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• **Philipp, Günther**
60311 Frankfurt (DE)
• **Parker, Andrew**
Richmond-Surrey TW10 6JW (GB)

(74) Representative: **Luderschmidt, Schüler & Partner**
Patentanwälte
John-F.-Kennedy-Strasse 4
65189 Wiesbaden (DE)

(71) Applicant: **European Central Bank**
60311 Frankfurt am Main (DE)

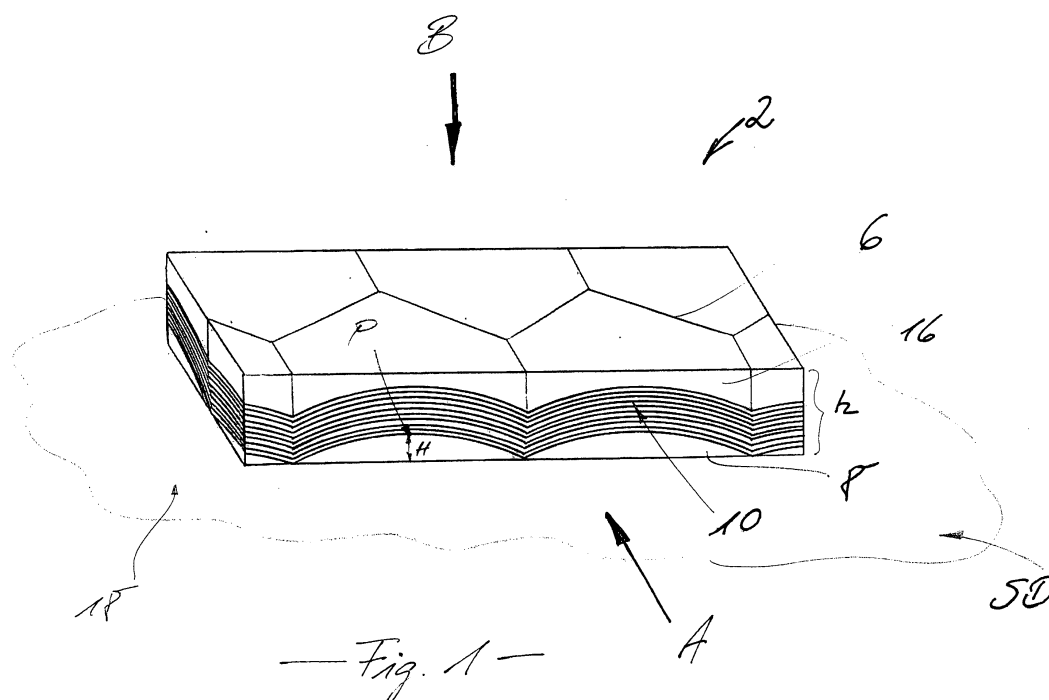
(72) Inventors:
• **Martin, Jerome**
60311 Frankfurt (DE)

(54) **Security document**

(57) The invention relates to a security document comprising a substrate 4 which is provided with a security feature. According to the invention, the security feature comprises an arrangement of optical elements 2 within a predetermined area 32, 34 of the security document, wherein each of said optical elements 2 forms an optical reflector and wherein each of said optical elements 2

comprises a stack of curved alternating layers 10 of different refractive indices.

The optical reflector changes its appearance depending on the type of incident illumination. When viewed from any direction under diffuse white incident illumination, the optical reflector has the appearance of a single dull colour, while under directional white incident illumination a bright sparkling effect is observed.



Description

[0001] The present invention generally relates to security documents comprising a substrate and at least one security feature, and in particular to banknotes.

[0002] Security documents such as banknotes, checks, stocks, bonds, passports, vouchers and the like are the subject to fraudulent copying. The authentication of security documents is a long standing problem. In order to solve this goal, security features have been developed to allow users and machines to discriminate among genuine and forged security documents as well as to discriminate among different values of security documents, in particular banknotes, using special papers, special inks, special patterns, the inclusion of watermarks and security threads and the like.

[0003] The security documents comprise a substrate, in particular a substrate made of paper or plastic. The security features are provided on the surface of the substrate and within the substrate.

[0004] It is an object of the present invention to make a contribution to the development of such security documents and to provide a security document comprising a security feature which is unusual and obvious to the unaided eye, and which can not be reproduced by means of any copying devices.

[0005] This object is solved with the features of claim 1. Preferred embodiments of the invention are the subject-matter of the dependent claims.

[0006] The security document according to the invention comprises a substrate which is provided with an arrangement of optical elements within a predetermined area of the security document. According to the invention, the arrangement of optical elements forms an optical reflector, wherein each of said optical elements comprises a stack of curved, preferably spherically curved, alternating layers of different refractive indices, i.e. an optical element having a lower refractive index follows an optical element having a higher optical element and vice versa.

[0007] The reflector produces a unique optical effect that when viewed from any direction under the illumination with directional incident light it provides a bright sparkling effect, while under the illumination with diffuse incident light it provides the appearance of a single dull colour over its surface, giving the appearance of plastic. This optical effect is unusual and obvious to the unaided eye, and can not be reproduced by means of any copying devices.

[0008] According to the invention, the optical elements can be arranged either on or within said substrate of the security document and the aperture of the optical elements can have different shapes. The optical elements preferably comprise a rectangular, quadratic, hexagonal or circular aperture, wherein the aperture diameter of each optical element is preferably 10 to 50 μm , in particular 15 to 25 μm .

[0009] The curved layers of the optical elements preferably comprise a constant thickness of 75 to 120 nm,

particularly a thickness of 90 nm. However, the curved layers can also have a different thickness.

[0010] The diameter of said stack of alternating layers is preferably greater or equal than the aperture diameter of said optical element so as to cover the aperture of said optical element as much as possible with active optical surface.

[0011] According to an aspect of the invention, said optical elements are covered with a protective layer of an optically inactive material. The protective layer can be formed as a layer providing an arrangement of optical elements having a plane or curved surface.

[0012] According to a preferred embodiment, the optical elements are arranged on a curved, preferably convex surface in order to provide a 3-dimensional effect.

[0013] According to an alternative embodiment, the optical elements are arranged on a plane surface which may be the plane surface of the substrate. In order to provide the 3-dimensional effect of the optical elements being arranged on a curved surface, the optical elements being arranged on a plane surface are preferably formed such that the optical elements have distorted apertures representing the projection of said optical elements arranged on the curved surface onto the plane surface.

[0014] According to another aspect of the invention, the security document is a banknote preferably comprising a paper based-substrate.

[0015] According to a further aspect of the invention, said banknote comprises a safety thread and / or a picture element, wherein said safety thread and / or picture element is provided with said arrangement of optical elements.

[0016] For the purpose of illustrating the present invention, there is shown in the accompanying drawings an embodiment which is presently preferred; it being understood that the invention is not limited to the precise arrangement and instrumentalities shown.

Fig. 1 shows a perspective view of a part of a security document according to the invention, comprising an arrangement of optical elements forming the security feature of the security document,

Fig. 2 shows a front view of the arrangement of optical elements of Fig. 1, the direction of the front view being indicated by arrow A in Fig. 1,

Fig. 3 shows a top view of the arrangement of optical elements of Fig. 1, the direction of the top view being indicated by arrow B in Fig. 1.

Fig. 4 shows a schematic illustration of a part of an arrangement of distorted optical elements of another security document according to the invention,

Fig. 5 shows a cross-sectional view of one of the optical elements of Fig. 4, and

Fig. 6 shows a banknote specimen provided with the arrangement of distorted optical elements of Fig. 4.

[0017] Fig. 1, 2, and 3 show only a part of the arrangement of optical elements according to the invention on a substrate of a security document.

[0018] The security document SD comprises a substrate 4 having an upper curved surface 18 on which an arrangement of micro-optical elements 2 forming an optical reflector is deposited within a predetermined area of the security document SD. Since the Figures show only a small sector of the whole preferably slight curved surface, the curvature of the sector of the surface could not be seen. However, a substrate having a plane upper surface can also be used, on which a basic layer can be arranged having a lower plane surface and an upper curved surface. The arrangement of the micro-optical elements 2 can also be included in the substrate 4 of the security document SD.

[0019] Each of the micro-optical elements 2 of the preferred embodiment comprises a basic layer 8 having a curved, preferably spherically upper surface. The basic layer is arranged on the curved upper surface of the substrate. On the upper curved surface of the basic layer a stack of alternating layers 10 of different refractive indices is deposited, the alternating layers 10 also having a curved, preferably spherically shape. If the layers are made of flexible material, the basic layer 8 causes the layers 10 to take on its spherical shape.

[0020] Furthermore, each of the micro-optical elements 2 comprises a hexagonal aperture 6 with an aperture diameter of $D = 19 \mu\text{m}$. The height H of the highest point P of the base 8 with respect to the substrate 4 measures $H = 1.5$ to $3.5 \mu\text{m}$, preferably $H = 2.25 \mu\text{m}$. The stack of the layers 10 comprises 10 high index layers 12 in total with a refractive index of 1.54 and 9 layers with a refractive index of 1, each of which is arranged between two high index layers 12. Each of the layers 10 has a constant thickness of preferably 90 nm. However, the thickness of the layers 10 can vary between 75 to 120 nm. On top of the stack there is deposited a protective layer 16 of an optically inactive material. The upper surface of the protective layer 16 has the same curvature as the upper surface 18 of the substrate 4. The height h of the optical element and the arrangement of optical elements, respectively, measures 4.5 to $8 \mu\text{m}$, preferably $6 \mu\text{m}$.

[0021] Apart from the illustrated hexagonal aperture of the optical elements, other aperture geometries can be realized, such as rectangular, quadratic or circular apertures, wherein the aperture diameter D of the optical element measures preferably 10 to 50 nm, particularly 15 to 25 nm.

[0022] The diameter d of the spherically shaped stack of layers 10 corresponds to the aperture diameter D of the optical element. The diameter d of the stack of layers 10 can be greater than the aperture diameter D of the

optical element so as to cover the aperture as much as possible with active optical surface. Fig. 5 schematically illustrates this arrangement, wherein the stack of layers 10 exceeds the aperture diameter D for the purpose of illustration only. The areas of this stack of layers 10 exceeding the aperture diameter D are actually truncated.

[0023] The optical elements 2 of the security document SD according to the invention form an optical reflector which provides the unique optical effect that it changes its appearance depending on the type of incident illumination. When viewed from any direction under diffuse white incident illumination, the optical reflector has the appearance of a single dull colour, while under directional white incident illumination a bright sparkling effect is observed, which is used for the purpose of verifying the genuineness of the security document.

[0024] According to an alternative embodiment of the invention, the security document SD, of which only a part is illustrated in Fig. 4, comprises a substrate 4 having a plane upper surface instead of a curved upper surface. In comparison to the previously described first embodiment, an arrangement of distorted micro-optical elements 2 forming an optical reflector is deposited within a predetermined area of the security document SD.

[0025] The arrangement of distorted micro-optical elements on a substrate having a plane surface replace the arrangement of the undistorted micro-optical elements on a substrate having a curved upper surface of the first embodiment of the invention. Each of the distorted optical elements 2 is formed with a distorted aperture 22 representing the projection of an optical element 23 arranged on a curved, preferably convex surface 20 onto the plane surface 18 of the security document, the projection being indicated by projection lines 23b. The distortions of the optical elements 2 occur either in one of the directions X , Y or in two directions X , Y which are orthogonal to each other with respect to one reference point 26 which remains undistorted. The arrangement of the distorted optical elements on a curved surface provides the same optical effect as the arrangement of the undistorted optical elements on a plane surface. The advantage of the distorted optical elements is that a substrate having a plane surface can be used.

[0026] Fig. 6 shows a banknote 28 as a security document SD comprising a plane paper-based substrate 30, on which surface analogous to the previously described embodiment of the invention is deposited said arrangement of distorted optical elements 2 forming the optical reflector. The distorted optical elements are included in the safety thread 32 and one of the picture elements 34 of the banknote.

Claims

1. A security document comprising a substrate (4) with a security feature, **characterised in that** the security feature comprises an arrangement of optical ele-

ments (2) within a predetermined area of the security document forming an optical reflector, and that each of said optical elements (2) comprises a stack of curved alternating layers (10) of different refractive indices.

2. A security document according to claim 1, **characterised in that** said optical elements (2) are arranged on said substrate (4) of the security document. 5
3. A security document according to claim 2, **characterised in that** said optical elements (2) are arranged within said substrate (4) of the security document. 10
4. A security document according to one of claims 1 to 3, **characterised in that** each of said layers (10) comprises a constant thickness. 15
5. A security document according to claim 4, **characterised in that** each of said layers (10) comprises a constant thickness of 75 to 120 nm, preferably a thickness of 90 nm. 20
6. A security document according to at least one of claims 1 to 5, **characterised in that** each of said optical elements (2) comprises a rectangular, quadratic, hexagonal or circular aperture. 25
7. A security document according to claim 6, **characterised in that** each of said optical elements (2) comprises an aperture diameter (D) of 10 to 50 μm , preferably 15 to 25 μm . 30
8. A security document according to claim 7, **characterised in that** the diameter (d) of said stack of alternating layers (10) is greater or equal than the aperture diameter (D) of said optical element. 35
9. A security document according to at least one of claims 1 to 8, **characterised in that** said optical elements (2) are covered with a protective layer (16) of an optically inactive material. 40
10. A security document according to at least one of claims 1 to 9, **characterised in that** said optical elements (2) are arranged on a curved surface (20), forming curved elements (23). 45
11. A security document according to at least one of claims 1 to 9, **characterised in that** said optical elements (2) are arranged on a plane surface (18). 50
12. A security document according to claim 11, **characterised in that** each of said optical elements (2) is formed such as the optical element has a distorted aperture (22) representing the projection of said op-

tical element arranged on a curved surface (20) onto a plane surface (18).

13. A security document according to at least one of claims 1 to 12, **characterised in that** said security document is a banknote (20). 5
14. A security document according to claim 13, **characterised in that** said banknote (20) comprises a paper based-substrate (30). 10
15. A security document according to claim 13 or 14, **characterised in that** said banknote (20) comprises a safety thread (32) and / or a picture element (34), wherein said safety thread and / or picture element comprises said arrangement of optical elements (2). 15

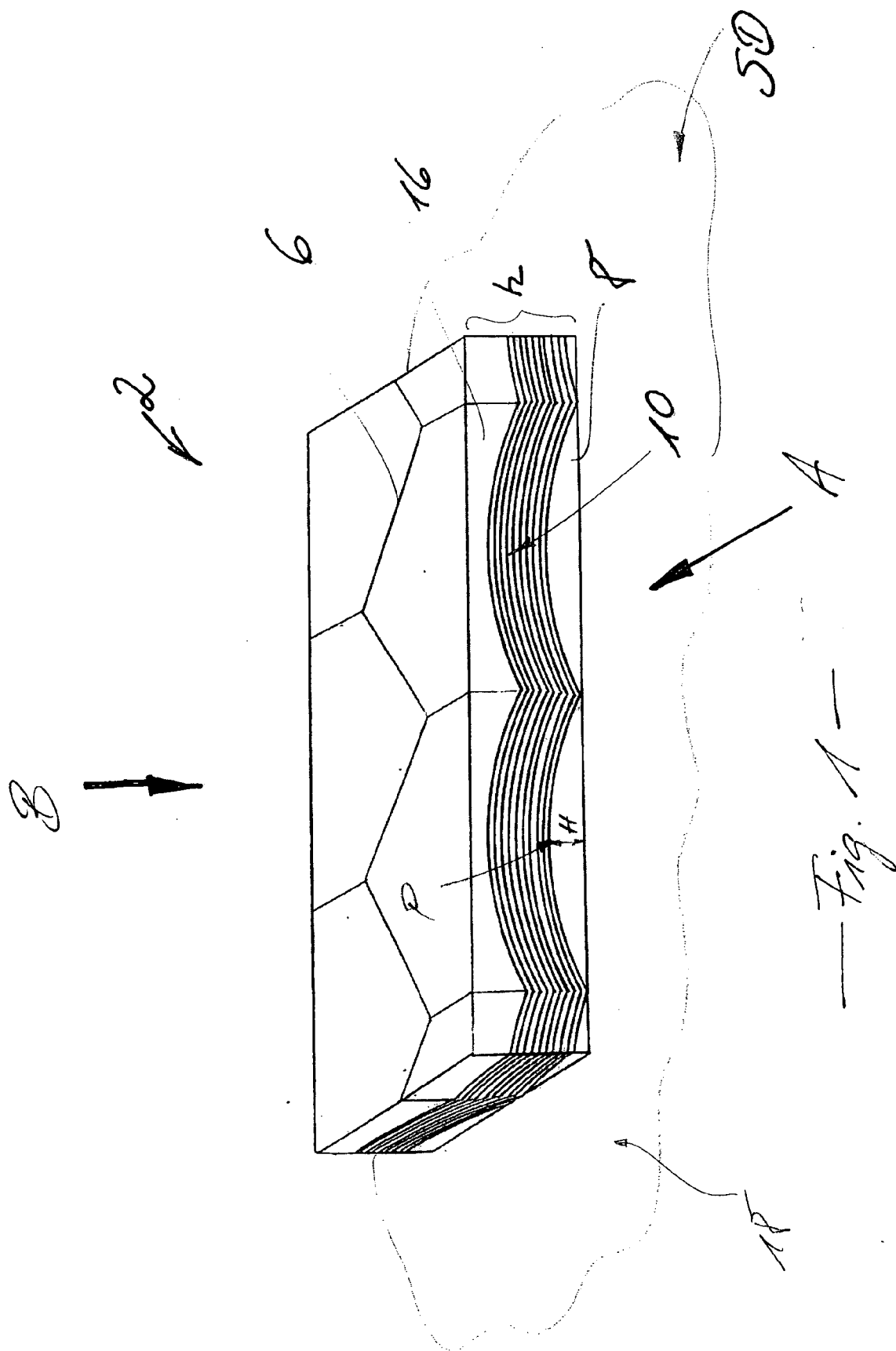


Fig. 1 —

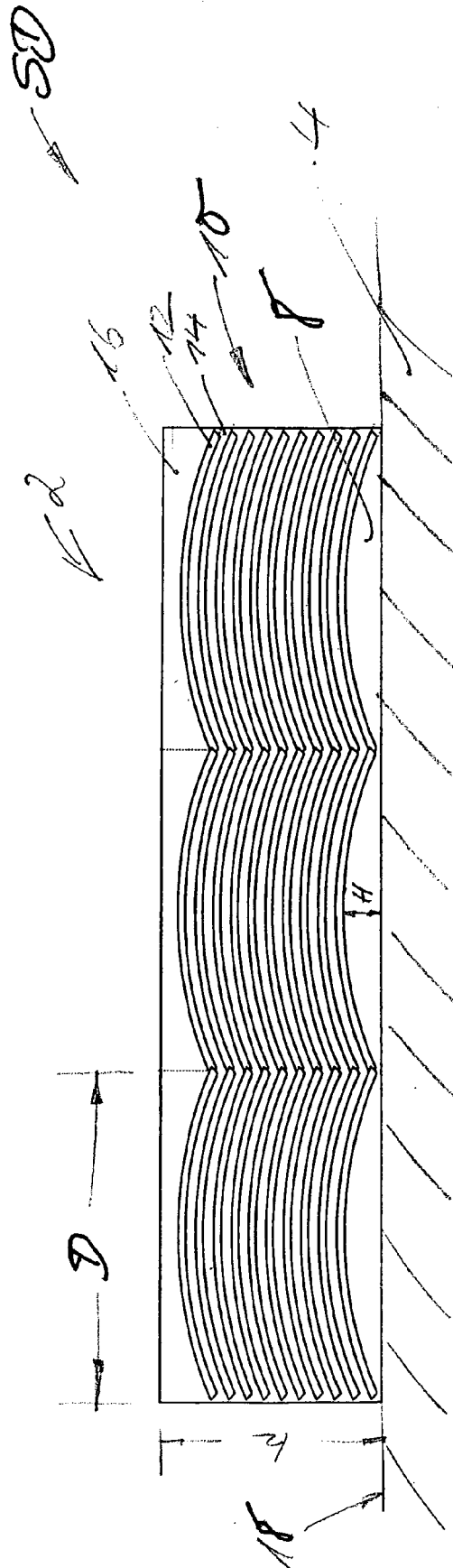


Fig. 2

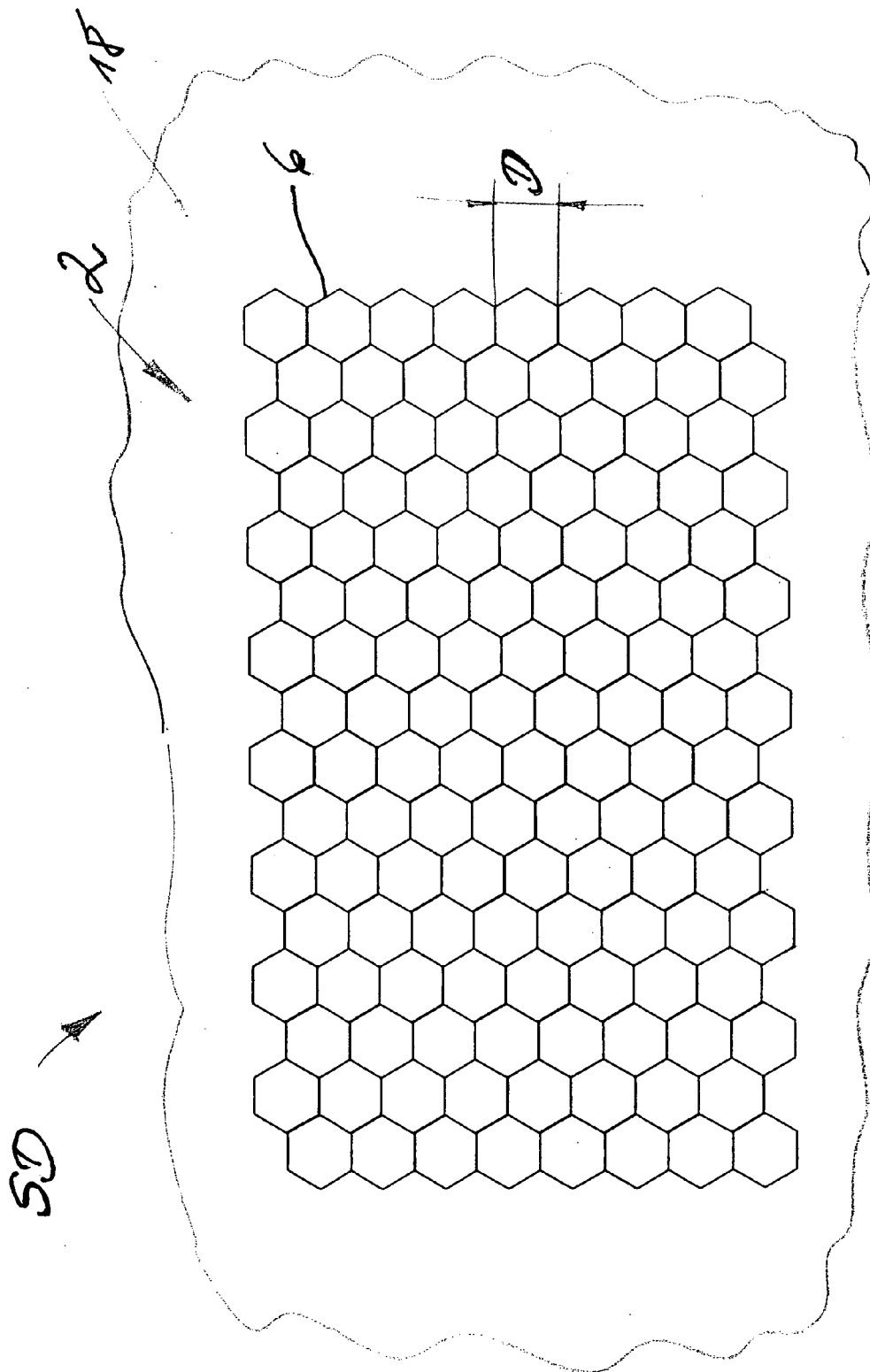
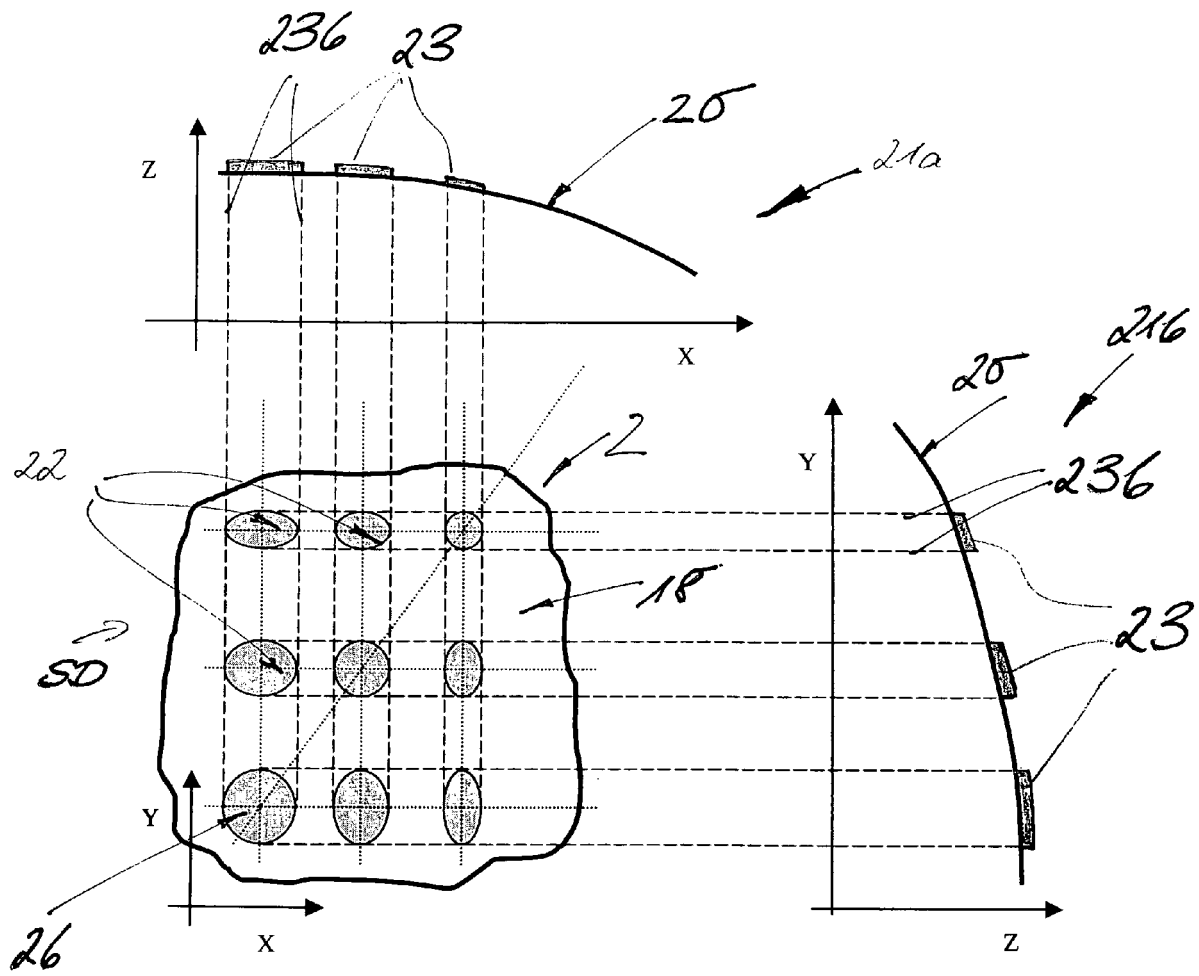
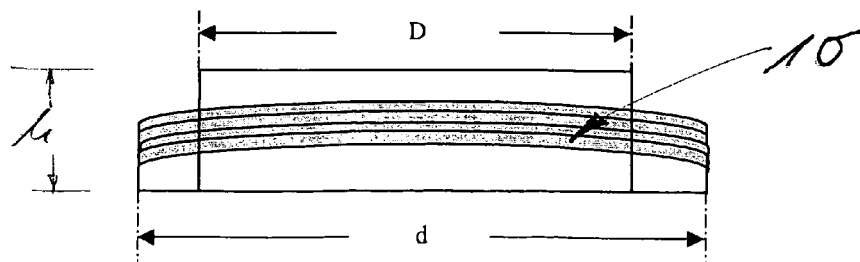


Fig. 3



- Fig. 4 -



- Fig. 5 -

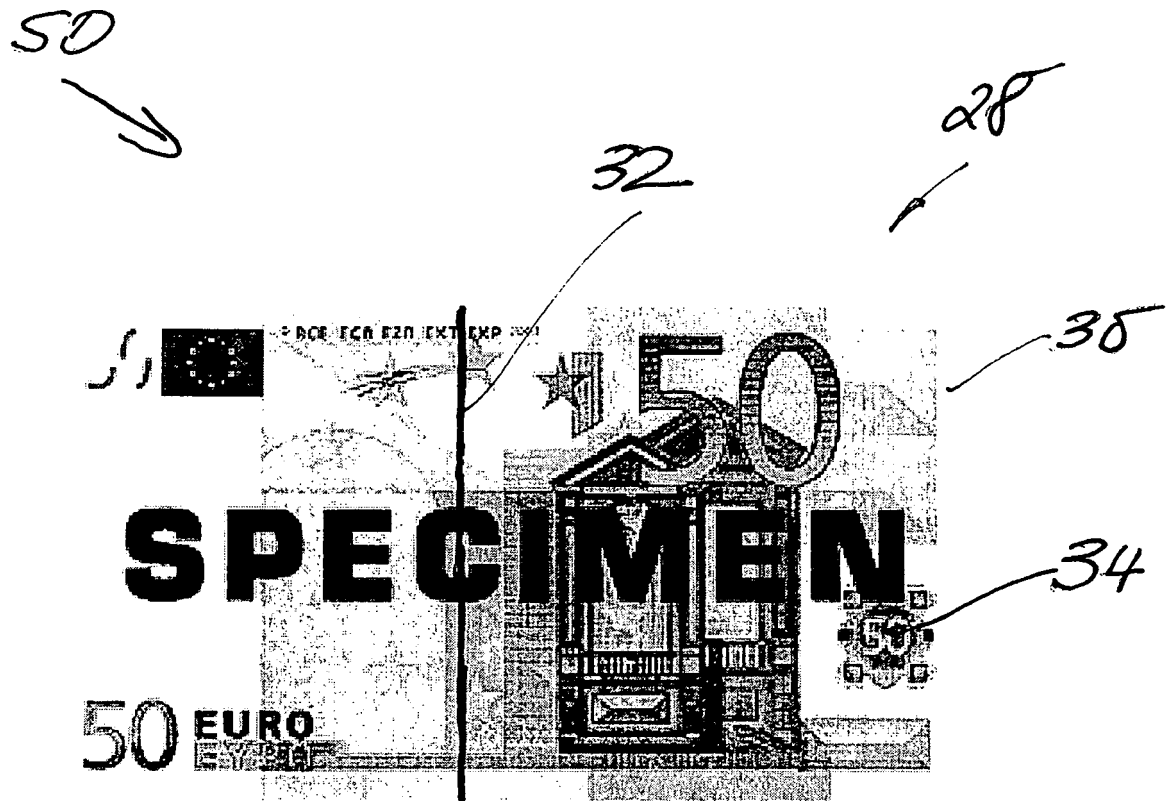


Fig. 6-



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 06 02 3970

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 September 2007	Examiner Evans, Andrew
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 02 3970

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