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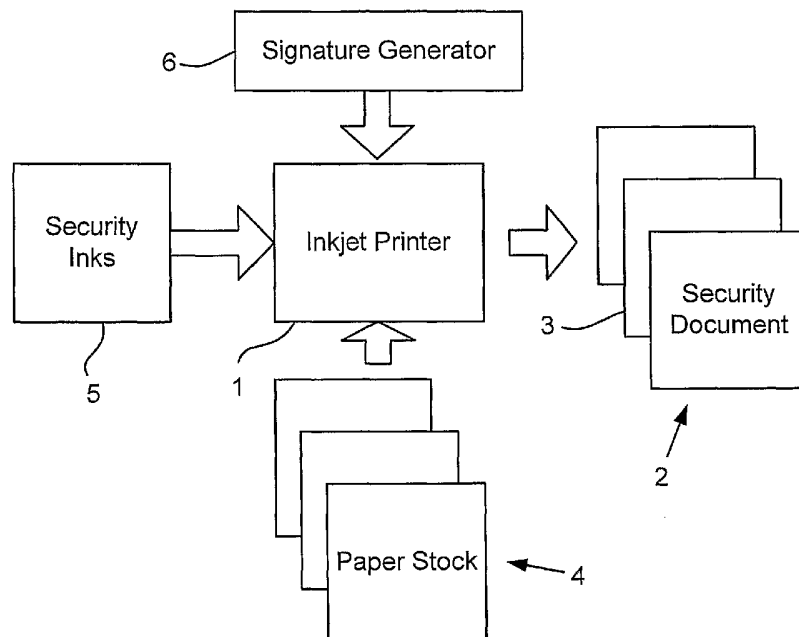
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(54) Title: AUTHENTICATION METHOD EMPLOYING COLOUR SIGNATURE



(57) Abstract: Colour signatures and a system for printing and authenticating security documents are disclosed. Reference colour data is generated by sensing the colour of a marker on a test article. The test article is then authenticated by sensing the colour of the marker on the test article to generate test colour data; and comparing the test colour data with the reference colour data. The colour signatures are printed using security inks by inkjet printing on paper, and measured by a multi-channel interferometer that uses white light to illuminate the signatures.

AUTHENTICATION METHOD EMPLOYING COLOUR SIGNATURE

5 The present invention relates to an authentication method, and related apparatus.

A conventional authentication method is described in GB-A-2340931. A colour image on a test object is read to generate a number representative of the colour of the image. This number is compared with a reference number to authenticate the test object. The method of generating the reference number is not described.

10 DE19909135 A1 describes an identification element with ink dots printed on a fibrous substrate. When checking the authenticity of the element, the outline and position of the ink dots is used as a test criterion.

The present invention provides a method of authenticating a test article, the method comprising:

- 15 a) generating reference colour data by sensing the colour of a marker on the test article;
- b) generating test colour data by sensing the colour of the marker on the test article; and
- c) authenticating the test article by comparing the test colour data with the reference
- 20 colour data.

The invention takes advantage of the fact that the reference colour data will depend on the exact manufacturing conditions used in producing the marker. Therefore, a successful forgery can only be achieved by reproducing these manufacturing conditions precisely. The invention also recognises that the colour of the marker may not only be determined by

25 the composition of the marker, but may also be determined by its size and shape. This is accounted for by making a direct measurement of the marker, instead of estimating the colour based on some manufacturing condition such as ink composition.

The marker may be sensed by a tri-stimulus light source and sensing system as described in GB-A-2340931. In this case, the reference colour data is three dimensional (for instance

RGB, or HSI). However preferably the colour of the marker is sensed by a multi-channel spectrometer which generates F_q -dimensional reference colour data, where F_q is greater than three, and most preferably greater than ten. In the preferred embodiment described below, F_q has a value of forty.

- 5 Preferably the colour of the marker is sensed in step a) and/or step b) by generating an interference image; sensing the interference image with a light sensor; and processing the output of the light sensor. This allows a large quantity of colour data to be acquired quickly.

10 The marker may be formed in any way, but preferably is printed on a substrate, typically a fibrous substrate such as paper. It has been found that the structure of a fibrous substrate contributes to the colour of the marker, thus making it more difficult to replicate.

Typically the marker comprises a series of dots, such as may be formed for example by inkjet printing. This also makes the marker more difficult to replicate since the dot pattern contributes to the unique colour of the marker.

- 15 The marker may comprise only a single colour, but preferably has a series of regions each with a different colour.

20 In a preferred embodiment each region in the marker contains a respective ink or mixture of inks; and a plurality of sets of colour data are sensed in step a) for each region. Thus in the preferred embodiment, four spectra are read for each bar in the colour signature. This takes advantage of the fact that different parts of the region may have different colour content, even though they are formed from the same ink(s): for instance a central part may have a different colour to an edge part.

25 Preferably the marker comprises an ink having a colour located outside at least one of the CMYK, RGB, Pantone and Hexachrome colour gamuts. This makes the marker harder to forge.

The invention also provides a method of producing an authentication marker by printing a series of regions of different colours (for instance by inkjet printing) on a fibrous substrate, and an authentication marker comprising a fibrous substrate carrying a series of printed regions of different colours.

The present invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a system for printing a reference sample;

- 5 Figure 2 is a schematic view of a signature portion of a document produced by the system of Figure 1;

Figure 3 is a schematic view of a system for producing signature data;

Figure 4 is a schematic view of the interferometer used in the system of Figure 3;

Figure 5 shows an interference image;

- 10 Figure 6 is a graph showing signature data;

Figures 7a-7j are graphs comparing the frequency profiles of ten 200 x 10 mm bars with ten 0.7 x 2 mm bars printed with the same combination of security inks; and

Figure 8 is a schematic view of a system for authenticating a test sample.

- 15 Referring to Figure 1, an inkjet printer 1 prints a stack 2 of security documents, from a stack 4 of uncoated paper stock. An exemplary one of the stack of security documents is given reference label 3. The security documents may be for example negotiable financial documents (e.g. banknotes, traveller's cheques, bearer bonds), passports, visas, immigration documents, stock certificates, postal stamps, lottery tickets, or sport and event tickets.

- 20 The inkjet printer prints onto each document a different colour signature 10 of the type shown in Figure 2. The signature has a length of 7mm and a width of 2mm, and comprises ten bars each having a size of 0.7×2 mm. The numbers and widths of the bars within the signature can be varied according to different applications.

- 25 The printer 1 prints the signature 10 using a supply 5 of three or more security inks. Each security ink has a colour which is located outside the CMYK, RGB, Pantone and Hexachrome colour gamuts. Thus the colour of the security inks is very difficult, or

impossible, to reproduce. The security inks are specially developed and checked by the CIE l.a.b. system that has a wider colour gamut than commercially used colour systems.

The printer 1 is driven by a signature generator 6. Each bar in the signature 10 contains a specified mixture of the security inks, as defined by the signature generator 6. The signature generator 6 runs software which can generate at least 10^{29} signatures using the stock 5 of three security inks with the described signature format. The possible numbers of signatures is described in the following equation:

$$\text{Total number of signatures: } n!/r!(n-r)! = 3840!/10!(3840-10)! = 1.89 \times 10^{29}$$

n: Sample size, $128 \times 3 \times 10 = 3840$ colours

10 r: Group size, 10 images

This equation is based on 128 bit colour resolution/colour, three security inks and ten bars per signature.

The printer 1 is a digital inkjet printer, which provides the maximum flexibility for producing large number of different signatures and also produces unique image patterns. Colour images printed using inkjet-printing technology are extremely difficult to reproduce on any other printing system such as litho or flexo-printing, especially when the images are small. In inkjet printing, the colours are formed by small dots that are controlled by the inkjet printer head. The printer head contains hundreds of nozzles that determine the printed image patterns that are used to form the signatures. Therefore if the signature 10 shown in Figure 2 was printed by two different types of printer, then the nature of the coloured images would be different when the two versions of the signature are compared under a microscope, due to diffraction and scattering effects. That is, the inkjet printing will produce a unique pattern of dots within each bar, along with a unique pattern of dots at the boundary between each pair of bars. Furthermore, the fibrous structure of the paper substrate will produce certain unique effects in combination with the pattern of dots. As a result, it will only be possible to provide an identical image by using the same inks, the same printer, the same paper stock, and printing the image at the same location and orientation on the paper stock.

For a region in the interior of a bar, the colour pattern will depend on:

- the mixture of inks used;
 - the dot pattern (which may vary as a function of bar width and between different printers);
 - the composition, structure and orientation of the paper substrate; and
- 5 • the location on the paper substrate.

For a boundary region near the edge of a bar, then apart from the variables mentioned above, the colour pattern will also depend on the variables for the adjacent bar.

After the system of Figure 1 has produced the documents, the system of Figure 3 is used to produce signature data for each document. Specifically, each document is scanned in turn
10 by an interferometer 20 (shown in further detail in Figure 4) to produce signature data (shown in further detail in Figure 6) which is recorded in a signature database 21.

Figure 4 shows the exemplary document 3 being scanned by the interferometer. A white light source 30 (such as a tungsten lamp) illuminates the document 3 in the region of the signature 10 through a 2×7 mm window 31 located at the front of the instrument. The
15 reflected light from the signature is delivered to an interferometer block 32, which creates an interference image of the signature, via a beam splitter and focal lenses. The image is projected onto an image sensor 33 via serial optical lenses. The principles of operation of the interferometer 20 are described in further detail in WO 01/07879.

A view of an interference image for a signature with ten bars coloured Red, Grey, Green, Orange, Blue1, Blue2, Purple, Pink, Blue, and Yellow; is given in Figure 5. The sensor
20 has a CCD with elements arranged in 400 rows and 256 columns. Each bar of the signature provides an interference pattern which is imaged onto forty rows of 256 CCD elements. Each set of forty rows is divided into four sets of ten rows, and each set of ten rows is labelled in Figure 5 with a Line No ranging from 1 to 40.

25 The sensor 33 is driven by an electronic board 34 with on-board memory card. The ten rows in each Line No are averaged to give a set of 256 intensity values. A standard FFT algorithm is then applied to convert the 256 intensity values into frequency spectra which are output to database 21 on an output line 35.

The signature data stored in database 21 for signature 10 is shown in Figure 6. The data comprises forty frequency spectra (Line Nos 1 to 40 shown along the X-axis of Figure 6.) with forty data points in each spectrum (the Fq index shown along the Y-axis of Figure 6). In total, 1600 signature data values are recorded and stored for each signature.

- 5 Apart from storing the raw data shown in Figure 6, the signature data in database 21 also includes a maximum signal value for each spectrum (for instance a value of 2000mV for Line No 1, and 50mV for Line No 24 etc), and a mean signal value for the forty data points in each spectrum.

10 Figures 7a-7j show frequency profile comparisons for the ten colours within the signature 10, between large separately printed samples of each colour (200 x 10 mm) and the actual (small) colour bars (0.7 x 2 mm) in the signature. The dashed line shows the measured frequency profile from the big printed colours; and the solid line shows a measured frequency spectrum from the third Line No. for a respective colour bar in the signature. All samples were printed on the same photo paper by the same printer and the same batch
15 of security inks. As can be seen in Figures 7a-7j there is a surprising amount of difference between the frequency profiles. Therefore, crude measurement of large colour patches is unlikely to give satisfactory signature data.

After the system of Figure 3 has recorded the data in database 21, the system of Figure 8
20 can be used to authenticate a test document. Specifically, the test document (in this example, document 3) is scanned by the interferometer 20 to produce test data 41 which is compared by authentication processor 42 with the signature data in database 21 to produce an authentication result which is output on a display device 43.

Specifically, the processor 42 performs the following algorithm to authenticate the test document.

- 25 1. Produce test data (1600 data points)
2. For each spectrum (ie each of the 40 Line Nos shown in Figure 6) calculate the maximum signal value and the mean signal value.

Calculate a correlation coefficient r as follows:

$$r = \frac{\sum (X_i - \bar{X}_i)(Y_i - \bar{Y}_i)}{\sqrt{\sum (X_i - \bar{X}_i)^2 \sum (Y_i - \bar{Y}_i)^2}}$$

where:

$$-1 \leq r \leq 1$$

5

$\sum$: is a summation over a parameter i which is the spectrum line number (ie the parameter along the X-axis of Figure 6) running from 1 to 40;

X_i is a maximum signal value from the i th test data spectrum;

10 Y_i is a maximum signal value from the i th signature data spectrum;

$\bar{X}_i$ is a mean signal value for the forty data points in the i th test data spectrum; and

$\bar{Y}_i$ is a mean signal value for the forty data points in the i th signature data spectrum.

3. If the coefficient r is above an upper threshold value $r(\text{upper})$ then output a VALID result on display device 43 indicating that the test document is authentic.
- 15 4. If the coefficient r is below a lower threshold value $r(\text{lower})$ then output an INVALID result on display device 43 indicating that the test document is not authentic.
5. If the coefficient r lies between $r(\text{upper})$ and $r(\text{lower})$ then another correlation coefficient is calculated based on all 1600 data values, compared with a threshold
- 20 lying between $r(\text{upper})$ and $r(\text{lower})$, and the result output on the display device.

CLAIMS

1. A method of authenticating a test article, the method comprising:
 - 5 a. generating reference colour data by sensing the colour of a marker on the test article
 - b. generating test colour data by sensing the colour of the marker on the test article; and
 - c. authenticating the test article by comparing the test colour data with the
10 reference colour data.
2. A method according to claim 1 wherein the colour of the marker is sensed in step a. and/or step b. by generating an interference image of the marker; sensing the interference image with a light sensor; and processing the output of the light sensor.
15
3. A method according to any preceding claim wherein the reference colour data is F_q -dimensional colour data, where F_q is greater than one.
4. A method according to any preceding claim wherein the marker comprises a printed
20 marker.
5. A method according to claim 4 wherein the marker comprises an ink having a colour located outside at least one of the CMYK, RGB, Pantone and Hexachrome colour gamuts.
25
6. A method according to claim 4 or 5 wherein the marker comprises a printed marker which has been printed onto a fibrous substrate.
7. A method according to claim 6 wherein the fibrous substrate is paper.
8. A method according to any preceding claim wherein the marker comprises a series
30 of dots.

9. A method according to claim 8 wherein the series of dots have been printed by inkjet printing.
10. A method according to any preceding claim wherein the marker contains a series of regions of different colours.
11. A method according to claim 10 wherein each region contains a respective ink composition; and a plurality of sets of colour data are sensed in step a. for each region.
12. A method according to any preceding claim further comprising the step of printing the marker.
13. A method according to any preceding claim wherein the reference and test colour data is generated by sensing a frequency spectrum of the marker.
14. Apparatus configured to perform a method according to any preceding claim.
15. A method of producing an authentication marker, the method comprising printing a series of regions of different colours on a fibrous substrate.
16. The method of claim 15 wherein each region comprises a series of dots.
17. An authentication marker comprising a fibrous substrate carrying a series of printed regions of different colours.
18. The marker of claim 17 wherein each region comprises a series of dots.

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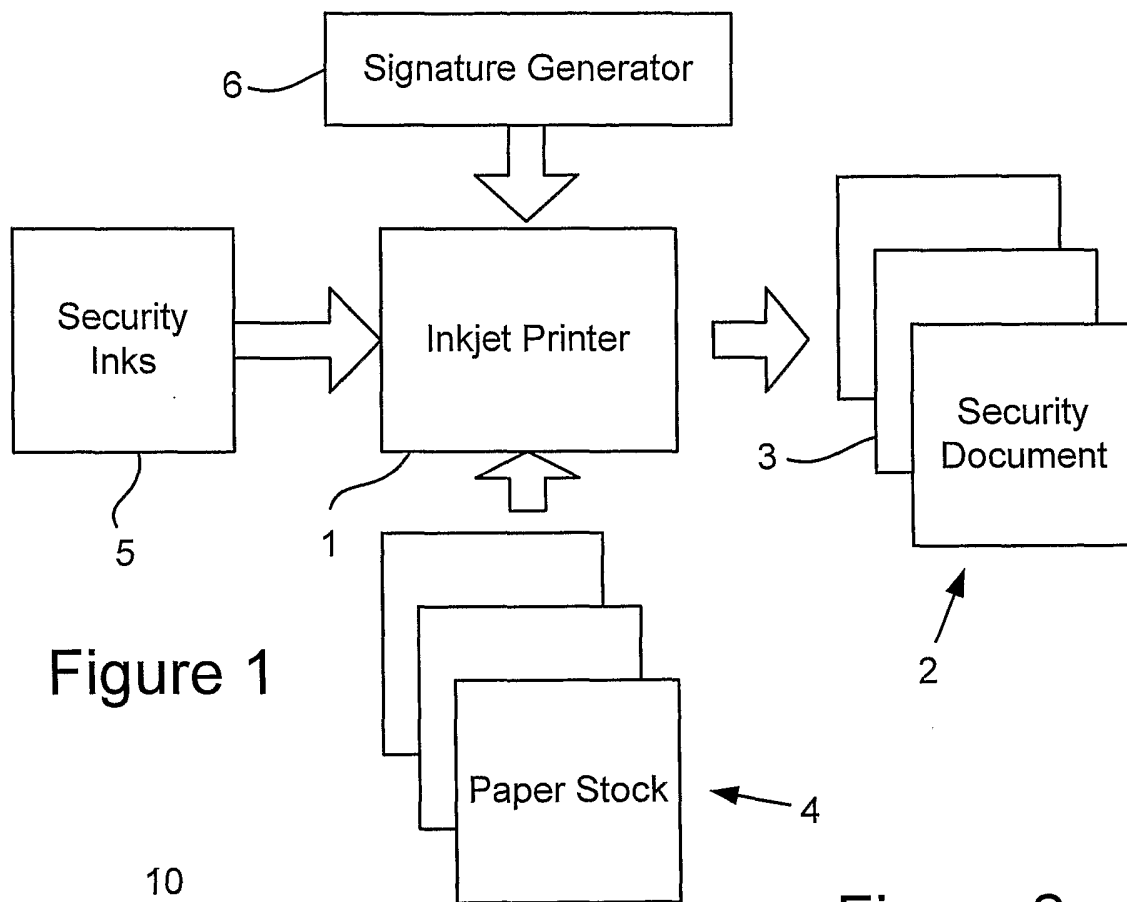


Figure 1

Figure 2

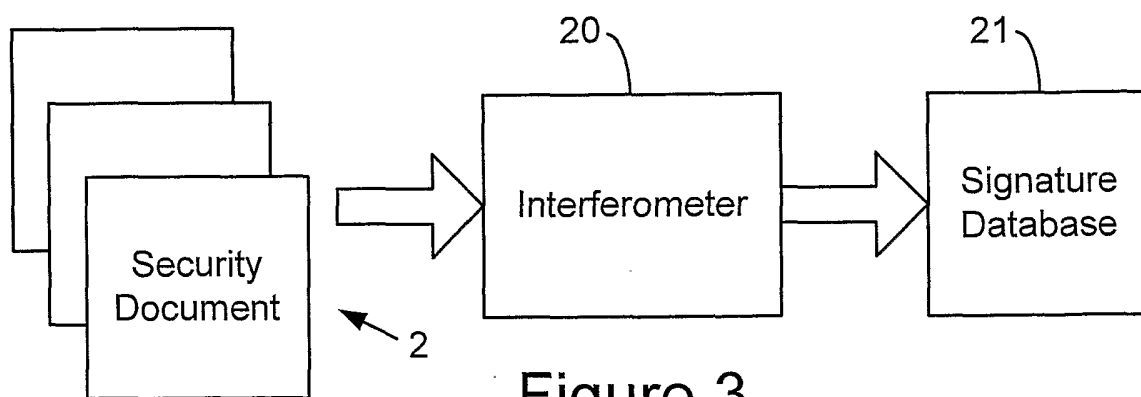
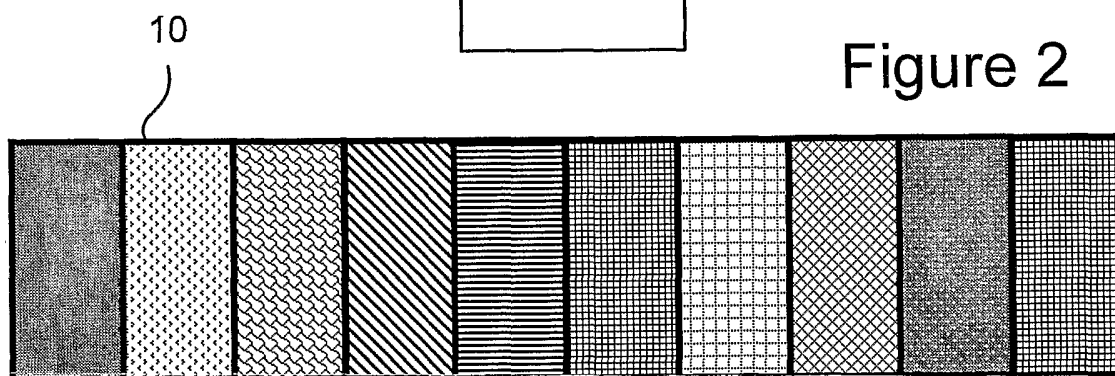


Figure 3

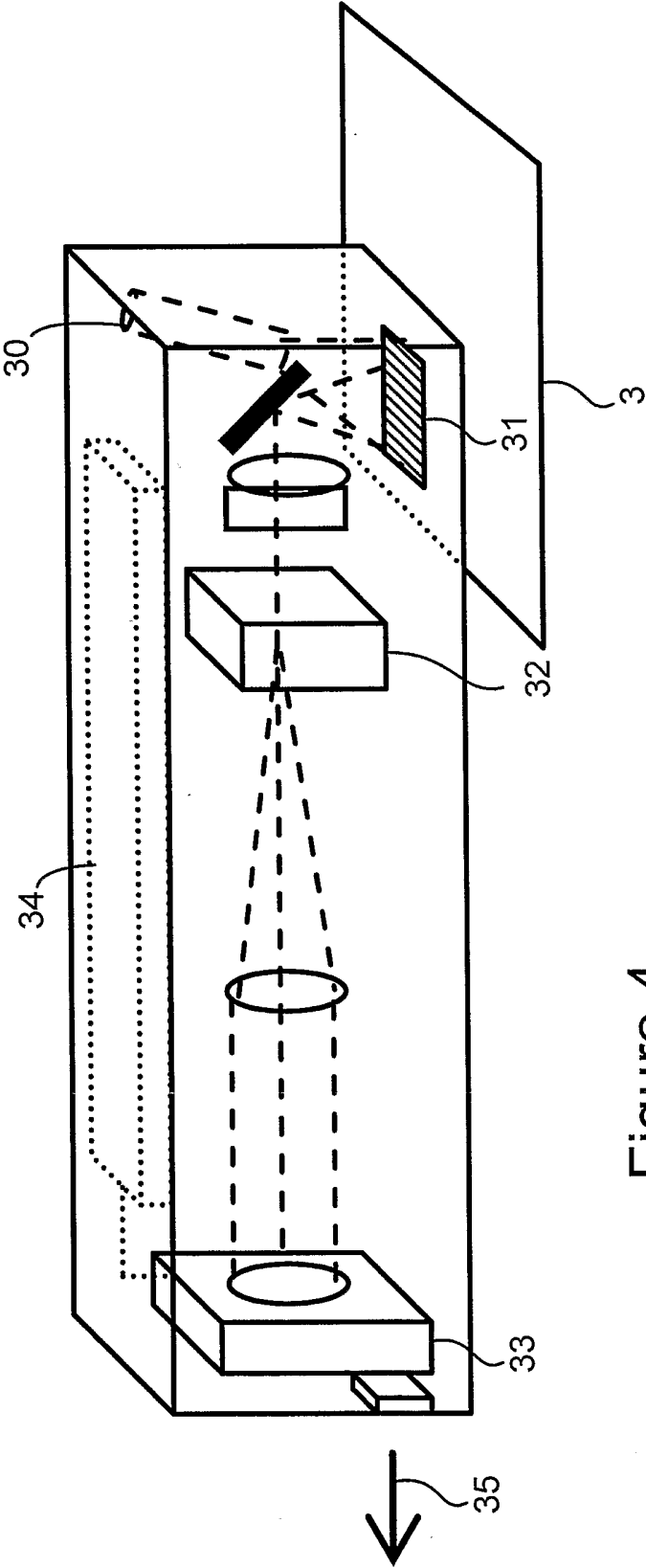


Figure 4

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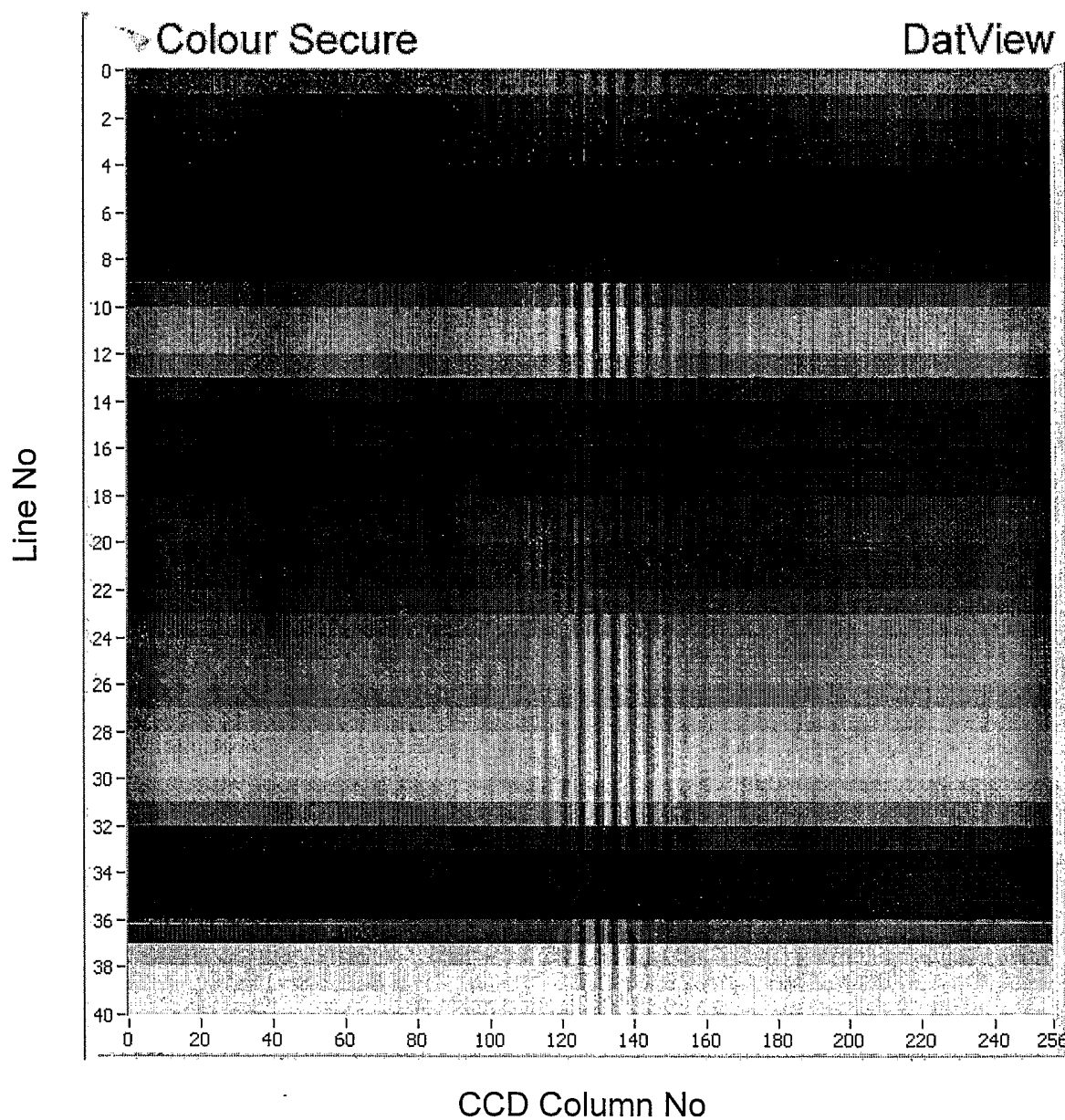


Figure 5

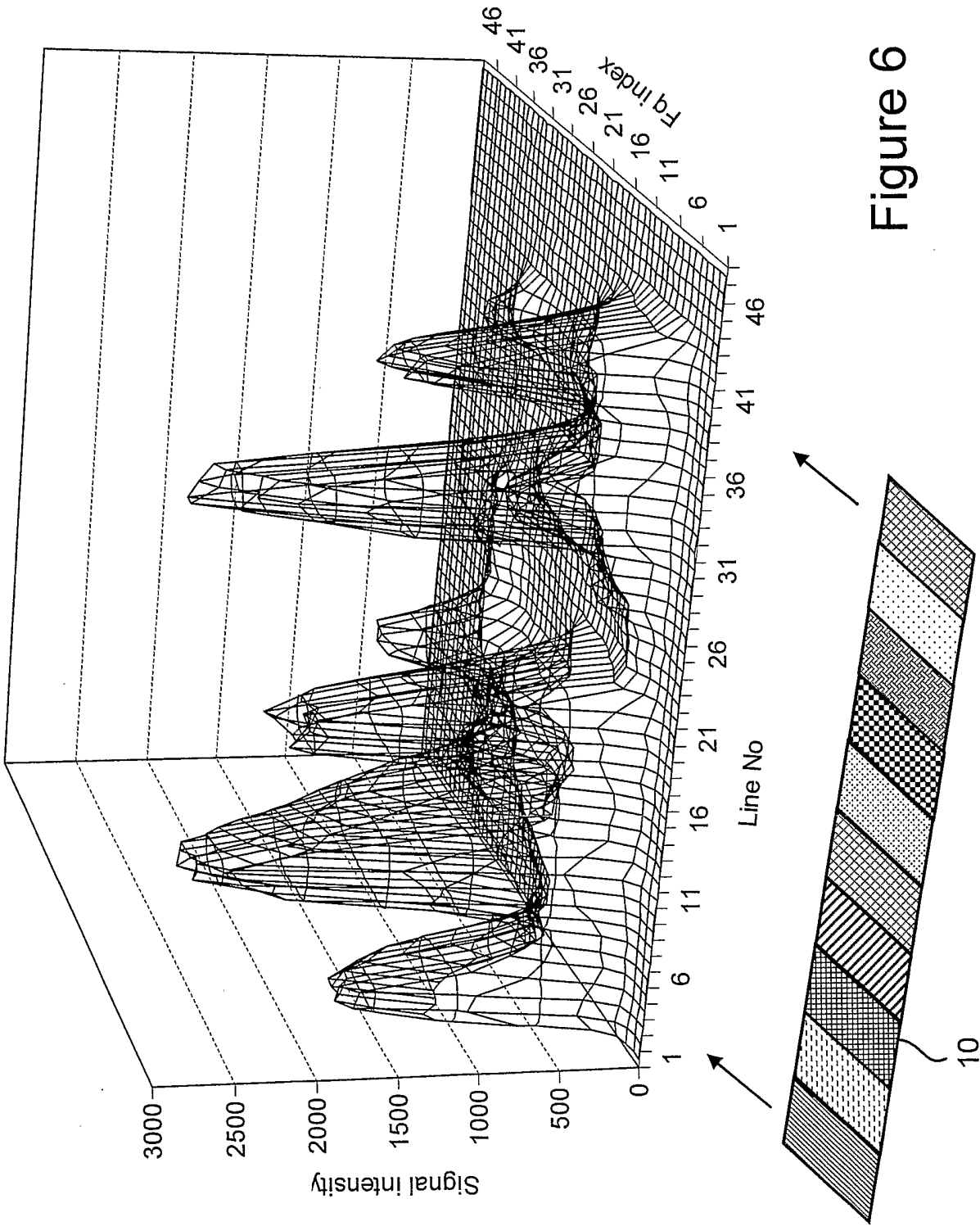


Figure 6

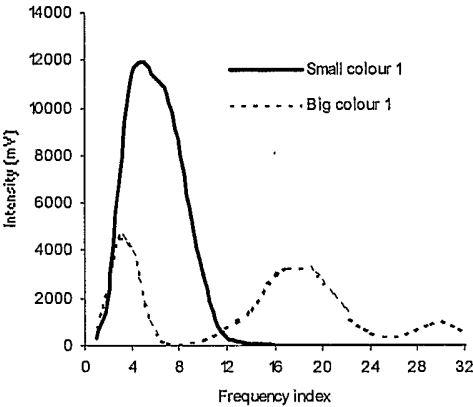


Figure 7a

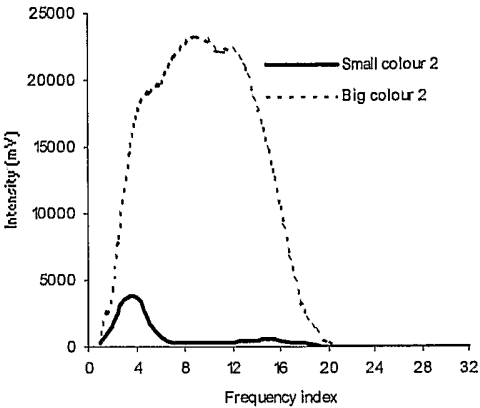


Figure 7b

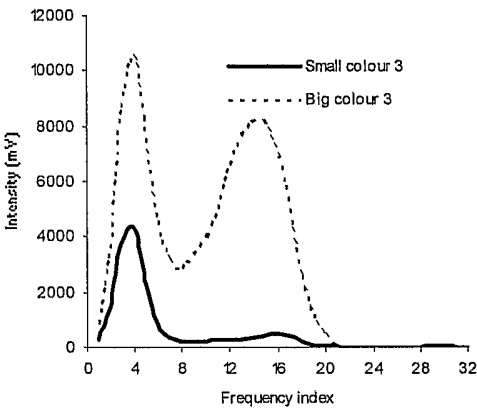


Figure 7c

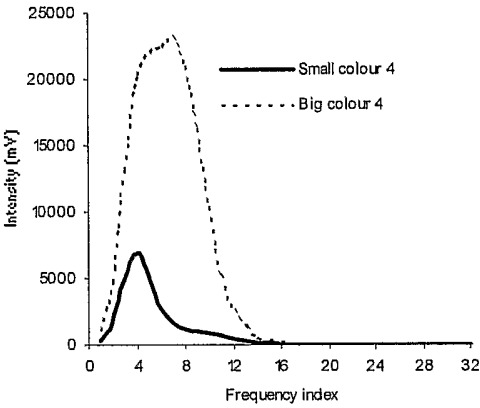


Figure 7d

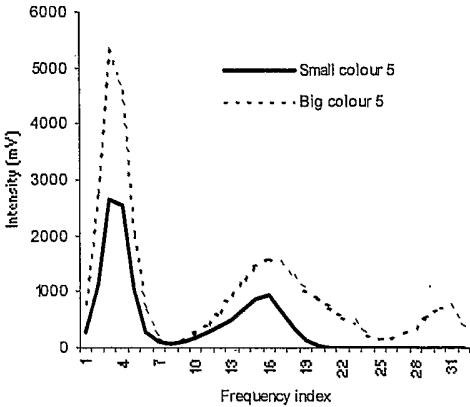


Figure 7e

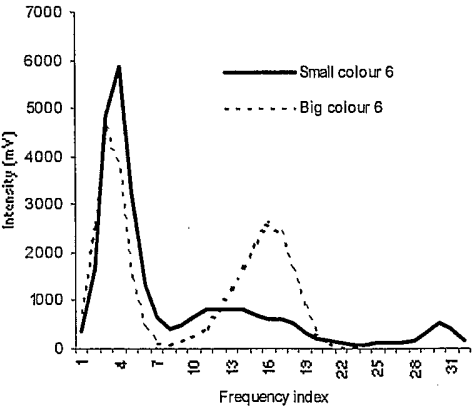


Figure 7f

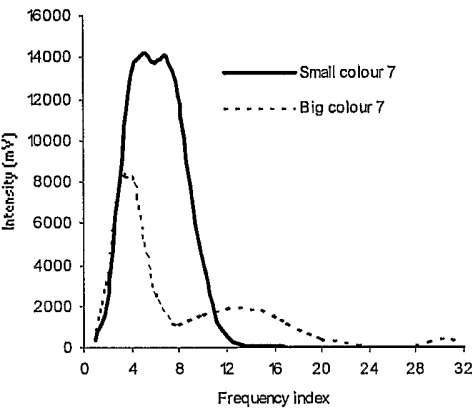


Figure 7g

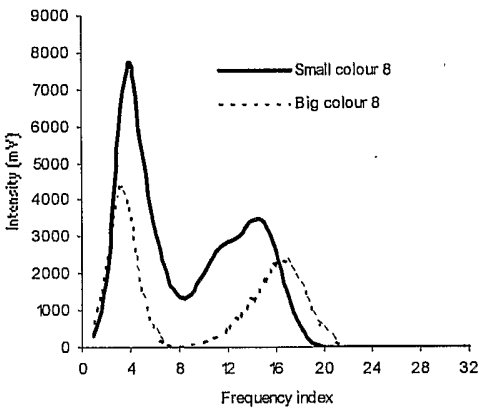


Figure 7h

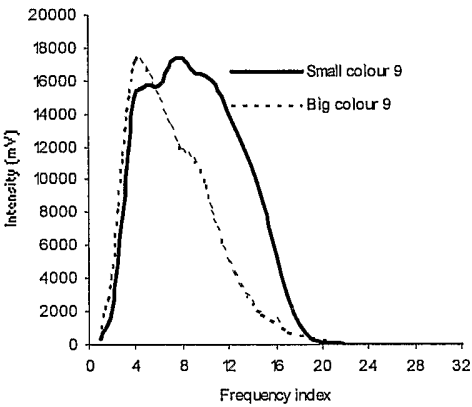


Figure 7i

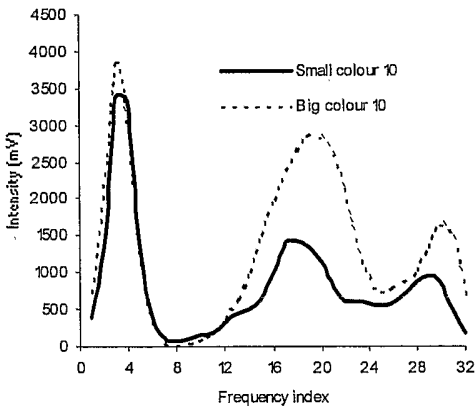
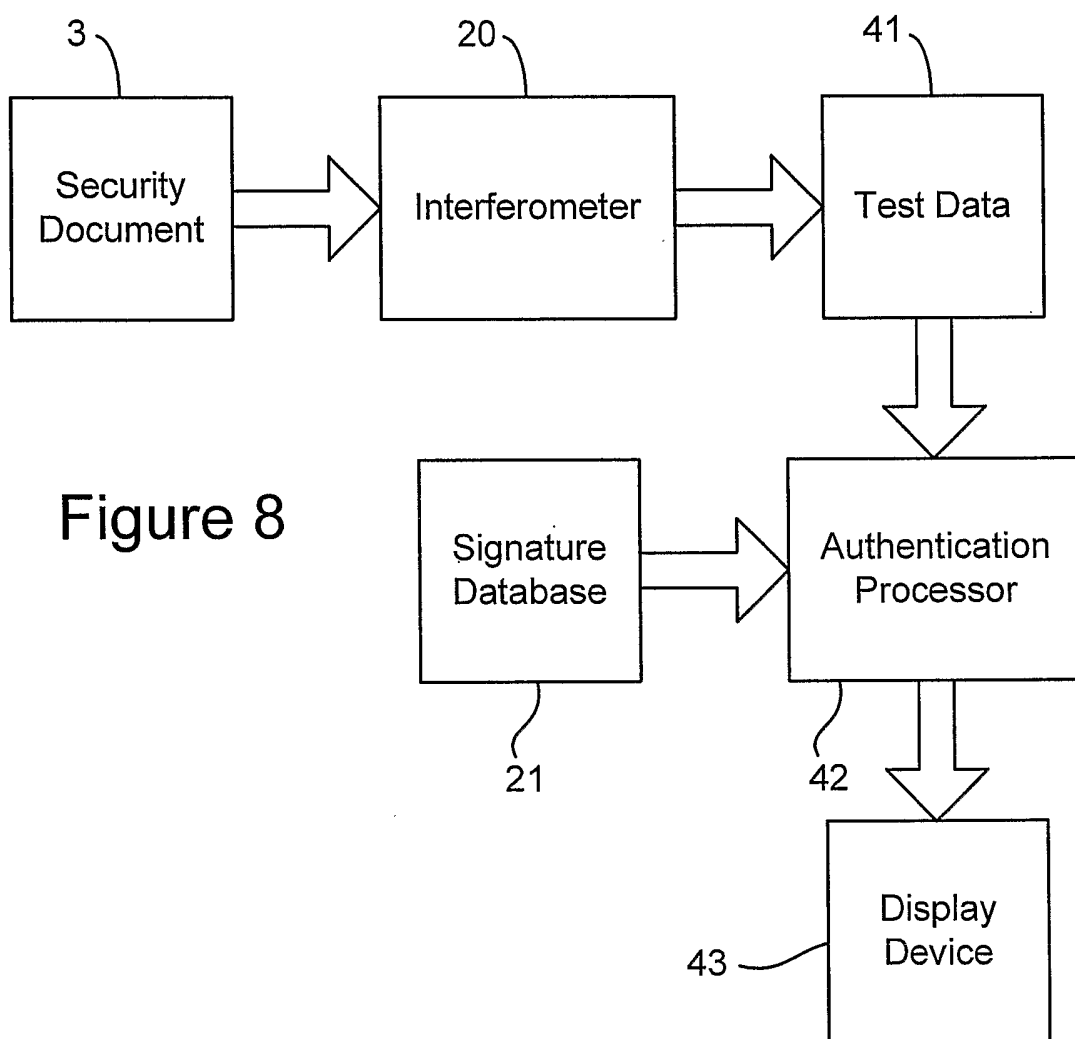


Figure 7j

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000907

A. CLASSIFICATION OF SUBJECT MATTER

INV. G07D7/20

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G07D

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 570 162 A (CANON) 18 November 1993 (1993-11-18) column 2, line 30 - line 47 column 4, line 12 - line 35 column 5, line 2 - line 29; figures 1,2 -----	1-18
X	US 4 785 290 A (GOLDMAN) 15 November 1988 (1988-11-15) column 27, line 17 - line 65; figure 19 -----	1-18
X	DE 199 09 135 A (RÖLLGEN) 7 September 2000 (2000-09-07) cited in the application column 2, line 44 - column 4, line 44; figures ----- -/--	1-18

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

29 May 2006

Date of mailing of the international search report

06/06/2006

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000907

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 324 065 A (SLATER ET AL.) 14 October 1998 (1998-10-14) page 2, line 30 - page 4, line 32; figures 1,4	1-18
X	DE 103 04 805 A (INFORMIUM AG) 19 August 2004 (2004-08-19) paragraphs [0017], [0023], [0026]; figures	1-18
X	WO 01/43086 A (MISCHENKO) 14 June 2001 (2001-06-14) page 11, line 5 - page 13, line 11; figures 3-5	1-18
X	GB 2 340 931 A (CELESICA LTD.) 1 March 2000 (2000-03-01) cited in the application page 2, line 4 - line 31 page 6, line 32 - page 7, line 14 claims 4,5,16 figures	1-18
X	EP 1 403 333 A (SICPA HOLDING SA) 31 March 2004 (2004-03-31) claims 12-17	1-18

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2006/000907

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0570162	A	18-11-1993	DE 69323348 D1	18-03-1999
			DE 69323348 T2	15-07-1999
			JP 3610079 B2	12-01-2005
			JP 6209415 A	26-07-1994
			US 5325167 A	28-06-1994
US 4785290	A	15-11-1988	NONE	
DE 19909135	A	07-09-2000	NONE	
GB 2324065	A	14-10-1998	AU 7058098 A	30-10-1998
			EP 0974138 A1	26-01-2000
			WO 9845826 A1	15-10-1998
DE 10304805	A	19-08-2004	EP 1597709 A2	23-11-2005
			WO 2004070667 A2	19-08-2004
WO 0143086	A	14-06-2001	AT 241834 T	15-06-2003
			AU 2087200 A	18-06-2001
			DE 69908425 D1	03-07-2003
			DE 69908425 T2	06-05-2004
			EA 3919 B1	30-10-2003
			EP 1153373 A1	14-11-2001
			US 6928552 B1	09-08-2005
GB 2340931	A	01-03-2000	EP 0989527 A2	29-03-2000
EP 1403333	A	31-03-2004	AU 2003283239 A1	19-04-2004
			BR 0314726 A	26-07-2005
			CA 2499820 A1	08-04-2004
			CN 1685019 A	19-10-2005
			WO 2004029163 A1	08-04-2004
			JP 2006500447 T	05-01-2006
			MX PA05003201 A	05-07-2005
			US 2006017957 A1	26-01-2006
			ZA 200502404 A	23-09-2005