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(54) **Infrared printing with process printing inks**

(57) Infrared printing with process printing inks falls into the domain of security printing,

The innovation refers to applying the infrared effect in printing technology with application in graphic product security against counterfeiting, regardless of the fact whether the print is made on paper, glass, ceramics or plastic surfaces, using digital printing process printing inks (CMYK). This solution determines color generating with a completely different behavior in areas under the influence of IR light. Detecting IR response is possible only with instruments that «see» in wavelengths above 700 nm and convert an IR graphic into an area visible to the human eye.

By making use of specific characteristics that come from the possibility of programming for digital and conventional printing, algorithms have been derived that include spreading of two or more inks that are the same color (in daylight), but with a completely different behavior in IR light. The same image is separated with a double algorithm depending on the targeted visibility or invisibility in IR light. Alternating of certain graphic surface areas color is programmed, first with one and then the other combination.



Fig. 1.2

Description

Area:

[0001] According to the international patent classification the subject of this invention may be classified according to the following tag:

B41-PRINTING

B41M 3/14 - Security printing

B44F 1/00 - Drawings or images characteristic for their special or unusual lighting effects

B44F 1/12 - Security or paper-based money if the image sample or protection against counterfeiting are important issues

The technical issue and the technical issue

[0002] The technical issue for which solution is given by this subject innovation implies the use of infrared effect in printing with application in graphic product security regardless of the fact whether the print is being carried out on paper, glass, ceramics or plastics. Detecting IR response is possible only with instruments that «see» in wavelengths over 700 nm and convert IR graphics into the area visible to the human eye,

[0003] The task for security printing is achieving the color designed by the designer when observing the graphic in daylight, and this solution determines creating of colors that behave quite differently in areas that are under the influence of infrared (IR) light.

[0004] The color responding in the IR light area is subject to complex design. The goal is to use this ink's characteristics for exchange of information under IR light. Programming includes making layers of two or more inks of the same color (in daylight) that behave quite differently under IR light. Scanning prints in IR light reveals many new areas of application in security printing. Proposals have been set for application standardization. Each ink is observed as possible in graphic product security application or, as the beginning of making a new individual solution in the general area of document and securities protection.

Technical situation

[0005] Colors seen by the human eye would not exist were there no light because light is reflected from a certain object creating the experience of color with a specific wavelength.

[0006] Each color has its own wavelength. Having a lower frequency than colors are the infrared spectrum, microwaves, radio and TV waves. Ultraviolet waves and X and gamma rays have a higher frequency. Such frequencies are detected with instruments.

As far as we know there is no generally known procedure of protection with IR inks. IR graphics are found on banknotes, shares, cards, and bank papers/documents and

similar. It is essential to stress that instructions on recognizing the IR effect remain in the domain of the printer. Graphics technology is included in the area of making products that are improved with special inks, papers and printing techniques. Security dyes and security paper have a wide field of application in economy, administration, arts and sciences. New chapters are unfolded because sophisticated printing techniques are available without the control and limitations that used to exist in the past. Therefore, multiple security methods are applied in order to make counterfeiting more difficult. At the same time a document contains a hologram, UV and IR inks, line spot graphics, and it is produced with several different printing techniques such as offset, relief-printing, intaglio, copperplate printing, screen printing, flexography. For almost all types of printing there are printing dyes with variable color that depends on the viewing angle, light intensity, light wavelength, ink density, special effects depending on ink penetration into paper, and depending on the combination with the raster element shape.

Printing with variable inks in digital printing is a new area that has not been researched yet. Such printing with a targeted application in the security graphics area appeared as late as 2004 when it was first presented with all due protection measures. An with variable ink for digital printing can not be purchased commercially so that research work with such materials in high security graphics has passed without much public exhibiting.

Experiments and measuring show that color systems such as RGB, Lab, HSB provide information on the colors only for the light visible to the human eye. Each color can be created in several ways in respect to the UV and IR detection. The mentioned systems do not deal with such issues and they do not provide an answer on the diversity of their internal structure. Each color, depending on the material characteristics provides different information when analyzed under infrared and ultraviolet light. This diversity in the UV and IR area is the initial point for creating, planning and designing of graphic product's top security.

[0007] The contemporary color systems (HSB, Lab, Cie, RGB, CMYK) do not deal with the issue how an ink color had been produced or how the color changes if it is treated with IR light wavelengths.

The ink color, if observed in daylight, may be produced in many ways. Information on the ink structure and production is extremely well hidden. Different prints with inks produced in different ways may provide the same ink color effect to our eye, the same graphics. According to this we are not sure whether the print was made with the original inks, in the identical paper and the same printing techniques. Each ink component of which it had been produced gives a separate response in IR light and that is the initial point for proving its authenticity. At the same time the effect of diverse light sources on the print reveals the presence of differently mixed inks, combinations of different printing techniques, program generated graph-

ics, simulation of colors generated from different sources.

[0008] In contemporary security documents the IR effect appears generally in a single color. It is either dark gray, dark brown, or green as the most frequent one. The graphic is usually separated into two elements or it is not even divided. Such inks are printed like spot inks /a spot ink is one that is mixed in advance; greenish, brown, blue used for printing the set color with one pass through the printing machine/.

Elaboration of the innovation's essence:

[0009] The essence of the innovation is in top security of the printed print /security against counterfeiting/ by using printing inks (CMYK) for visibility and invisibility in the IR area, i.e. to improve designing security graphics by using the characteristics of inks such as cyan (C), magenta (M) and yellow (Y) in the fact that they can produce the effect of viewing BLACK after printing one dye over the other but this is invisible in IR light. It is programmed that in the same spot CMY is replaced with a black that is observed in IR light.

By using specific characteristics that come from the possibility of programming for digital printing and conventional graphic make-ready, an algorithm was found that includes spreading of two or more ink systems of the same color (in daylight) but with totally different behavior in IR light. A dye exchange is programmed for certain graphic parts with one, and then with a different combination.

[0010] The subject innovation also deals with ink color change depending on the source of light from 700 to 1000 nm that may be used in proving the authenticity of the print, paper and dye.

The innovation's goal is to improve security graphics design using printing inks (CMYK) for visibility in the IR area, because the ink that responds in IR light is subject to complex design. The ink's characteristic to respond in IR light is used for information exchange under IR light.

Proving the graphic's authenticity is done on professional scanners that have IR filters with the possibility to change wavelengths.

This innovation shows that by programming the graphic element structure a better quality security can be achieved with application of conventional inks if more is known about their structure. The use of conventional inks in the proposed IR protection does not make the printing process more expensive. The initial step is to analyze each ink and its behavior in the invisible spectrum part. Programming of graphics that includes the combination of the IR effect with conventional inks expands the security printing area with enhanced security properties of the graphic product.

Designers usually dwell on the graphics visible in daylight. When doing so they do not plan the security system and observation under IR light. Only in some cases they apply invisible UV inks. Knowledge on the IR printing ink system is a new area in printing. Programmed designing,

targeted designing and coded graphic product design are possible. Security graphics programming has begun following the research work on ink behavior under IR light by making use of the said properties. Collaborators on this task have developed visible RGB system algorithm separations for printing ink graphics make-ready using information on the light response in the IR area.

Printing inks perform differently in the IR area. Inks for offset, inks for inkjet, toners for digital printing have their own visibility characteristics in the transition of the visible and near IR area (560 nm to 700 nm) and the area of wavelengths above 700 nm. The visibility characteristics of certain printing inks that have been determined experimentally are used for programmed mixing of inks with the goal to have some parts of the image seen and some to be invisible under IR radiation. CMYK separation depends on our wish: what we wish to see in the IR area and what we do not wish to see in the IR area. A different transformation algorithm of RGB towards CMYK is applied on each vector graphics pixel or line element. The same image is separated with a double algorithm for determining the targeted visibility or invisibility under IR light.

The ink color of the print must be independent in respect to addition or removing of certain CMYK components. In the Attachment to this paper separation examples are shown for extreme appearance of the image at 1000 nm. The visible area from 400 to 700 nm must remain the same as though no separate separation had been programmed.

It has been determined for certain printing (examples have been made on the Xeikon) that a curve on the IR effect dependence can be determined quite well for each ink. The concept «IR effect» can be «dosed» from a minimal to a maximum value that depends on the previously mentioned system of the minimum component and ink visibility characteristics in the border areas of the near IR). Transformation of RGB into CMYK implies achieving the same values of all RGB, HSB and Lab system parameters. The sameness of the image in the visible light area is provided by this, i.e. the independence in respect to the RGB/CMYK separation achieved.

Print scanning in IR light reveals many new areas of application in security printing. Proposals have been made for application standardization. Each ink is observed as a possible one in graphic product security application, or as the beginning for making a new, individual solution in the general area of document and security protection.

Industrial application of the innovation

[0011] With the subject innovation printing becomes more interesting because there is hidden information in the printed material that opens new research possibilities.

The innovation can be applied in producing all graphic products in commercial graphic design whereby the printing process is not more expensive, with the goal being

to protect the product, i.e. the producer /trade mark/ but also for simple design into which secret information is incorporated and determined by experts having special knowledge on the structure of prints, inks and paper.

[0012] Here is a list of possible application:

- admission tickets, membership cards, credit cards, packaging material (medicaments, cosmetic products, food products, technical goods...), certificates (diplomas, certificates, letter-heads, legal documents...), bank securities (bank transfers, checks, payment receipts, statements, ...), labels (for glass and plastic packaging material), bar-codes, postal stamps, tax stamps, prize coupons, posters, magazines, brochures and books.

Besides the above listed it is possible to make a database with originals and counterfeits containing precise information on IR protection on a graphic product.

The multiple application possibility of different ink colors in the same print will significantly prevent counterfeiting. The print with a proposed IR security protection can not be reproduced and then maintain the same IR characteristics. Any scanning, filming or graphic reproduction editing destroys the internal information structure that has been programmed as a targeted IR effect.

Anyone endeavoring to do such a job would have to possess instruments for IR graphics and overall knowledge on the internal ink structure found in the original. The area becomes a privilege only to those researchers who have chosen to study the depths and specialties in graphic technology.

[0013] This innovation can be more clearly illustrated with the following examples:

Images are the attachments.

Figure 1.1. Vector graphic portrait with color scarf containing the letters IVANA - two versions

Figure 1.2. Vector graphic 1.1 under 1000 nm IR light

Figure 2.1. Vector graphic rosette with green and violet colors and the designed IR response under 1000 nm

Figure 3.1. Color typography and the result in the 1000 nm IR area

Figure 3.2. Security graphics on postal stamps with masked IR response in the 1000 nm area

Figure 3.3. Merging of two pixel images. The town of Šibenik with the town of Rovinj mask and IR response in the 1000 nm area

Figure 4.1. Infrared effects in multicolor images

Figure 5.1. Uniform background in a bar-code

Figure 5.2. Minimal contrast of bar-code lines and background

Figure 5.3. Multicolor vector graphic backgrounds in a bar-code

Figure 5.4. Multicolor pixel graphics backgrounds in a bar-code

Figure 6.1. Multicolor IR presentation with some ten colors

Figure 6.2. Two-colored check design with two IR colors and two colors without IR response

Figure 7.1. Rosette with red IR color and blue color without IR response

Figure 7.2. Rosette with two greens, visible and invisible in IR light

Figure 8.1. Continuous color of two inks with IR response and two inks that do not respond in the IR area

Example 1.

[0014] For better understanding it is necessary to observe pictures in Attachment no. 1 containing the portrait printed in the original form and its appearance in IR light.

[0015] The portrait in the image was created in the vector graphic production manner by using some ten colors with different hues. Some CMYK inks have a small and some a great share. CMY inks respond differently in IR light, also depending on their presence, i.e. coverage Figure 1.1. shows the print of a portrait with several colors. Both images look the same in daylight, on the computer screen and in all printing techniques, whereas there is drastic difference when observed in daylight and that is the essence of this innovation's solution.

In the upper image the multicolor vector pattern has a black component and the lower does not have it. Quite the contrary is in respect to the letters IVANA where there is no black component in the upper letters and there is a black component in the lower letters. The letters are sufficiently spotty with colors so as to show through the original in the upper as well as the lower graphic. The face is also covered with a black vector drawing. Picture 1.1. is scanned in 1000 nm IR /shown in Picture 1.2/. The IR scanned gray scale shows designing of certain graphic parts. The letters in the upper portrait have disappeared because they had closed the way to colors beneath, and they themselves do not contain the black component. The lower portrait picture has shown the text IVANA because those inks do contain the black component. A vector graphic face contour remains in the face printed three times because in all positions it has been printed with the black ink.

Experiments have been carried out for other IR light values as well. The ink is analyzed as to IR effect loss from daylight towards soft and hard IR areas. Each of the 16 observed inks /HSB table, Lab values of the print in the portrait/ have their own path of disappearance under IR light.

Example 2.

[0016] For better understanding it is recommended to observe images in Attachment 2 containing rosettes and testing stamps.

[0017] Two rosettes have been printed as well as

green and violet testing stamps. The stamps that do not contain the black component are not observed in IR light. Both of the rosettes have been printed in the same color, with continuous alternating of the green and violet color and also with a continuous flow of the line thickness from violet towards the green. The upper rosette has a black component according to the recipe with values marked on the stamps (upper right edge). The upper rosette is seen under IR light and the lower disappears because the colors in the lower rosette consist of only CMY inks. The same principle can be used in designing IR application with other spot inks. Including two or more different inks with response in the IR area provides endless security combinations for the designer.

Example 3.

[0018] For better understanding images from Attachment no. 3 should be observed.

Typography in pixel graphics

[0019] A mask is set over the multicolor image dividing the image into invisible and visible areas under IR light wavelengths. The mask consists of the black and white drawing, graphic, and sign. The black graphic part controls visibility of the basic image in the IR area. The white graphic part provides invisibility of the image in the IR area. Figure 3.1. shows the letters «cut» into two parts or fully separated for achieving IR coloring over the mask. The examples show the influence of various masks in the IR test, and application in postal stamps (Figure 3.2.) and some future securities. A mask has been added to the postal stamps that cuts the nominal and the portrait head. Šibenik with Rovinj mask

[0020] The information about which pixels will be observed and which pixels will not be observed in the IR area can be determined in several ways. A software tool has been developed that uses two images. The first one is the one that is visible in the human eye wavelength area, and the other image is the one determining the visibility of the first image in the IR area. The second image is only a mask with which the bordering area of the visible-in-daylight-only is set in respect to visibility under IR and daylight. The second image may be an image in a continuous color. Photographs of Šibenik and Rovinj (airplane view) are incorporated into a unique structure for IR concealment (Figure 3.3.). Rovinj is a «mask» with a continuous color that is not observed among Šibenik houses. The color image of Šibenik observed under 1000 nm IR light shows Rovinj with intensity values from the Šibenik image.

Both the first as well as the second image may be a vector or pixel graphic. If the second picture is a vector one and the first picture is a pixel graphic, then the second picture is preliminarily translated into a pixel graphic. Individual-

ization of the IR area is carried out with a generated mask during printing depending on the set ratio between the visible and the IR areas.

5 Example 4.

[0021] For better understanding pictures from Attachment 4. should be observed.

Infrared effects in multicolor images.

10 **[0022]** Incorporation of the infrared effect is achieved with two images. The first image is visible to our eyes and it was set as the original. The second image has the role of a mask. The appearance area and intensity of the first image in infrared light is determined by the mask. 15 Both of the pictures have the same pixel number. The

first example is merging an image of Šibenik the sea (A) with the other image (B) that only has a drawing and letters:

20 I-KP-JŠibenik V, the word INFRARED and a miniature text in the image head. A merge of images A and B produces the image C carrying information from both images (Figure 4.1.). We can not see that some information has been incorporated into image A, - hidden data.

25 **[0023]** After IR scanning, the image C's print will show an image in infrared light that shows only those parts of image A that had been influenced by the mask. Due to the fact that images A and C provide the same experience for our eyes, there are in general illustrated here only images C carrying hidden information. In the area visible to the human eye there is no information on the presence of letters from the mask in image B. Information contained in image C may be detected in infrared light only. It may be translated with the help of instruments that allow detection of such effects in such a way that we observe them as black, gray or colored with a pseudocolor system. 35

A mask can be planned with effect intensity. The same letters are incorporated into the mask with different coverage values; overall coverage (1), with decrease coverage (2) and with only little coverage (3). Image C has been subject to the influence of various IR wavelengths. The response of the infrared effect is less in lower wavelengths and is the most intensive in the 1000 nm scanning. Infrared scanning of the image may be recorded as permanent information on the detachment of some of the image parts that have been designed with the goal to hide the image data.

40 Image A is produced after IR scanning image C. The same thing happens after photocopying or shooting with a digital camera. After such copying-scanning procedures the information from image C has disappeared that has been provided by the mask, i.e. image B. The presented image C prints have been printed with incorporated infrared effect so they can be subject to subsequent analysis with an infrared scanner. Due to the fact that images A and C appear the same to our eye in daylight, most of the illustrations are reproduced through image 55

C only.

Example 5.

[0024] For better understanding images from Figure 5. of the Attachment should be observed.

Bar-code in security graphic/colored bar-codes.

[0025] The near infrared area is in the function of colored bar-codes. The conventional approach to printing bar-codes is based on black-and-white graphics. Designers do not endeavor experimenting with the use of various colors because the bar-codes legibility may come into question.

By knowing the rules as to response under IR light, it is possible to create an endless number of dyes. Regardless of the fact that they are colored and that top quality equipment has been used, after photocopying of such bar-codes they will not be legible. Mixing of inks with a fully determined structure is necessary. Figure 5.1.

Some examples show that it is possible to have results with small contrast between the codes and backgrounds. Examples are given for pastel solutions as well as for dark color combinations. The bar-code background is designed with two inks: magenta and yellow. The bar-code lines are designed with carbon-black and cyan. Figure 5.2.

[0026] The third group of examples is the design with a combination of several background colors in vector graphics. Such design will be the subject of application in products that are often counterfeited. Packaging material becomes secure to a certain degree. It is not possible to achieve the same coloring structure after scanning or photo static copying that would be legible afterwards with bar-code readers. Picture 5.3.

The fourth group of examples is the design with a multi-color background. Picture 5.4. The countryside image is the bar-code background base. These examples offer color changing of the bar-code lines themselves in the same bar-code. The design area is thus expanded as well as the security graphics area.

Example 6.

[0027] For better understanding images from Attachment No. 6 should be observed.

IR in multicolor application.

[0028] The sample with multicolor inks demonstrates the matrix /square/ consisting of 36 randomly chosen colors. Figure 6.1. The IR component has been added to some of them. This abundance of colors is observed in daylight and then the colors seen in IR light (R). Half of the squares respond in IR wavelengths whereas the rest of the squares are invisible in IR light. Some of the squares are even in daylight.

Samples (1,2,3) /red and blue check pattern/look almost the same in daylight. Figure 6.2. The check pattern from sample No. 1 has the IR effect in vertical columns: the first, third and fifth (R1). Columns 2,4, and 6 are not visible

in IR light.

[0029] The check pattern No. 2 shows the IR component in all the red squares. The blue ink does not have an IR component. The red color begins with its alternating pattern in the lower right corner.

The check pattern No. 3 shows visibility in IR wavelengths for blue squares that begin from the second chess board position. For better orientation a frame has been added that responds in IR light.

Example 7.

[0030] For better understanding images in Attachment no. 7 should be observed.

Infrared rosettes.

[0031] The first graphic has blue lines and fills are in dark red. In IR light the fills are visible and the rosette lines are not visible, image 7.1. The next example is the same graphic printed in green, both the lines and the fills. Only the rosette lines are observed in IR light, but not the fills; Figure 7.2. The green ink fill the rosette does not respond in IR light.

Example 8.

[0032] For better understanding it is recommended to observe images in Attachment No.8.

Infrared continuous color.

[0033] The richness of IR control is demonstrated by the continuous transition of red into green. Several samples have been made determined as 1,2,4,5, and 6. In samples 1 and 2 the prints are the same in daylight. The IR component is different; Figure 8.1. In sample No. 1 the IR effect is increased from the green area position towards the red. Samples 4 and 5 are composed of green and red colors that appear differently in IR light with continuous transitions. It is demonstrated how it is possible for the IR effect to appear independently of the designed colors that we observe with our eyes. Example 6 shows that the same color may be obtained in a countless number of ways. Continuous transitions of ink colors are possible for inks that are not observed in IR light and inks observed in IR light. Each of the procedures may be used as the carrier of separate targeted information that is detected in IR light.

The power of this security is in the knowledge that there is no fixed recipe for forming of inks with the intention of using IR security characteristics. The document security designer is given a wide field of choice to incorporate IR security on a mass level and at the same time not to disturb the graphic design when observed in daylight. The security document's visual designer remains with the task to plan colors for observing in daylight. He is the one who designs the visual appearance of the graphic product in question and does not have to be concerned with IR element security element technology that will be completed by experts on IR visibility/invisibility printing in the graphic product segments.

[0034] The prints enclosed are made on the Xeikon so that the examples in the Attachment may be checked with an IR scanner or camera with an IR filter.

5

Claims

1. Infrared printing method using process printing inks (CMYK) in digital and conventional printing aimed at graphic product security, **characterized in that** the procedure where there is printing with process inks (CMYK) three (CMY) or more of the same color in daylight, but completely different, targeted, with programmed behavior in IR light. 10
2. Infrared printing method using process printing inks according to claim 1, **characterized in that** for its prepress where the change of color in certain graphic surfaces is programmed first in one combination and then with another combination - with the second one responding in IR light; however, the visible area from 400 to 700 nm remains the same as if the (RGB/CMYK) separation with two different algorithms had not taken place. 15 20
3. Infrared printing method using process printing inks according to claim 1 or 2, **characterized by** the fact that CMYK separation depends on the wish as to what should be observed in the IR area, where a different transformation algorithm for transformation of RGB towards CMYK is applied for each pixel or line element, and under transformation it is understood that the same values of RGB, HSB and Lab systems are reached providing for the sameness of the graphic in the visible area, i.e. independency in respect to the RGB/CMYK separation achieved. 25 30 35
4. Infrared printing method using process printing inks according to claim 1, 2 or 3, **characterized by** the fact that the IR effect may be precisely dosed from the minimal to the maximum values. 40
5. Infrared printing method using process printing inks according to claim 1, 2, 3 and 4, **characterized in that** by knowing the IR printing ink system there are possibilities opened in the area of programmed and targeted designing and coded graphic product security. 45

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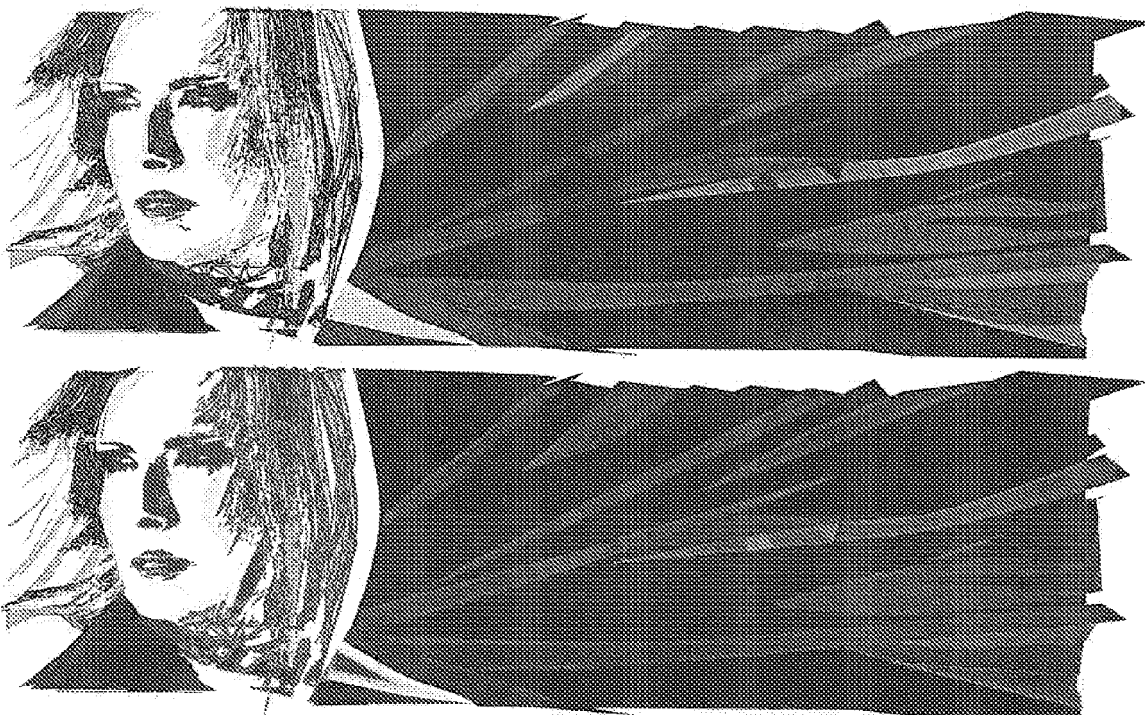


Fig. 1.1



Fig. 1.2

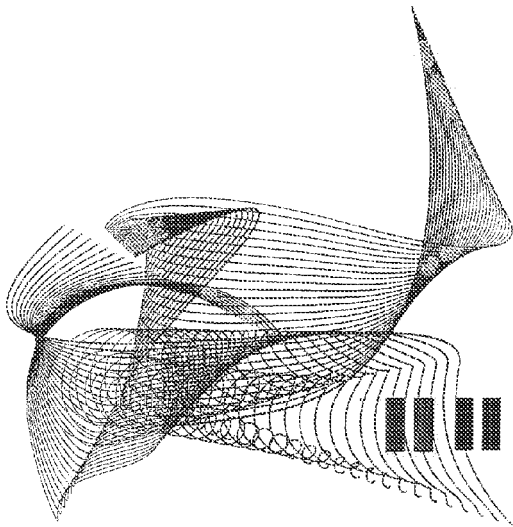


Fig. 2.1

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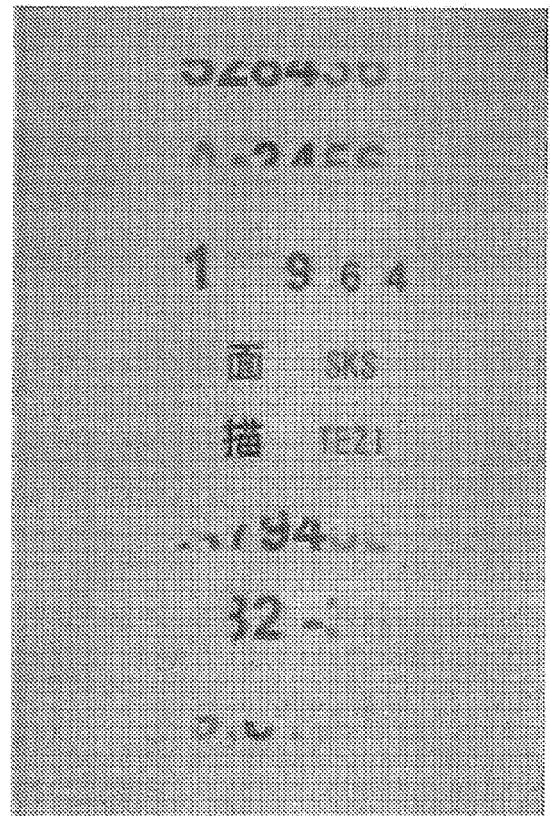


Fig. 3.1

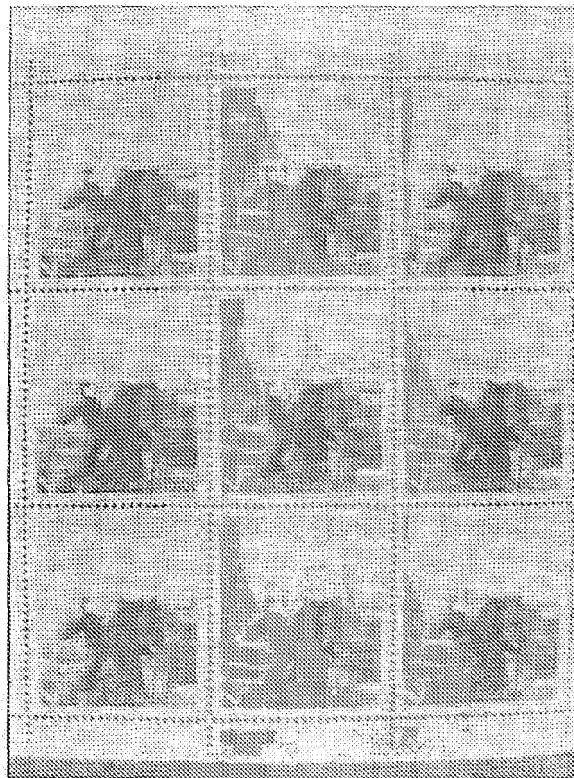


Fig. 3.2

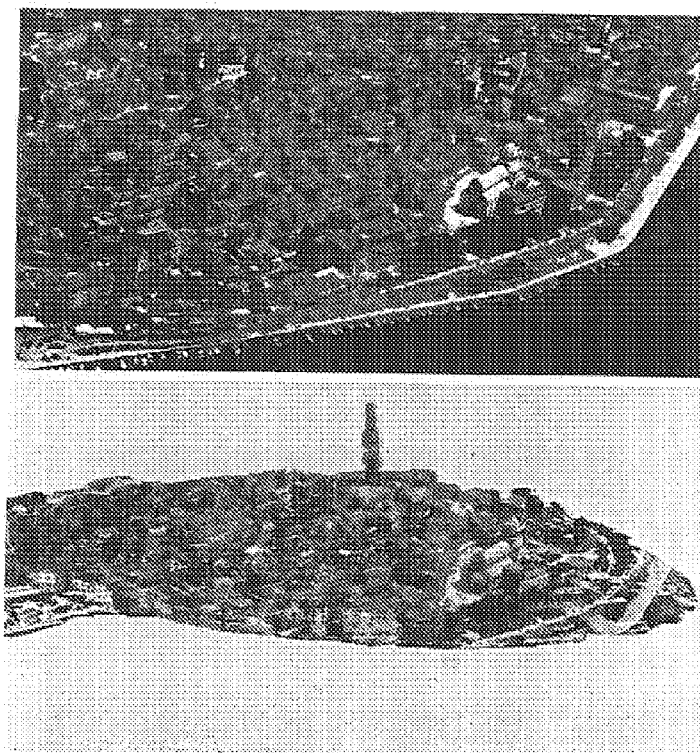


Fig. 3.3



Infrared security with process printing foil, Zagreb, 2008

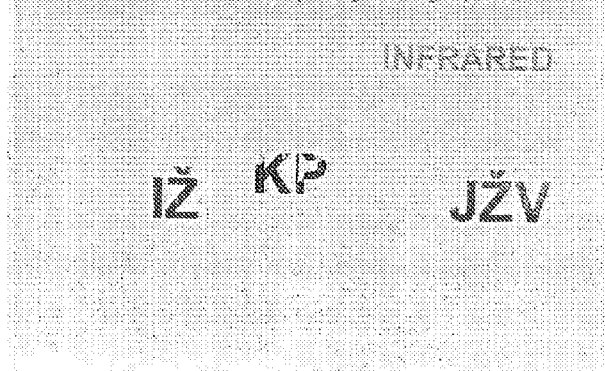


Fig. 4.1.

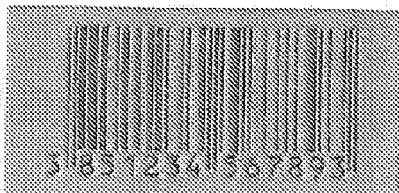
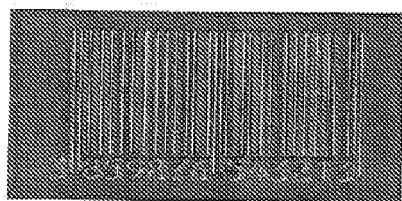


Fig. 5.1.

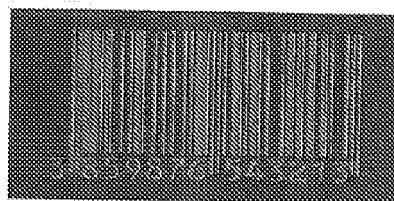


Fig. 5.2.

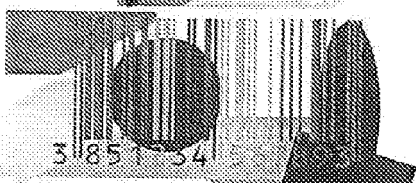
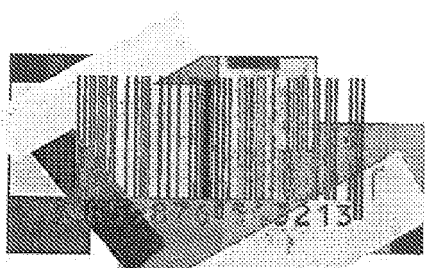


Fig. 5.3.

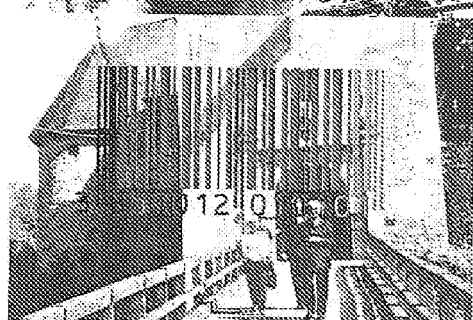
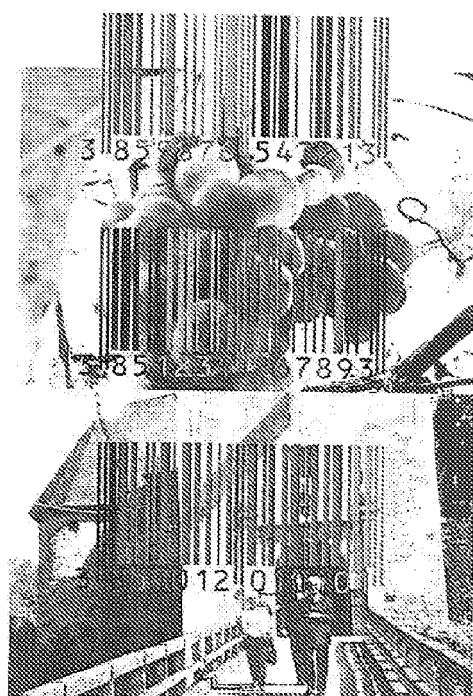


Fig. 5.4.

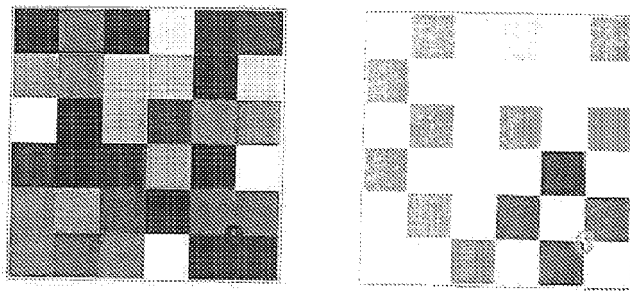
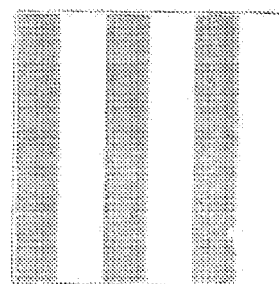
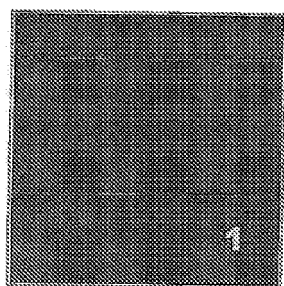
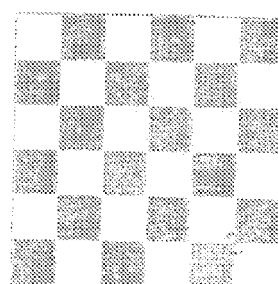
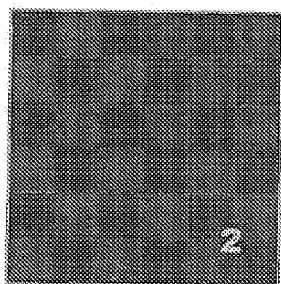


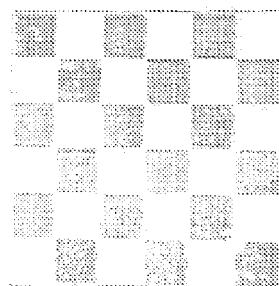
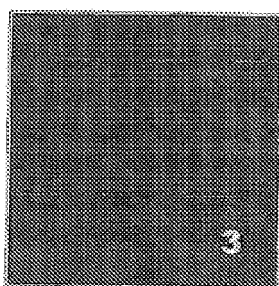
Fig. 6.1.



Šahovnica 1



Šahovnica 2



Šahovnica 3

Fig. 6.2.

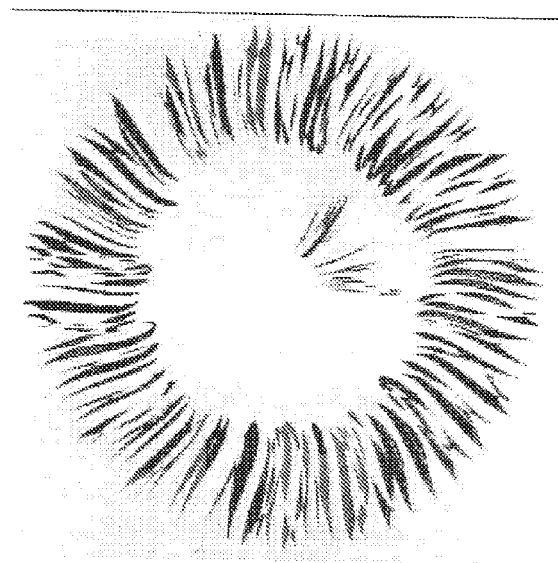
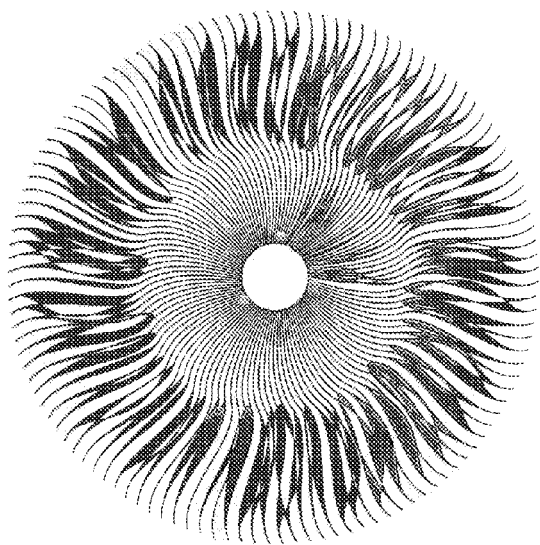


Fig. 7.1.

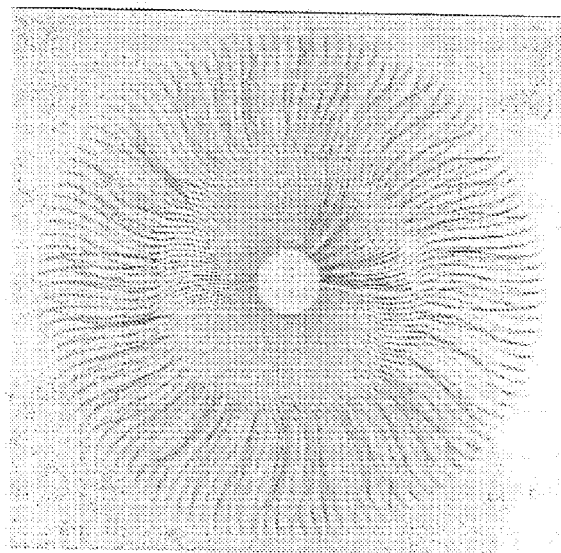
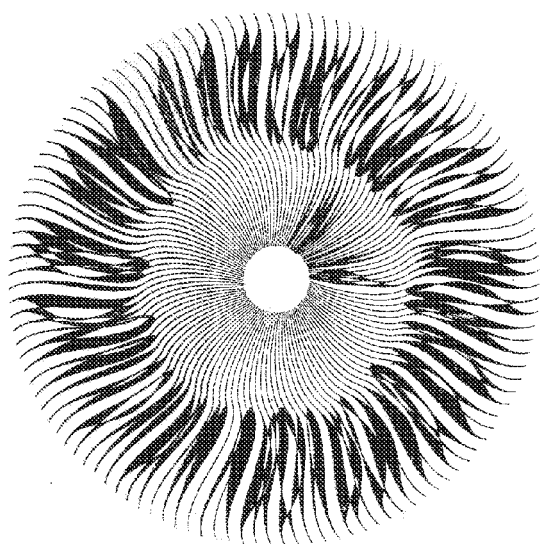


Fig. 7.2

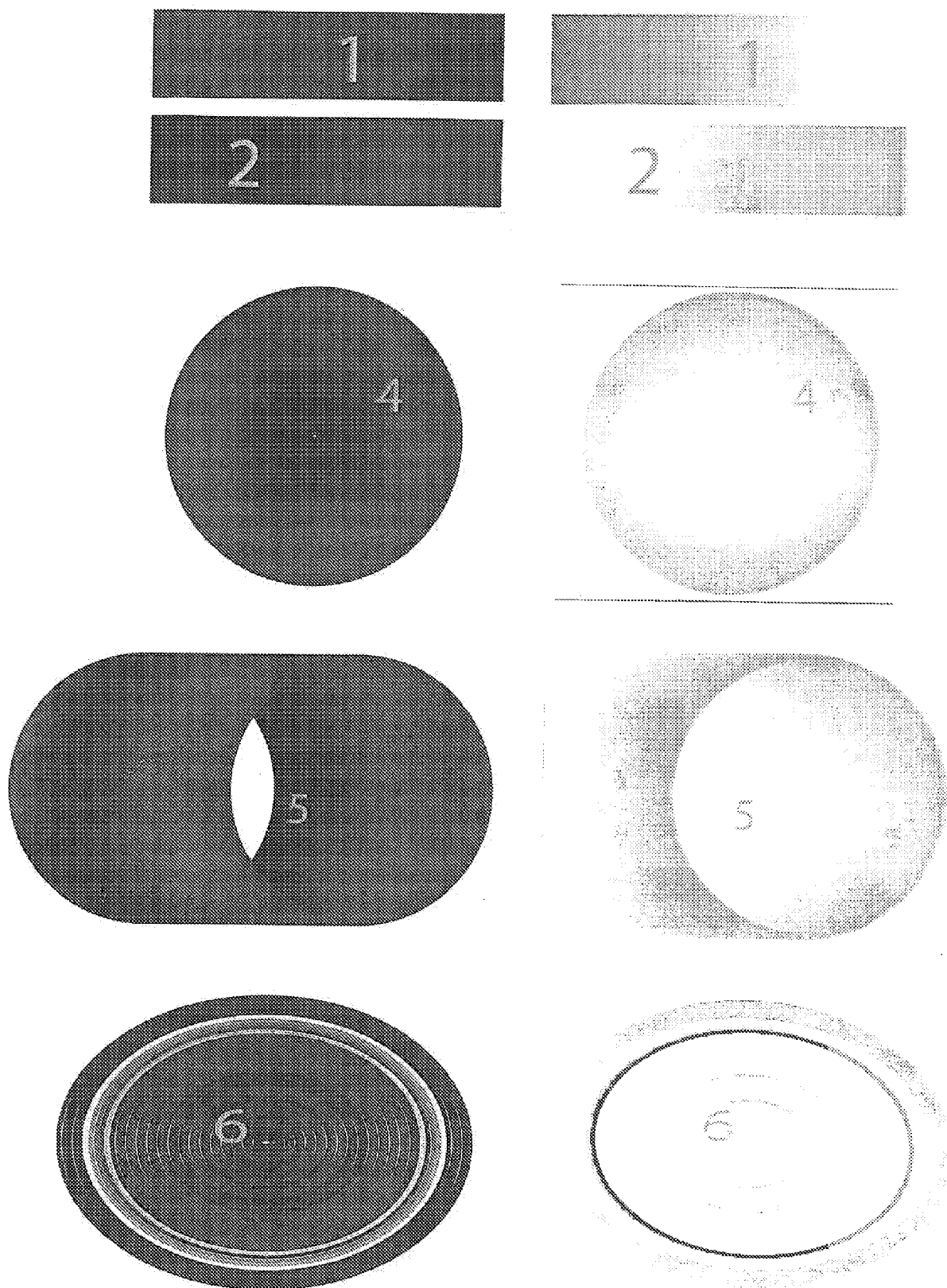


Fig. 8.1