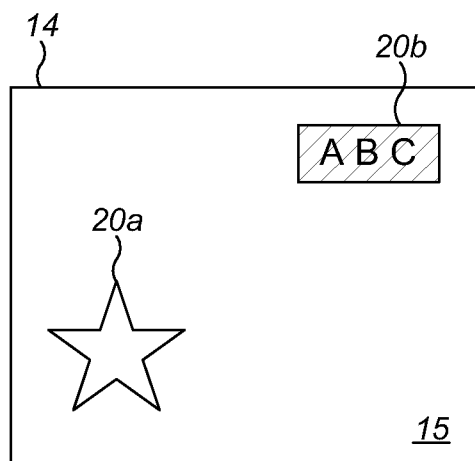
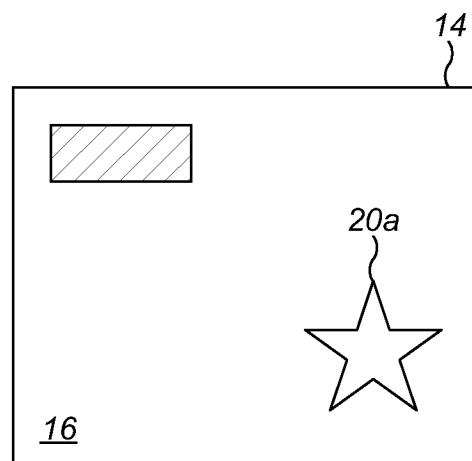
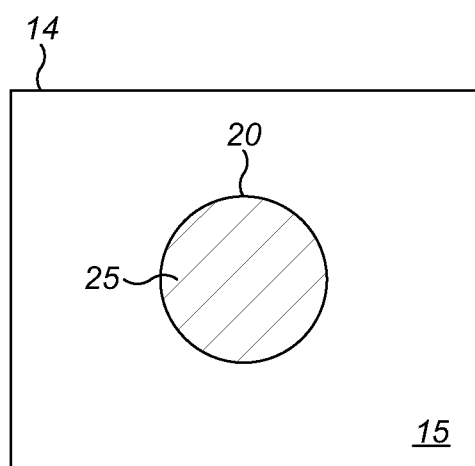
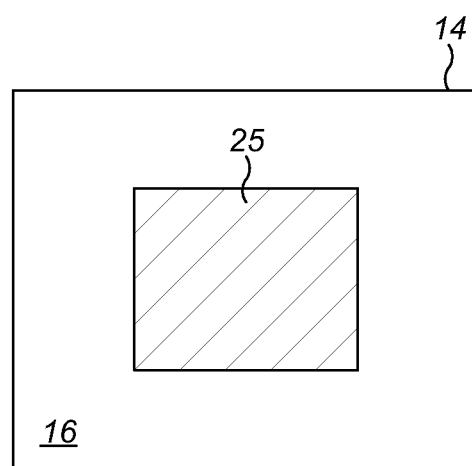
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*FIG. 10A**FIG. 10B**FIG. 11A**FIG. 11B*

*FIG. 12A**FIG. 12B**FIG. 13A**FIG. 13B*



*FIG. 16A**FIG. 16B**FIG. 17A**FIG. 17B*

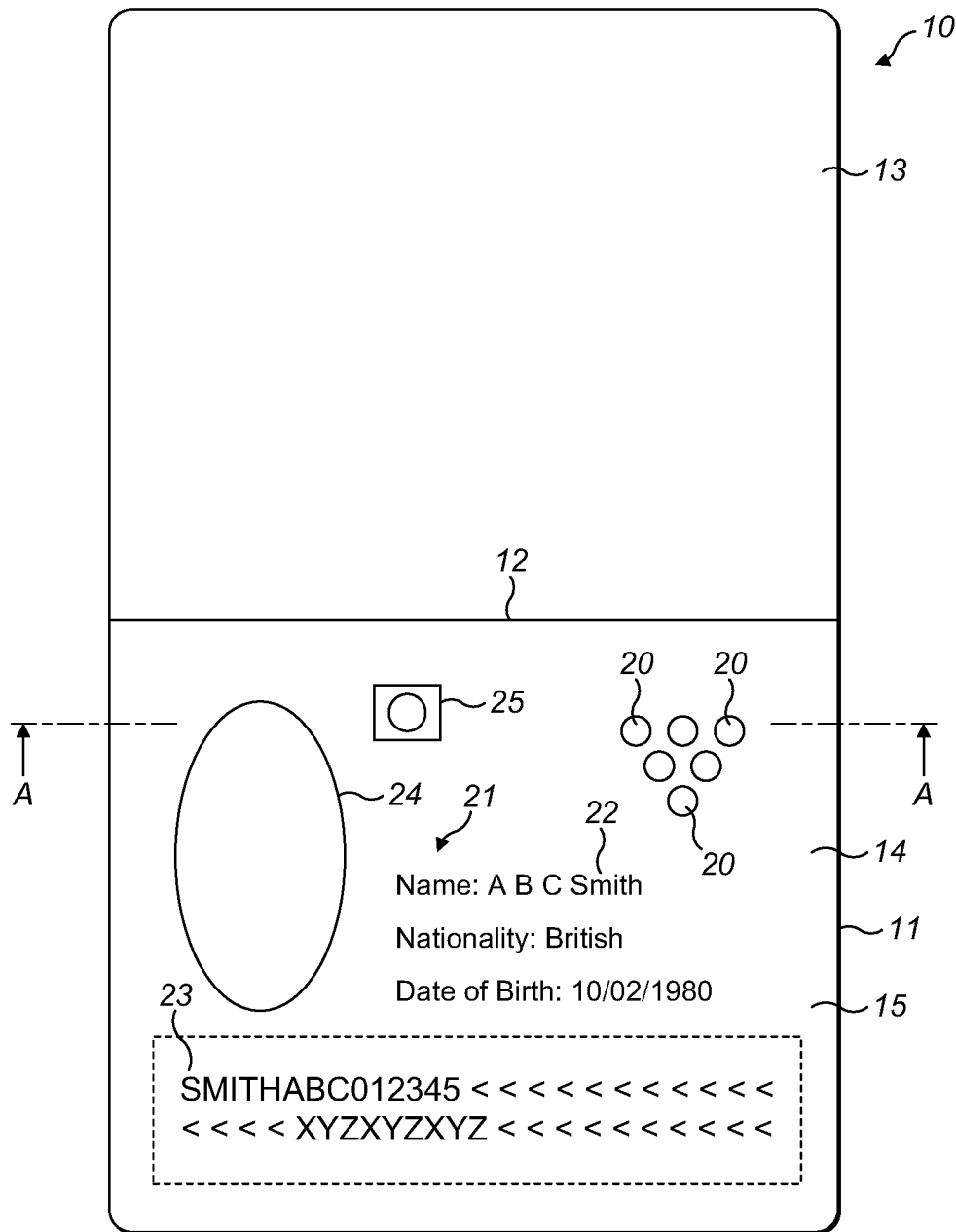


FIG. 1