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- **KURYATNIKOV, Andrey Borisovich**  
Moscow 129128 (RU)
- **LAZARYUK, Sergey Nesterovich**  
Moscow 119180 (RU)
- **NIKIRUY, Ehrnest Yaroslavovich**  
Moscow 125480 (RU)
- **SMIRNOV, Andrey Valentinovich**  
Moskovskaya oblast  
Dubna 141980 (RU)
- **SMIRNOV, Leonid Igorevich**  
Moskovskaya oblast  
Dubna 141980 (RU)
- **KHARLAMOV, Konstantin Vladimirovich**  
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(71) Applicant: **Aktsionernoe Obshchestvo "Goznak"**  
**St. Petersburg, 197046 (RU)**

- (72) Inventors:
- **GONCHAROV, Alexey Mikhailovich**  
Moscow 109451 (RU)
  - **IVANCHENKO, Evgeniya Alexandrovna**  
Bryanskaya obl.  
Klintsy 243146 (RU)
  - **KSENOFONTOV, Valentin Anatolievich**  
Moscow 115372 (RU)

(74) Representative: **Zimmermann, Tankred Klaus et al**  
**Schoppe, Zimmermann, Stöckeler**  
**Zinkler, Schenk & Partner mbB**  
**Patentanwälte**  
**Radtkoferstrasse 2**  
**81373 München (DE)**

(54) **MULTI-LAYERED POLYMERIC ARTICLE, SUCH AS AN IDENTIFICATION DOCUMENT**

(57) The invention relates to counterfeit-protected printed products, in particular, to a multi-layered polymeric article such as an identification document. Article comprises a plurality of polymeric layers joined without adhesive, at least one of the layers having colored identifying and individualizing images inscribed therein. Images are inscribed in the form of semi-transparent pixel matrixes consisting of thin-film pixel elements with sub-pixel structures consisting of areas with metallized diffraction gratings. At least two polymeric layers are joined by fusion. Pixel matrixes are formed on surfaces between fused layers, one the layers being transparent, and consist of pixels of a size of 30 to 200  $\mu\text{m}$  spaced apart by a distance of 30 to 500  $\mu\text{m}$ .

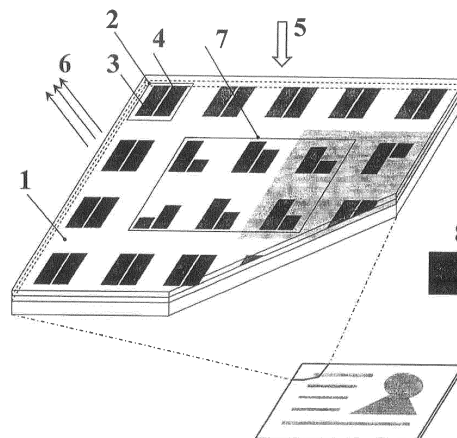


FIG. 1

## Description

### Field of the Invention

**[0001]** The invention relates to polymer chemistry, technology of thin-film polymeric materials, and composite multi-layered polymeric products. Polymeric films have currently found wide application in the manufacture of various multi-layered products e.g. documents that must be secure from counterfeit and are intended to identify their owner. Composite materials for production of secure documents are being improved constantly, and they should ensure high physical and mechanical characteristics of the product in terms of its durability and resistance to the effects aimed at delamination and changes to graphics and other data. For mass production of identification documents, it is necessary that the used materials were produced without changing the existing technologies.

**[0002]** The use of polymeric multi-layered materials in identity documents such as passports, identity cards, driver's licenses, is important to ensure counterfeit protection. To protect such documents against forgery at their manufacture and issuance, personal information about the document's owner is inscribed in them. Typically, this is a portrait and biometric data of the owner, date and place of birth, time and place of issue of the document, etc. In current technology of applying multi-layered polymeric materials for identification documents, personal information is inscribed in the form of portrait and text images that are placed on/or in individual layers of the multi-layered plastic structures. To protect the document from counterfeit, in addition to the basic personal information in many cases additional or duplicate images and information related to the basic information are inscribed, which are semi-transparent, visualized in transmitted and/or reflected light, and do not interfere with the perception of the basic information. In some cases, hidden or encrypted information is added to the additional or duplicate images, which allows authentication of the document with the use of dedicated instruments.

**[0003]** The biggest security effect is achieved, if the duplicate images are colored and easily recognizable, and the image formation technology is available only to the manufacturer of the documents.

**[0004]** Additional colored graphic or text images are effective for counterfeit protection of not only documents, but also individual multi-layered polymeric elements, for example, non-removable protective stickers applied to the articles to confirm their authenticity. These articles may include any product, in particular printing products. In this case, elements are individualized, that is images applied to them are individual for each element or a limited group of such elements, and these images can be related to individual characteristics of the protected products e.g. their serial numbers.

### Background Art

**[0005]** Conventional colored digital and analog images, widely used in multi-layered polymeric products, are formed by standard technologies based on direct printing methods, in which paint or colored ink is applied onto a carrier by various methods. The main disadvantage of these colored images, in terms of their use in identification documents, is the widespread availability of technologies for their production, allowing replacement and forgery of photos and graphic personal data in the documents individualized by such methods.

**[0006]** A variety of unique methods of recording colored images in multi-layered polymeric materials are also known at present, which require the use of special substances and materials available to only a limited number of companies.

**[0007]** The methods include e.g. a method of recording in multi-layered structures containing inks that change color when exposed to laser radiation (RU 2286888 C2, 10.11.2006), or a method of laser engraving of sub-layers of a multi-layer structure including a sequence of layers of pigments of various colors (US 7763179 B2 27.07.2009). The disadvantage of the methods is the need for unique multi-layered materials with special composition and pigment coatings, which complicates implementation of the methods and their use in industry.

**[0008]** Various methods are also known for inscribing colored holographic 3D images in photopolymeric layers, e.g. using a lenticular array (US 20130301090 A1, 14.11.2013). The main disadvantage of these methods is the need to produce the holograms on a film carrier in a separate process followed by application of a film with the hologram to the document.

**[0009]** A method is known, in which an additional image is formed in a multi-layered polymeric document in a semi-transparent layer by laser engraving of partially demetalized diffraction grating, which is a component of the main fixed holographic image (US 2013/0082458 A1 04.04.2013). This is done at laser marking of the underlying layer, which is carbonized under laser radiation. Partial demetallization of the diffraction grating protects the document against delamination since it provides fusion of the material of adjacent layers in the areas free of metallization. The main disadvantage of this method is that it is impossible to form an arbitrary colored image.

**[0010]** One of the most promising methods for personalization and individualization of documents is a method of forming full-color holographic images in a multi-layered polymeric structure (RU 2079167 C1, 10.05.1997). Images are inscribed on internal diffraction gratings, one above the other in multi-layered polymeric carriers. The full-color images are restored in white light. Information placed on the carrier is in the form of text and graphic images.

**[0011]** The method described in RU 2079167 is the most relevant prior art for the present identification document. The disadvantage of the method is that it cannot

form transparent and semi-transparent images. Furthermore, such multi-layered holographic structures are not homogeneous. In production of plastic documents, solid metallized diffraction gratings are disposed within multi-layered polymeric structures, and this often facilitates separation between layers and counterfeit of the documents.

## SUMMARY OF THE INVENTION

**[0012]** The object of the invention is to provide a multi-layered polymeric article such as a secure identification document, which comprises, in addition to basic personal data, additional colored images related to the personal data and individualizing the document, the document being protected from delamination and counterfeit of the inscribed personal information. To attain the object, the additional colored images are formed as a semi-transparent matrix of pixels comprising metallized diffraction gratings and spaced apart so that the polymeric layers of the article can be fused together in the areas free of diffraction gratings in the manufacture of the article.

**[0013]** In an embodiment, the layer with a semi-transparent pixel matrix is disposed above the layer with personalized graphics and text data.

**[0014]** In an embodiment, the pixels are diffraction gratings reflecting electromagnetic radiation of a predetermined wavelength in a predetermined direction.

**[0015]** It should be noted that the article manufactured according to any embodiment can be a banknote, protective sticker, blank sheet for a valuable document, excise stamp, passport, identity card, travel document, driver's license, diploma, plastic card or similar document.

**[0016]** In an embodiment, the pixels are formed by masking and then etching the matrix structures on the surface of transparent polymer films prior to fusing together the layers of the identification document.

**[0017]** Images are inscribed in the present identification document by a focused laser radiation on laser engraving machines. Images are formed by partially destroying the metallized diffraction gratings, which changes the color saturation and brightness of the sub-pixel areas owing to modulation of intensity, duration and number of laser pulses, with precise positioning of the laser beam on elements of the pixel matrix and/or special markers disposed on the surface of the pixel matrix.

**[0018]** The ability to remove the diffraction grating is determined by the presence of its metallization, since engraving is generally performed by infrared lasers with the electromagnetic radiation wavelength of  $1.064\ \mu\text{m}$ , which is well absorbed in metals and leads to demetallization of the diffraction gratings and loss of their reflective properties.

**[0019]** Laser beam is moved over pixels of the matrix structure and focused on subpixels with diffraction gratings that reflect light of a specific wavelength. Depending on the duration and power of laser pulses, the diffraction grating in the selected pixel is removed completely or

partially.

**[0020]** By moving on pixels and subpixels of the matrix structure, colored images are formed which can be observed in predetermined directions of observation.

**[0021]** Pixel elements of the matrix structure may have various forms, for example, rectangular, diamond-shaped or round. The pixels can have a size of 30 to  $200\ \mu\text{m}$ . Furthermore, at least two polymeric layers are joined together by fusion, and pixel matrixes are formed on the surfaces between the fused layers, one of which is transparent, and consist of pixels spaced apart by a distance of 30 to  $500\ \mu\text{m}$ . Predetermined transparency of the formed images is from 50 to 99%. Size, location and distance between the pixels determine the transparency of inscribed images and the complexity of delamination of the multi-layered polymeric card without destroying the diffraction gratings in subpixels of the matrix structure, therefore, without destroying the inscribed images.

**[0022]** Minimum size of the pixels is determined by the diameter of the laser beam used in practice, which is in the range of from  $5\ \mu\text{m}$  to  $100\ \mu\text{m}$ , and the ability of pointing the beam to pixels with precision that allows engraving the diffraction gratings.

**[0023]** Maximum size of the pixels is limited by the fact that non-transparent pixels overlap underlying images and make them inaccessible for observation. For a typical thickness of the transparent layer between the additional and main image of 50 to  $100\ \mu\text{m}$  the maximum pixel size should not exceed  $200\ \mu\text{m}$ .

**[0024]** At the same time, to provide protection from delamination, two adjacent polymeric layers must be uniformly fused together over the area not less than 50% of the total area of the layer because the metallized diffraction structure relates to easily peelable components.

**[0025]** Sub-pixel diffraction gratings can be disposed inside the pixels both adjacent to each other and at some distance from each other; this is determined by the resolution of the laser engraving machine employed. As a result of laser individualization in identification of documents, the density of diffraction pixels performs the function of control of the transparency of the diffraction structure. Any attempt to separate the layer with the applied additional image from the layer with personal data will result in distortion of spatial relationship between the elements, which will be easily discernible at instrumental authentication of the document in a case of poor legibility of the image with the naked eye.

## Brief Description of the Drawing

**[0026]** Fig. 1 shows a schematic diagram of an identification document according to the invention, where 1 is an upper transparent polymeric layer comprising thin-film aluminum reflecting elements; 2 - pixels in nodes of a matrix with sub-pixel structures; 3, 4 - sub-pixels filled with diffraction gratings, which reflect white light 5 falling on them in a predetermined direction 6, radiation of red and blue color, respectively.

**[0027]** When a personalization image is inscribed in each of subpixels 7, part of the diffraction grating is burned out; 8 is a pixel consisting of a single sub-pixel comprising a diffraction grating that reflects light of a predetermined wavelength in a predetermined direction. It can be used for personalization of a document by inscribing a monochromatic image of a predetermined color.

#### Description of Preferred Embodiment

**[0028]** An exemplary embodiment of the present invention is a multi-layered identification document, in which an upper transparent polymeric layer 1, disposed above underlying layers with main graphic images and personal data, comprises thin-film aluminum reflective elements. Images are formed in a matrix with nodes, in which pixels 2 are disposed; the pixels 2 have sub-pixel structures consisting of two areas with different diffraction gratings reflecting electromagnetic light radiation of red and blue color, respectively, in a predetermined direction. The pixels may have rectangular or any other shape with typical sizes of 30 to 200  $\mu\text{m}$ . The pixel elements of the matrix are spaced apart at distances of 30 to 500  $\mu\text{m}$ , which determine the transparency level of the image - the transparency of the formed images can be adjusted by the density of pixels. Transparency of the images formed according to the invention is from 50 to 99%. Each pixel is divided into two areas: subpixels 3, 4, filled with diffraction gratings, which reflect radiation of red and blue color, respectively, when white light 5 falls on them, in a predetermined direction 6, for example, perpendicular to the surface of the information carrier. The number of subpixels is not limited to two, there may be 3, 4, etc. Areas occupied by the diffraction gratings are identical in each of the subpixels. When a personalization image, for example, colored text, is inscribed, part of the diffraction grating is burned out in each of the subpixels 7. By changing the reflectivity of the diffraction gratings of the subpixels in different pixels of the pixel matrix, a colored image is formed, which can be restored under exposure to white light 5 and observed in a predetermined direction 6 to the surface of the pixel array. The size and diffraction efficiency of the sub-pixel areas can be varied by changing the intensity, duration and number of laser pulses. For precise positioning of the laser beam at engraving in sub-pixel areas, high-precision methods are used to point the beam to pixel elements of the matrix and special marking labels. Given the quite large number of pixels (thousands or more) coding by positions of each pixel is very secure.

**[0029]** It should be noted that the predetermined transparency of the formed images is dictated by the following: the upper limit of the range is selected owing to the fact that if the layer contains a distributed array of metallized diffraction pixels occupying 1% of the area of the layer, light reflected by the matrix will be still sufficient for perception of the image. The lower limit of the range is selected owing to the fact that 50% of transparency is di-

rectly related to the requirement of protection from delamination, since the document will be able to be delaminated if the area of non-transparent pixels is more than 50% of the total area of the layer.

**[0030]** A further exemplary embodiment comprises two sub-pixel structures (reflecting blue and red color), rather than three, as in the RGB color image system (red, green, blue), to illustrate a simplified procedure of image formation with a laser, because in this case the laser beam pointing system is simpler. The embodiment with two basic colors can form a colored image having a limited range of colors, but easily distinguishable and identifiable. Use of two basic colors reduces requirements to the complexity of scanning and laser beam guidance control algorithms, but retains the counterfeit security of the document owing to the unique method of laser control.

**[0031]** According to one feature of the invention, the security feature comprises a reflective layer containing aluminum reflective elements. The observer perceives the area as non-transparent or totally reflective when 85% of incident light is reflected and as transparent when less than 20% of the incident light is reflected and more than 60% is transmitted. It has been determined that the transparency and/or reflectivity level of the metal layer depends on the wavelength. Therefore, color effects can be observed under exposure to polychromatic, for example, day light.

**[0032]** Pixel areas can be of various shapes, for example, hexagon, rectangle, rhombus, square, irregularly shaped spot, etc. To ensure maximum use of the area of pixels in the observed images, the shape of sub-pixel areas may be chosen, for example, as rectangles with coincident boundaries; in this case pixels have the shape of squares.

**[0033]** For personalization of the identification document, in addition to the visible image, hidden information can be inscribed on the pixel matrix by changing the shape and/or size of pixels. For example, a pixel consists of two rectangular subpixels of different color. In the process of personalization, the upper or lower half of one sub-pixel can be removed. At visual observation, the difference is undetectable because the pixel is seen at distance as having the average color and area. Hidden encoded information can be formed by changing the place of removal of the sub-pixel grating, that is, by changing the overall shape of the pixel, which consists of shapes of subpixels, and maintaining the total area of removal. This information can be decoded with the aid of a dedicated instrument.

**[0034]** In addition to visible graphical information, the inventive identification document may contain personal information in electronic form, inscribed on an electronic carrier integrated in the document.

**[0035]** A special case of the invention is a document, which is personalized by inscribing a monochromatic image of a predetermined color. In this case, each pixel consists of only one sub-pixel 8 containing a diffraction grating that reflects light of a predetermined wavelength

in a predetermined direction.

**[0036]** It should be noted that protection of a multi-layered polymer product from delamination is definitely determined by the location and size of the pixels, that is, the complexity of delamination is determined by the pixel structure. As known, delamination of a product occurs at the areas where the adhesion between the layers is the least. If two layers with identical molecular structure are fused together, maximum bond between the layers is provided owing to formation of a monolithic layer. However, absolute fusion is difficult to implement technologically. Diffraction grating is formed on the surface of one polymeric layer. To enhance its reflectivity, a thin metal layer is applied to the grating surface. However, it is known that the strength of adhesion between metal layer and polymeric layer is low because molecules of polymer and atoms of metal poorly adhere because of different properties. When the product is delaminated, disruption between the layers passes through the contact area of metal, that is, diffraction gratings, and polymer. It has been found that when a pixel matrix with metallic diffraction gratings, uniformly distributed on the surface of the layer, is present, the force of delamination is below the established standards (not less than 0.35 N/mm) at the metallization area of more than 50% of the area of the layer.

#### Industrial Applicability

**[0037]** The invention relates to polymer chemistry, technology of thin-film polymeric materials and can be used in the production of various multi-layered products, such as documents that require protection from counterfeit and are intended to identify their owner.

#### Claims

1. A multi-layered polymeric article, such as an individualizing identification document or a security element, including a plurality of polymeric layers joined without adhesive, wherein at least one of said layers comprising colored identifying individualizing images inscribed therein, said article **characterized in that** the images are inscribed in the form of semi-transparent pixel matrixes consisting of thin-film pixel elements with sub-pixel structures consisting of areas with metallized diffraction gratings, the reflectivity of which on predetermined light wavelengths is changed when the article is individualized by laser engraving of diffraction gratings with precise pointing of the laser beam to the areas of their location; at least two polymeric layers are joined together by fusion; wherein the pixel matrixes are formed on surfaces between the fused layers, one of which being transparent, and consist of pixels of a size of 30 to 200  $\mu\text{m}$  spaced apart by a distance of 30 to 500  $\mu\text{m}$ , so that the formed images have a predetermined transparency of 50 to 99%, and the area of the met-

allized diffraction gratings does not exceed 50% of the area of the layer in which they are disposed.

2. The article according to claim 1, **characterized in that** the pixels are diffraction gratings reflecting electromagnetic radiation of a predetermined wavelength in a predetermined direction.
3. The article of claim 1, **characterized in that** the pixels are formed by masking and then etching the matrix structures on the surface of transparent polymeric films prior to fusing them together to produce a multi-layered identification document or a security element.
4. The article according to claim 1, **characterized in that** each pixel comprises a plurality of subpixels with different reflective properties for different wavelength ranges of electromagnetic waves.
5. The article according to claim 1, **characterized in that** the layer with a semi-transparent pixel matrix is above a layer with personalized graphics and text data.
6. The article according to claim 1, **characterized in that** the layer with a semi-transparent pixel matrix comprises at least part of the personal information inscribed in an electronic carrier integrated in the article.
7. The article according to claim 4, **characterized in that** it comprises a hidden mark provided by differences in the size and/or shape of the pixels.
8. The article according to any one of claims 1 to 7, **characterized in that** it is a banknote, protective sticker, blank sheet for a valuable document, excise stamp, passport, identity card, travel document, driver's license, diploma, plastic card or similar document.

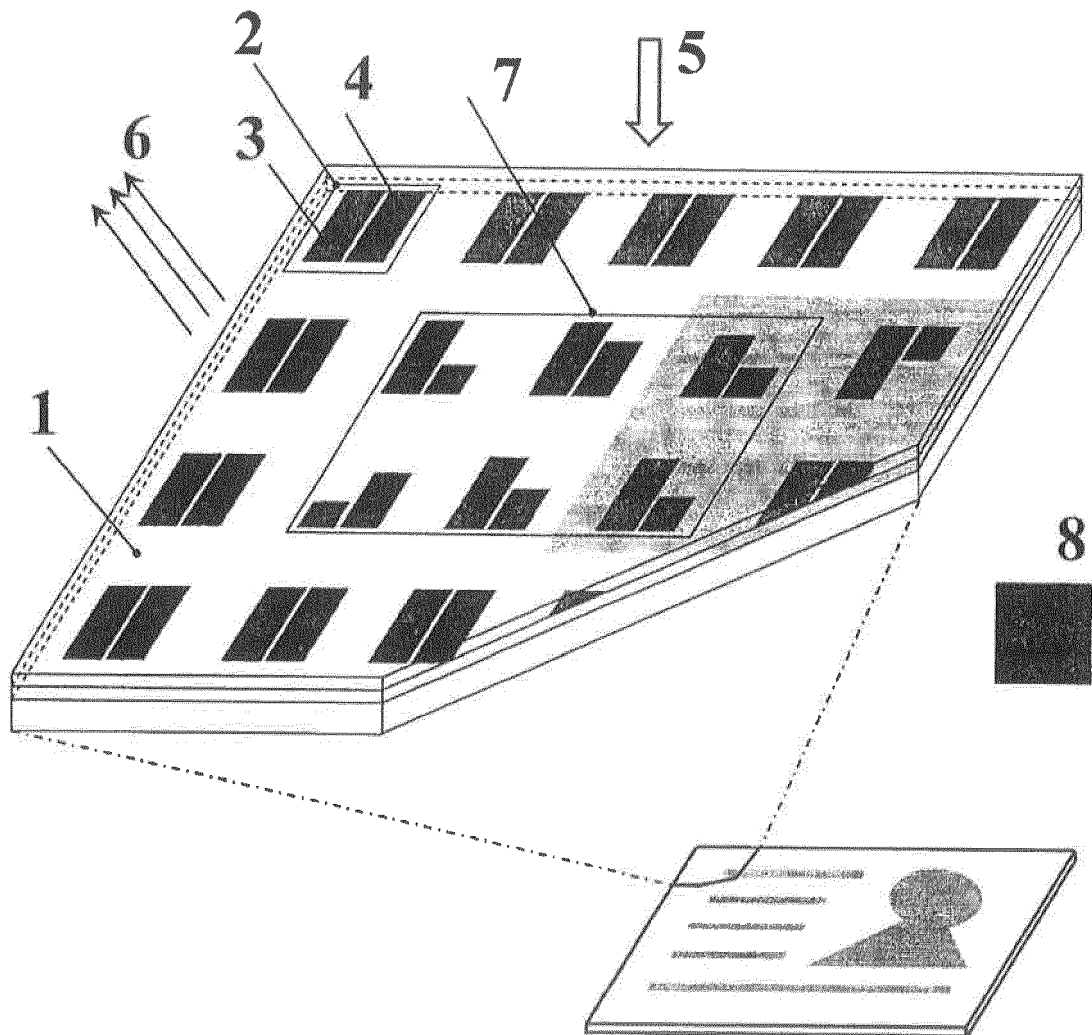


FIG. 1

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/RU 2015/000649

5	A. CLASSIFICATION OF SUBJECT MATTER		
	<i>B42D 25/00 (2014.01) B42D 25/455 (2014.01)</i> <i>B42D 25/328 (2014.01) B42D 25/351 (2014.01)</i>		
	According to International Patent Classification (IPC) or to both national classification and IPC		
	B. FIELDS SEARCHED		
10	Minimum documentation searched (classification system followed by classification symbols)		
	B42D 25/00-25/369, 25/455, D21H 21/00-21/44, G07D 7/00-7/20, B41M 3/00-3/14, B32B 33/00		
	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
	PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
	C. DOCUMENTS CONSIDERED TO BE RELEVANT		
20	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	A, D	RU 2079167 C1 (NIKIRUI ERNEST IAROSLAVOVICH) 10.05.1997	1-8
25	A, D	US 2013/0301090 A1 (BOWATER HOLOGRAPHIC RESEARCH (MALTA) LIMITED) 14.11.2013	1-8
	A	US 2013/0082458 A1 (LILY O'BOYLE et al.) 04.04.2013	1-8
30	A	EA 011968 B1 ( DE LIA RIU INTERNESHNL LIMITED) 30.06.2009	1-8
35			
40	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "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		
50	Date of the actual completion of the international search		Date of mailing of the international search report
	22 January 2016 (22.01.2016)		18 February 2016 (18.02.2016)
	Name and mailing address of the ISA/		Authorized officer
55	Facsimile No.		Telephone No.

**REFERENCES CITED IN THE DESCRIPTION**

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