(54) Title: METHOD AND DEVICE
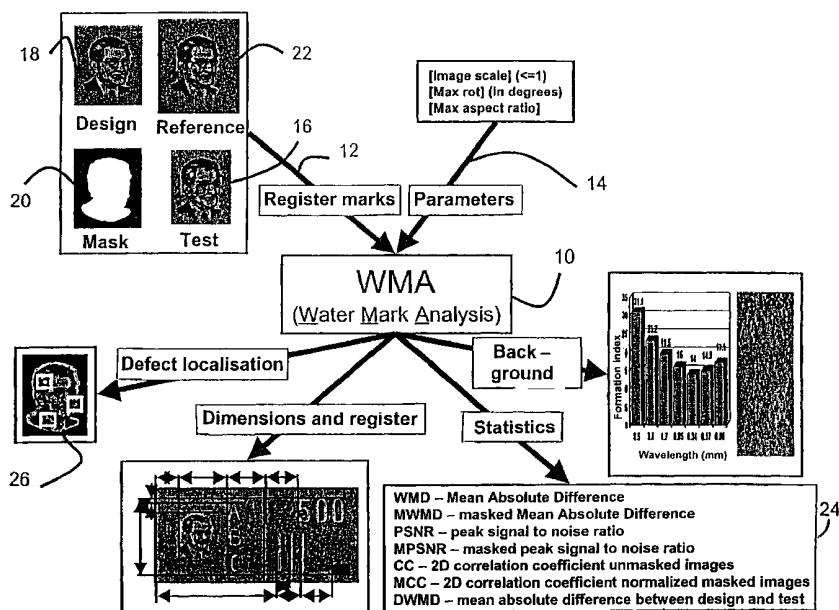
(57) Abstract: The invention concerns a method and a device for quality examination of through radiated security elements (16, 22) comprised in a valuable document by image analysis processing for the determination of its quality, dimensions and internal distances. The security element may specifically be a watermark. The quality of the security element (16, 22) is determined via statistical analysis, whereby this is determined via previously obtained statistics and via threshold values.

TECHNICAL FIELD

The present invention concerns a method and a device for quality inspection and quality examination of through radiated security elements, such as different types of watermarks, security threads, holograms in patches and in bands, security fibres and other visible security ingredients that may be caught in a medium, either being paper or a plastic like medium, in connection with the through radiation.

TECHNICAL BACKGROUND

The expressions "safety" and "security paper" comprises all papers in which any kind of protection against forgery has been provided. This may be provided in different ways according to desires and requirements. A common type is a watermark. Sometimes also a hologram or a kinegram is provided on or in the paper.

Another important way of preventing forgery is printing patterns which are difficult to copy, special dye and using printing methods of such a high quality that the access is strongly limited for forgers.

Almost every security paper is designed for its special purpose, for example, a passport paper for a passport of one country is only made for this country, all this for trying to make this paper as unique as possible.

Concerning watermarks it may be stated that a true watermark always is achieved by a cylinder mould or on a forming cylinder. It is also possible to obtain something reminding of a watermark by embossing the paper in a flat wire machine,

where a mark is embossed in the paper by means of a top couch roller, also called "dandy roll". However, this mark shows less quality than an approved watermark and is only used in more exclusive civil papers or when the value of the document is low.

In order to provide a true watermark a substantially more advanced technique is required. Watermarks are created by thicker and thinner portions in the paper during the forming process on a cylinder mould. The thicker portions give a darker impression and the thinner a lighter impression when the paper is held towards a lamplight.

There are three different types of true watermarks: cylinder mould, cylinder mould two tones and cylinder mould half tone watermark. The latter is also called portrait watermark and is the most exclusive. To obtain a good security it is necessary to use a two-tones or preferably a half-tone watermark. Other known types of watermarks are "Electrotype" and "Bar-code" watermarks.

To check that a watermark is true a visual examination is made today. The paper with the watermark is put on a black paper. If it is a true watermark the thicker portions of the mark looks whiter while the thinner portions become dark. It is also possible to illuminate the paper with ultra violet light, in which light a true watermark is hardly seen. An embossed watermark may fluoresce alternatively obstruct the fluorescence of the paper, but this does not apply to paper made of non-fluorescent fibres as for example cotton.

It also exists three paper forgeries where the middle sheet
have had an embossed watermark, for example forgeries of
French ID cards. These forgeries commonly give unusually
sharp nuance transitions. Therefore, soft transitions are put
into true watermarks.

It also happens that a true watermark has been photographed.
Printing a disturbing print over portions of the watermark
prevents this opportunity. The print may of course not
disturb as much so the check of the quality is made more
difficult. Generally a watermark is considered to give the
best security but if the value of the document is high it
usually is combined with for example one or two other types
of watermarks and a security thread.

In order to provide a true watermark a high technology and
skilled personnel is required as stated above. Nowadays image
analysis technology is used to rapidly and securely create a
new watermark. The new technology facilitates the production
of three dimensionally images, which are used subsequently
for the engraving of wire embosses with automatic milling
machines. The traditional production of a watermark is still
in use. A short run-through will follow point by point.

First an artist engraves the original in a wax plate. The
artist must take into consideration, which portions to be
light and dark, respectively, in the paper. Also the fact
that the paper is subjected to strain tensions and will be
slightly stretched in the paper machine must be taken into
consideration. In order to avoid getting a stretched image a
compressed image of the original is engraved so that a normal
image will be obtained in the paper. The portions which shall

be dark obtains a higher profile than a zero plane in a wax.
Plate and the portions which shall be light obtains a lower
profile than the zero plane of the wax plate.

1. A cast of plaster is made on the wax engravement, which
    forms a mirror copy of the wax plate.

2. On the plaster plate a copper plate is deposited, a so-
    called master, which is identical with the wax
    engravement.

3. On the master a copper matrix is deposited, which is a
    copy of the plaster plates. This is used only for the
    manufacturing of new subplates.

4. On the matrix as many subplates as is required to make up
    a wire, i.e. the wire arranged on the cylinder mould or
    forming cylinder.

5. On each subplate a top plate is deposited and these two
    are both used to emboss the desired pattern in the copper
    wire.

The completed copper wire is usually welded to other copper
wires up to five layers making up an entire wire. This is a
precision work. In order to avoid obtaining any disturbing
edge the 0.18-0.20 mm thick copper threads are grinded to
half and thereafter welded with silver to the grinded threads
of another part. When a round wire is obtained it is welded
to two stronger copper wires to obtain stability.

Hologram and kinegram are nowadays common types of security
elements, which are used in for example the Finnish 20, 100
and 500 Mark notes. The difference between hologram and
kinegram is that it does not have to be a physical image to
produce a kinegram but the image may be created by a computer
and by means of laser technology. This protection prevents
colour photo copying, which means that this could be an
interesting complement, since the development of better and
better colour photo-copying machines is rapid. The
application on the bank note is made by heat sealing. It is
also possible to combine kinegram and hologram with
microprint.

An important factor when analysing valuable documents, such
as bank note paper, passport paper, security document paper
and other security paper is the homogeneity of the document,
for example regarding its variation in fibre distribution in
small scale over a determined surface, called formation in
the art of paper manufacturing.

SUMMARY OF THE DESCRIBED INVENTION
The present invention concerns a method and a device for
checking the quality and the distance between through
radiated security elements, such as preferably different
types of watermarks, but also hologram and the like, security
threads, security fibres, by means of image analysis.

In the present application the expression through radiation
of security elements refer to any kind of radiation that may
be used to register density differences in the paper, for
example, transmitting visual light or IR-light or X-rays
through the security element/s.

6

In order to obtain adequate quality analysis of the security elements the present invention states a method and a device for through radiation of the different security elements comprised in valuable documents with image analysis processing for the establishing of its quality, dimensions and distance there between.

The present invention is also directed to analysis and quality examination of through radiated areas around, in the vicinity of the security elements comprised in the valuable document.

By means of image analysis of valuable documents, such as bank note paper, passport paper, security document paper and other security paper, the quality also is examined concerning the homogeneity of the document, for example concerning the variation of the fibre distribution in small scale over a predetermined surface area, called formation in the art of paper manufacturing. This is determined by calculating a formation coefficient distributed in different wave length areas.

The security element (for example a watermark) is through radiated (for example with light of a wavelength within the visual interval or of another type: for example infrared or ultra violet light or X-rays), the radiation passing is registered by digital means for the receiving of transmitted radiation. The method may also comprise at least any one of the following steps:

correction of the area weight (weight per unit of area, which
is a critical parameter for, for example, the light
absorption of the paper) with an average value of the same;

determination of statistics for the different values by
analysis of the mark if it is a reference mark, compared to
an original or design mark, the statistics are used for
quality check of test marks;

storing of produced statistics for the reference mark and of
the reference mark;

correction of the size of the reference or test mark
according to original, design mark and digital cutting of the
representation of the mark to the size of the original;

checking of the radiation permeability of a test mark
compared to a determined threshold value for the same in said
statistics;

rejection of the quality of the test mark if the radiation
permeability is less than the threshold value, whereby the
quality check is interrupted;

digital comparison of the reference mark with the test mark
if the radiation permeability is greater than said threshold,
whereby a mask with the outline of the original mark is
provided overlapping the mark;

determination of the difference in radiation transmittance
between the reference mark and the test mark within the mask
for the defined area of the marks where the difference is

pronounced in comparison with acceptable statistics for
acceptable difference;

statistic determination of differences between the reference
mark and the test mark by comparison of the same with said
produced statistics for quality determination of the test
mark in said areas;

determining if the test mark has approved quality from a
predetermined threshold level for differences in the
statistics between the reference and the test mark; and

communication of said differences in the statistics and
possible acceptance or rejection of the quality of the mark.

Rejection of the quality of the mark is provided according to
an embodiment of the invention if its average value of weight
per unit of area in the valuable document exceeds a maximum
threshold value for the average according to said
predetermined statistics.

Rejection of the quality of the mark is provided in a further
embodiment of the invention if its average value of weight
per unit of area in the valuable document is below a minimum
threshold value for the average value according to said
predetermined statistics.

Rejection of the quality of the mark is provided in another
embodiment of the present invention if its rotation in
relation to said mask exceeds a predetermined rotational
threshold value in degrees according to said predetermined
statistics.

Rejection of the quality of the mark is provided in a further
embodiment if its rotation in relation to said mask exceeds a
predetermined rotational threshold value in degrees according
to said predetermined statistics in combination with said
maximum threshold value.

Rejection of the quality of the mark is provided in another
embodiment of the present invention if its rotation in
relation to said mask exceeds a predetermined rotational
threshold value in degrees according to said predetermined
statistics in combination with said minimum threshold value.

Rejection of the quality of the mark is provided in an
embodiment of the invention if the shrinkage factor differs
in relation to the predetermined statistics of the same.

Rejection of the quality of the mark is provided in further
embodiments of the invention if the shrinkage factor differs
in relation to the predetermined statistics in combination
with said statistics for other values and/or factors.

The statistics is used in an embodiment to check the distance
between watermarks and/or other security elements in a row of
valuable paper at manufacturing thereof in a machine for this
purpose.

The statistics are used for checking the distance between
security elements in a row of valuable paper in the so-called
machine direction in an embodiment of the present invention.

In a further embodiment of the present invention the statistics are used for checking the distance between marks in a row of valuable paper crosswise the machine direction and the row in front.

In another embodiment of the invention the statistics are used to check the distance between marks in a row of valuable paper in the so called machine direction and crosswise the machine direction to the row in front.

In a preferred embodiment of the invention the mark is a watermark.

Through radiation is effected in one embodiment of the invention by means of at least two different wavelengths for the light so that at least two formation indexes is obtained for statistical determination of the quality of a mark.

Statistics is created in one embodiment when a reference mark is registered, whereby a mark to be tested immediately may be registered for quality determination by means of the statistics for the reference mark.

Further, the present invention comprises a device for quality examination of the through radiated security element comprised in the valuable document by means of image analysis processing for the determination of its quality. Through radiation is provided, whereby radiation passing is registered by means of digital means for receiving transmitted radiation, which means is connected or connectable to computer means for analysis of the quality of

the security element. The device may also comprise at least
one of the means below;

correcting means for the average value of weight per unit of
area of the valuable document and with the size of the
reference or test mark according to the original (design);

digital cutting means for cutting the image of the mark to
the size of the original;

analysis means for determination of statistics for different
values by means of analysis of the mark if it is a reference
mark, in comparison with an original mark, design mark,
whereby the statistics is used for quality check of test
marks;

digital storing means for obtained statistics for the
reference mark and of the reference mark;

checking means for checking of the radiation permeability of
the test mark in comparison with a threshold value for the
same in said statistics;

rejection communication means for the quality of the test
mark if the radiation permeability is lower than the
threshold value, whereby the quality check is interrupted
giving a communication of the quality;

digital comparison means for the comparison between the test
mark and the reference mark if the radiation permeability is
greater than said threshold value, whereby a mask with the
contour of the original mark is overlapping the test mark;

determination means for determination of differences in
radiation permeability between the reference mark and the
test mark within the mask for defined areas of the mark where
the difference is pronounced in comparison with statistics
over acceptable differences;

statistical means for calculation of the difference and for
comparison of the same with said statistics for quality
determination of the test mark in said areas;

determination means for determination if the mark is approved
according to a predetermined threshold level for differences
in the statistics; and

communication means for communicating said differences in the
statistics and possible acceptance or rejection of the
quality of the test mark.

The device may further perform steps in the method in
accordance with the appended dependent device claims.

SHORT DESCRIPTION OF THE DRAWINGS
In the following text describing examples and embodiments it
is referred to the appended figures for a better
understanding of the present invention.

Fig. 1   illustrates schematically a watermark analysis
         according to the present invention.

Fig. 2   illustrates a watermark and some parameters for
          quality examination according to the present
          invention.

Fig. 3   illustrates a masking of an image background
          according to the present invention.

Fig. 4   illustrates schematically fault localisation of a
          watermark according to the present invention.

Fig. 5   illustrates schematically the distance between
          different security elements, here watermarks, at
          manufacturing of valuable documents according to the
          present invention.

Fig. 6   illustrates schematically dimensional determination
          and register, here for a bank note with different
          types of security inserts.

Fig. 7   illustrates a formation index for different wave
          lengths according to the present invention; and

Fig. 8   illustrates schematically different types of
          security inserts or security prints, which may be
          quality determined according to the present
          invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention concerns analysis and quality judgement
of through radiated security elements comprised in valuable
documents. For example; image analysis processing of the
invention with analysis of geometrical factors of the

14

security elements, such as watermarks, whereby such factors
are length and width relations (aspect ratio), comparison in
relation to an original (design), a reference mark or
reference image and background information, so called
formation, are intended. Additionally, laboratory and
manufacturing scale information "on-line", such as the
distance between several watermarks and/or other security
elements, such as security thread, hologram, is intended at
the same time.

Fig. 1 illustrates schematically a watermark analysis 10
according to the invention. Here, one or more watermarks are
registered 12, during manufacturing (see Fig. 5) in a
computer (not shown) by means of digital means for
registration of received light, for example a digital camera
(not shown). The test mark 16 has then been through radiated
via for example a shining table, whereby the mark transmits
different amounts of light at different grey scales of the
ornament of the mark.

Further, parameters 14 is input or determined at the analysis
10 for admissible scale deviation, rotation "max rot", length
and width relation "max aspect ratio".

In the analysis 10, the originally produced mark (design) 18
is comprised and used to form a digital contour mask 20 for
the mark and a reference mark 22 approved as manufactured
according to recognised practice for manufacturing of value
marks. The mask 20 is overlapped over the reference mark 22
whereby, statistics 24 and threshold values for the through
radiation with light is produced. This statistic 24 is
dependent of the formation of the valuable document, i.e. the

fibre distribution in small scale at analysis of valuable

paper and surface weight, so called "grammages" weight per

square meter, commonly g/m² (Amer.: basis weight).

Additionally, statistics 24 for the length and width ratio

for a digitally scanned and cut out reference value mark 22

and the rotation of the mark in relation to the mask 20 is

produced.

Obtained statistics 24 may comprise for example the following

statistical determination methods, WMD (Mean Absolute

Difference), PSNR (Peak Signal to Noice Ratio), mWMD (masked

Mean Absolute Difference), mPSNR (masked Peak Signal to Noice

Ratio), CC1-2D (Correlation Coefficient Unmasked Images),

CC2-2D (Correlation Coefficient Unmasked Images on nonzero

pixels), mCC1-2D (Correlation Coefficients Masked Images),

mCC2-2D (Correlation Coefficients Normalized Masked Images),

mCC3 (see mCC1), Fit3D (3D adaptation for the designed mark

18), Scale 3D (Optimum 3D-scale for calculation of Fit3D).

When one or more of these statistics differences between the

design mark 18 and the reference mark 22 are registered in

the analysis, acceptable differences are stipulated in the

form of threshold values for disturbance levels, which are

used for stipulation the quality of the test mark 16. The

level for the quality 26 of the mark is shown via, for

example, a print-out or a computer display in the form of an

image with for example marked cross-rule areas (see fig. 4

for a more detailed description of this) where the

differences between the reference mark 22 and the test mark

16 are greatest according to said statistics. The differences

may of course be shown by other means known to the skilled

person within the scope of the present invention. Obtained
statistics may in one embodiment of the invention concern
each cross-rule area per se, in such a way the statistics
become more detailed dependent on now finely cross-ruled area
has been used, see fig. 4.

The expression rejection is meant that what is rejected is
not accepted due to poor quality.

Fig. 1 illustrates by means of arrows which results that a
mark analysis 10 may perform in the form of defect
localisation 26, dimensions and registers (see Fig. 6),
statistics, background information (Fig. 7) etc.

In one embodiment the through radiation is metered for the
mark 16 under test, whereby it immediately is determined if
the analysis should be interrupted at the registration due to
the permeability is too high or too low in relation to a
predetermined threshold value. If this occurs, it is not any
idea to carry on with the analysis since already the input,
registration of the mark reveals deficiencies in it.

In order to carry out the analysis 10 it is given by the
present invention a device for quality examination of through
radiated security elements comprised in valuable documents by
means of image analysis processing for the stipulation of its
quality, dimensions and internal distances.

The device comprises means (for example, shining table or IR-
lamp) for through radiation, which radiates through the mark,
whereby the radiation hitting digital means (for example a
digital camera) for receiving transmitted radiation is   -

registered, which means is connected or connectable to computer means (for example a personal computer or other computer) for analysis of the quality of the mark. Further, the device comprises:

correction means for the average value of weight per unit of area of the valuable document and with the size of the reference 22 or test mark 16 according to the original (design) 18;

digital cutting means for cutting of the image of the mark to the size of the original;

analysis means for determination of statistics for different values by means of analysis of the mark if it is a reference 22, in comparison with an original mark 18, whereby the statistics is used for quality check of test marks 16;

digital storing means for produced statistics for the reference mark 22 and of the reference mark 22;

check means for checking the radiation permeability of the test mark 16 in comparison, with a threshold value for the same in said statistics;

rejection communicating means for the quality of the test mark 16 if the radiation permeability is less than the threshold value, whereby the quality check is interrupted with a communication about the quality;

digital comparison means for comparison of the test mark 16 with the reference mark 22 if the radiation permeability is

greater than said threshold value, whereby a mask 20 with the contour of the original mark is overlapped over the test mark 16;

determination means for the determination of differences in radiation transmittance between the reference mark 22 and test mark 16 within the mask 20 for defined areas of the mark where the difference is pronounced in comparison with statistics over acceptable differences;

statistical means for calculation of the difference and for comparison of the same with said statistics for quality determination of the test mark 16 in said areas;

determination means for determination if the mark is approved based on a predetermined threshold for differences in the statistics; and

communication means for communicating said differences in statistics and possible acceptance or rejection of the quality of the test mark 16.

A unique property of the device and the method according to the present invention is provided by the fact that the statistics 24 may be created with the device when the designed mark 18 is used as original/reference, whereby the real reference 22 is used as a test mark 16.

The above mentioned means may suitably be built up of software or in a combination with hardware previously known to the skilled person within the art.

Below some preferred embodiments of the present invention
will follow, which may be performed by the device or the
method according to the present invention.

Rejection of the quality of the mark is performed if its
average value of weight per unit of area in the valuable
document exceeds a maximum threshold value for the average
value according to said predetermined statistics.

Rejection of the quality of the mark is performed if its
average value of weight per unit of area in the valuable
document is below a minimum threshold value for the average
value according to said predetermined statistics.

Rejection of the quality of the mark is performed if its
rotation in relation to said mask exceeds a predetermined
rotational threshold value in degrees according to said
predetermined statistics.

Rejection of the quality of the mark is performed if its
rotation in relation to said mask exceeds a predetermined
rotational threshold in degrees according to said
predetermined statistics in combination with said maximum
threshold value.

Rejection of the quality of the mark is performed if its
rotation in relation to said mask exceeds a predetermined
rotational threshold value in degrees according to said
predetermined statistics in combination with said minimum
threshold value.

Rejection of the quality of the mark is performed if the
shrinking factor differs in relation to the predetermined
statistics.

Rejection of the quality of the mark is performed if the
shrinking factor differs in relation to the predetermined
statistics in combination with said statistics for other
values and/or factors. The shrinking factor comes from the
tendency of a mark to shrink from its original size at
manufacturing of for example a value paper having a watermark
when joining paper sheets, for example due to moisture and
solvents that have been applied.

If certain rotation is measured but the value is below the
threshold value a correction must be done for the measured
rotation so that the rest of the statistical values may be
comparable. The corresponding is true for the shrinking
factor.

Fig. 2 illustrates a watermark with an indicated height and
width. The relation between these parameters is used in the
invention to determine the quality of a mark. In the mark
there is an arrow, which indicate possible rotation of the
mark in degrees at a digital cut of the mark at analysis 10.

Fig. 3 illustrates a masking of the background 30 of a mark,
i.e. the contour 32 of the mark emerges according to the
masking 20. The mask 20 masks the background 30 of the test
image 22. The method has previously been described above.

Fig. 4 illustrates as an embodiment of the invention fault
localisation in the analysis 10. The test mark 16 is here

divided in an embodiment of the invention into a closer

masked net (cross-ruled area) from image to image when it is

compared with the reference 22. The plus signs indicate

statistical differences of the test mark 16 in comparison

with the reference mark 22. The minus signs for each checker

indicates good conformity between the reference mark 22 and

the test mark 16. In this comparison it was determined that

the difference between the both marks where $\Delta = 15.2$, which

is accepted or rejected according to predetermined threshold

values in the analysis 10, which determined the threshold

values from statistical analysis according to any of the

above methods for statistical determination of the designed

value in comparison with the reference 22.

The first deviation shows a white patch in the upper left

cross-ruled area of the tested mark 16, which is missing in

the reference mark 22. This quality deviation has been marked

with a plus sign to the right of the tested mark 16 for the

checker in concern.

The cross-ruled area is made with a finer mask for the

subsequent tested marks 16 in fig. 4. In the new cross-ruled

area comprising sixteen checkers a further statistical

deviation is discovered in the quality of the tested mark 16,

which has been indicated by a plus sign in the second checker

in the lowest row of checkers. The deviation is a black spot

on the shirt collar in the test mark 16.

In similar ways the cross-ruled area may be made even finer

masked, which is shown in the mark 16 furthest down, which

has been divided into 64 checkers, whereby another

statistical deviation is discovered. This time it is a

rupture in the contour line of the face in the mark 16. The
finer marked the cross-ruled area is the more statistics,
since the statistics refers to each checker.

In fig. 5 it is illustrated schematically how tested marks
16, at manufacturing, is positioned in rows and columns in
the machine direction (vertical arrow) and cross wise the
machine direction (horizontal arrow) on a valuable paper
sheet, whereby the machine direction is the direction the
sheet is transported in a manufacturing machine. In this
embodiment of the present invention produced statistics are
used to check the distance between the watermarks in a row of
valuable papers at manufacturing of the same in a machine for
this purpose. Here, a faulty printing of the valuable paper
sheet thus may be stopped when too large statistical
deviations for distance between marks 16 arise both in the
machine direction and the cross wise machine direction, which
is shown with double arrows at the valuable paper sheet in
fig. 5.

Fig. 6 illustrates schematically dimension determination and
register, here for a bank note with different types of
security inserts or security prints. It should be noted that
security inserts that are not in themselves possible to
though radiated with advantage may be through radiated in its
immediate vicinity, for example the surroundings, for example
by means of the method according to fig. 7.

In fig. 6 different distances is illustrated, which may be
checked for examination of the quality. Arrows in fig. 6
indicate the distances. The distances are measured on the
security elements described in more detailed in fig. 8.

Fig. 7 illustrates a formation index for different
wavelengths according to the present invention. By means of
image analysis of valuable documents, such as bank note
paper, passport paper, security document paper, other
security paper etc, also the quality of the homogeneity of
the document in for example its variating fibre distribution
in small scale over a determined area, called formation
within the field of paper manufacturing, is also examined.
This is determined by calculating a formation coefficient
distributed in different wavelength ranges.

Such a range is shown to the right of the columns in fig. 7,
whereby a formation index for the range may be obtained from
the column diagram in fig. 7, which is different for
different wave lengths of the light coming from the one and
same image. Sampling and rescaling of the image produce the
different wavelengths. Thus, it is possible to obtain a more
accurate quality examination if several wavelengths in the
image are analysed.

Fig. 8 illustrates different types of security inserts or
security prints, which may be quality determined according to
the present invention. The security elements are security
inserts, security prints etc. and comprises here of portrait
watermark, text watermark, security thread, foil in a band,
coated areas, number watermark, patch foil, applied elements,
such as hologram.

The present invention has here been described in the form of
examples and preferred embodiments but is not limited to

24

5   these, the wording of the appended claims define possible
       embodiments for the skilled person in the art.

CLAIMS

1. A method for quality inspection of through radiated security elements (16, 22), security marks and areas in the vicinity of such comprised in valuable documents, by image processing analysis via computer means for the determination of its quality, **characterised in** that a mark (16, 22) is through radiated, whereby the radiation passing the mark is registered by means of digital means for receiving transmitted radiation.

2. A method according to claim 1, **characterised in** the step: correction of the weight per unit of area of the valuable document by an average value of the same.

3. A method according to claim 1, **characterised in** the step: determination of statistics for different values by analysing the mark, if it is a reference mark (22), in comparison with an original mark, design mark (18), whereby the statistics is used for quality check of test marks (16).

4. A method according to claim 1, **characterised in** the step: storing of produced statistics for the reference mark (22) and of the reference mark per se (22).

5. A method according to claim 1, **characterised in** the step: correction of the size of the reference mark or test mark (16) according to the original (18) and digital cutting of the image of the mark to original size.

6. A method according to claim 1, **characterised in** the step: checking the radiation permeability of the test mark (16) in comparison with a threshold for the same in said statistics.

7. A method according to claim 1, **characterised in** the step: rejection of the quality of the test mark (16) if the radiation permeability is less than the threshold value, whereby the quality, check is interrupted.

8. A method according to claim 1, **characterised in** the step: digital comparison of the reference mark (22) with the test mark (16) if the radiation permeability is grater than said threshold value, whereby a mask (20) with the contour of the original mark (18) is overlapped over the mark (16).

9. A method according to claim 1, **characterised in** the step: determination of differences in the radiation transmittance between the reference mark (22) and the test mark (16) within the mask (20) for defined areas of the marks (16, 22) where the difference is pronounced in comparison with acceptable statistics for acceptable differences.

10. A method according to claim 1, **characterised in** the step: statistical determination of differences between the reference mark (22) and the test mark (16) by comparison of the same with said produced statistics for quality determination of the test mark (16) in said areas.

11. A method according to claim 1, **characterised in** the step: determining if the test mark (16) has approved quality from a predetermined threshold level for differences in the

statistics between the reference mark (22) and the test mark (16).

12. A method according to claim 1, **characterised in** the step: communication of said differences in the statistics and possible acceptance or rejection of the quality of the mark.

13. A method according to claim 1, **characterised in** that rejection of the quality of the mark (16) is performed if its average value of weight per unit of area in the valuable document exceeds a maximum threshold value for the average value according to said predetermined statistics.

14. A method according to claim 1, **characterised in** that rejection of the quality of the mark is performed if its average value of weight per unit of area in the valuable document is below a minimum threshold value for the average value according to said predetermined statistics.

15. A method according to claim 1, **characterised in** that rejection of the quality of the mark is performed if its rotation in relation to said mask (20) exceeds a predetermined rotation threshold value in degrees according to said predetermined statistics.

16. A method according to claim 13, **characterised in** that rejection of the quality of the mark is performed if its rotation in relation to said mask (20) exceeds a predetermined rotation threshold value in degrees according to said predetermined statistics in combination with said maximum threshold value.

17. A method according to claim 14, **characterised in** that rejection of the quality of the mark is performed if its rotation in relation to said mask (20) exceeds a predetermined rotation threshold value in degrees according to said predetermined statistics in combination with said minimum threshold value.

18. A method according to claim 1, **characterised in** that rejection of the quality of the mark is performed if the shrinking factor of a mark differs in relation to the predetermined statistics.

19. A method according to claim 13-18, **characterised in** that rejection of the quality of the mark is performed if the shrinking factor of a mark differs in relation to the predetermined statistics in combination with said statistics for other values and/or factors.

20. A method according to 1-19, **characterised in** that the statistics is used for checking the distance between marks in a row of valuable paper at manufacturing thereof in a machine for this purpose.

21. A method according to claim 20, **characterised in** that the statistics is used for checking the distance between marks in a row of valuable paper in the so-called machine direction.

22. A method according to claim 20, **characterised in** that the statistics is used for checking the distance between marks in a row of valuable paper cross wise the machine direction to the row in front.

23. A method according to claim 1-20, **characterised in** that the statistics is used for checking the distance between marks in a row of valuable paper in the so called machine direction and cross wise the machine direction to the row in front.

24. A method according to claim 1-23, **characterised in** that the mark is a watermark.

25. A method according to claim 1-24, **characterised in** that the mark is analysed for at least two different wavelengths of light so that at least two formation indexes is obtained for statistical determination of a quality of a mark.

26. A method according to claim 1-25, **characterised in** that statistics is produced when a reference mark is registered, whereby a mark to be tested immediately may be registered for quality determination with the statistics for the reference mark.

27. A device for quality inspection of through radiated security elements, security marks and areas in the vicinity of such comprised in valuable documents by image processing analysis via computer means for the determination of its quality, **characterised in** means for the through radiation of a reference mark (22) or a test mark (16), whereby passing radiation is registered by digital means for receiving incident radiation, which means is connected or connectable to the computer means for analysing of a quality of a test mark (16).

28. A method according to claim 27, **characterised in** correction means for the average value of weight per unit of. area of the valuable document and of the size of the reference mark or test mark (16, 22) according to the original (18).

29. A method according to claim 27, **characterised in** digital cutting means for cutting the image of the mark to the size of the original.

30. A method according to claim 27, **characterised in** analysis means for determination of statistics for different values by analysis of the mark, if it is a reference mark (22), compared to an original, design mark (18), whereby the statistics are used for quality check of test marks (16).

31. A method according to claim 27, **characterised in** digital storing means for produced statistics for the reference mark (22) and of the reference mark (22) per se.

32. A method according to claim 27, **characterised in** checking means for checking the radiation permeability of the test mark (16) in comparison with a determined threshold for the same in said statistics.

33. A method according to claim 27, **characterised in** rejection communication means for the quality of the test mark (16) if the radiation permeability is less than the threshold value, whereby the quality check is interrupted with communication of the quality.

34. A method according to claim 27, **characterised in** digital comparison means for comparison of the test mark (16) with the reference mark (22) if the radiation permeability is greater than said threshold value, whereby a mask (20) with the contour of the original mark is overlapped over the test mark (16).

35. A method according to claim 27, **characterised in** determination means for determination of differences in the radiation transmittance between the reference mark (22) and the test mark (16) within the mask (20) for defined areas of the mark (16, 22) where the difference is pronounced in comparison with statistics over acceptable differences.

36. A method according to claim 27, **characterised in** statistical means for calculation of the difference and for comparison of the same with said statistics for quality determination of the test mark (16) in said area.

37. A method according to claim 27, **characterised in** determination means for determining if the mark is approved from a predetermined threshold level for differences in the statistics.

38. A method according to claim 27, **characterised in** communication means for communication of said differences in the statistics and possible acceptance or rejection of the quality of the test mark (16).

39. A method according to claim 27, **characterised in** that rejection of the quality of the mark is performed if its average value of weight per unit of area in the valuable

document exceeds a maximum threshold value for the average
value according to said predetermined statistics.

40. A method according to claim 27, **characterised in** that
rejection of the quality of the mark is performed if its
average value of weight per unit of area in the valuable
document is less than a minimum threshold value for the
average value according to said predetermined statistics.

41. A method according to claim 27, **characterised in** that
rejection of the quality of the mark is performed if its
rotation in relation to said mask (20) exceeds a
predetermined rotation threshold value in degrees according
to said predetermined statistics.

42. A method according to claim 27, **characterised in** that
rejection of the quality of the mark is performed if its
rotation in relation to said mask (20) exceeds a
predetermined rotation threshold value in degrees according
to said predetermined statistics in combination with said
maximum threshold value.

43. A method according to claim 27, **characterised in** that
rejection of the quality of the mark is performed if its
rotation in relation to said mask (20) exceeds a
predetermined rotation threshold value in degrees according
to said predetermined statistics in combination with said
minimum threshold value.

44. A method according to claim 27, **characterised in** that
rejection of the quality of the mark is performed if the
shrinking factor differs from the predetermined statistics.

45. A method according to claim 29-43, **characterised in** that rejection of the quality of the mark is performed if the shrinking factor differs from the predetermined statistics in combination with said statistics for other values and/or factors.

46. A method according to claim 27-45, **characterised in** that the statistics are used to check the distance between marks in a row of valuable papers at manufacturing thereof in a machine for this purpose.

47. A method according to claim 46, **characterised in** that the statistics are used to check the distance between marks in a row of valuable papers in the so called machine direction.

48. A method according to claim 46, **characterised in** that the statistics are used to check the distance between marks in a row of valuable papers cross wise the machine direction to the row in front.

49. A method according to claim 27-45, **characterised in** that the statistics are used to check the distance between marks in a row of valuable papers in the so called machine direction and cross wise the machine direction to the row in front.
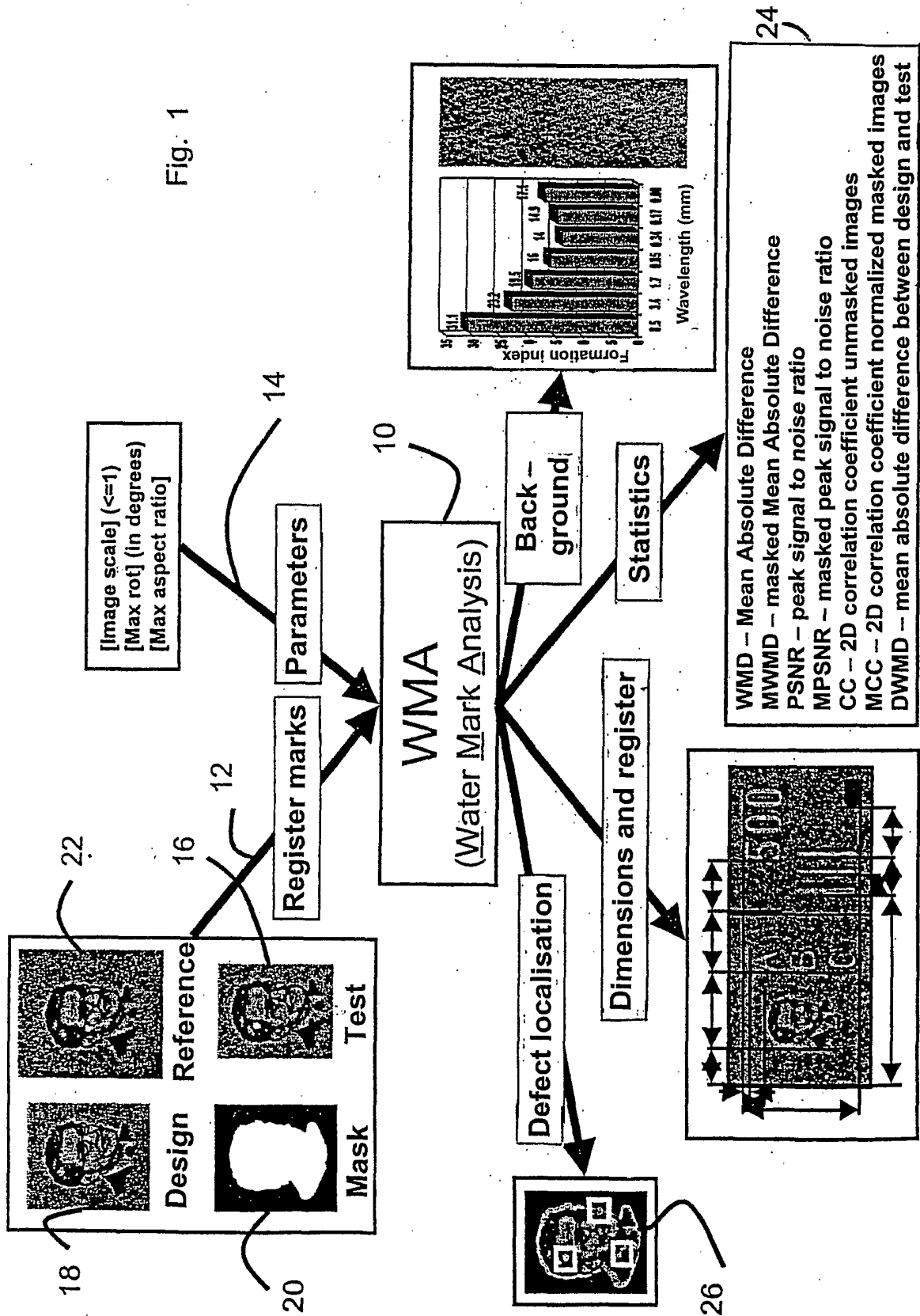
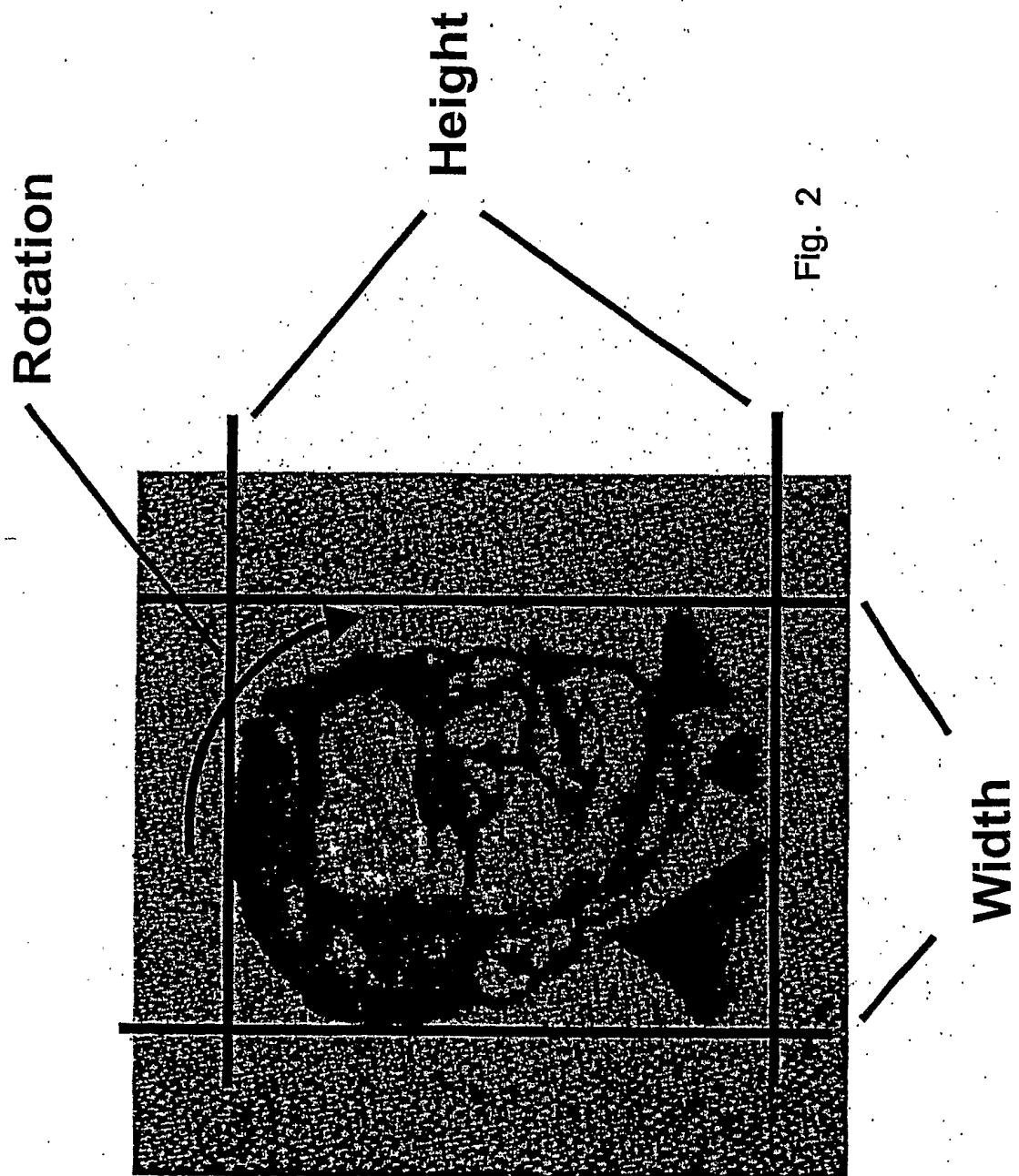50. A method according to claim 27-49, **characterised in** that the mark is a watermark.

51. A method according to claim 27-50, **characterised in** that the mark is analysed for at least two different wavelengths

34

of light so that at least two formation indexes is obtained
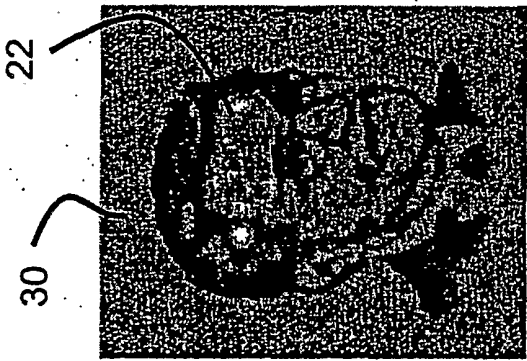for statistical determination of a quality of a mark.

52. A method according to claim 27-51, **characterised in** that
statistics are produced when a reference mark is registered,
whereby a mark to be tested immediately may be registered for
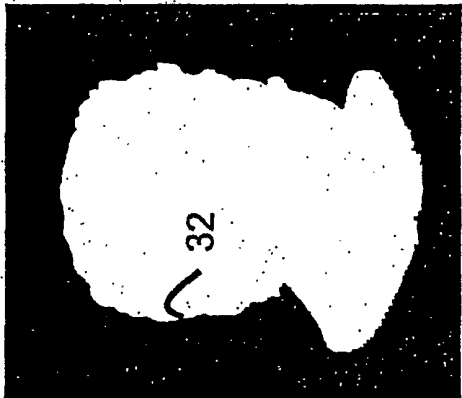quality determination by the statistics for the reference
mark.

1/8

Fig. 1

[Image scale] (<=1)
[Max rot] (in degrees)
[Max aspect ratio]

14

Parameters

16
12

Register marks

22

18

Design   Reference

Test

Mask

20

WMA
(Water Mark Analysis)

10

Back-
ground

Statistics

Defect localisation

Dimensions and register

Formation Index
Wavelength (mm)

24

WMD – Mean Absolute Difference
MWMD – masked Mean Absolute Difference
PSNR – peak signal to noise ratio
MPSNR – masked peak signal to noise ratio
CC – 2D correlation coefficient unmasked images
MCC – 2D correlation coefficient normalized masked images
DWMD – mean absolute difference between design and test

26

Fig. 2

Originaldesign + Mask = Testimage
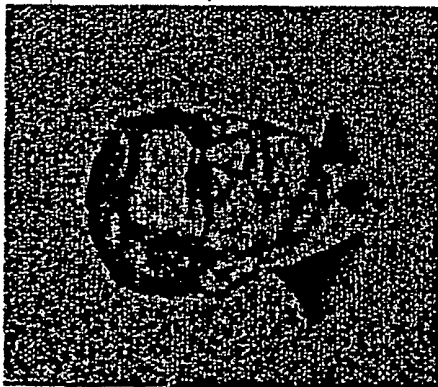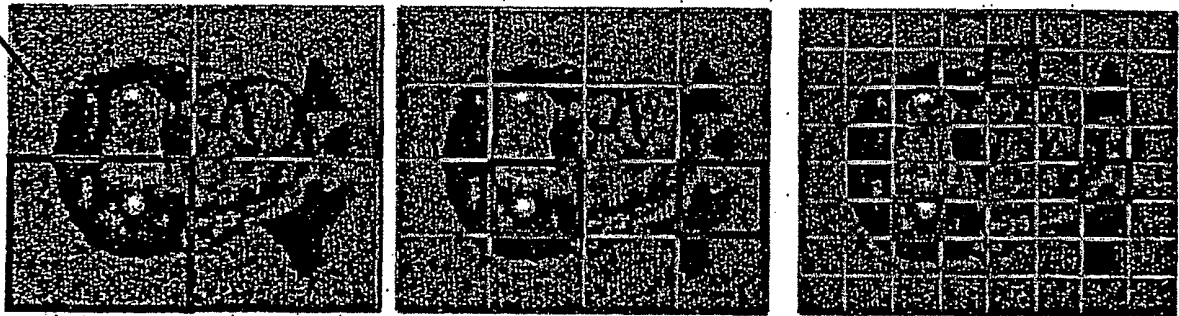
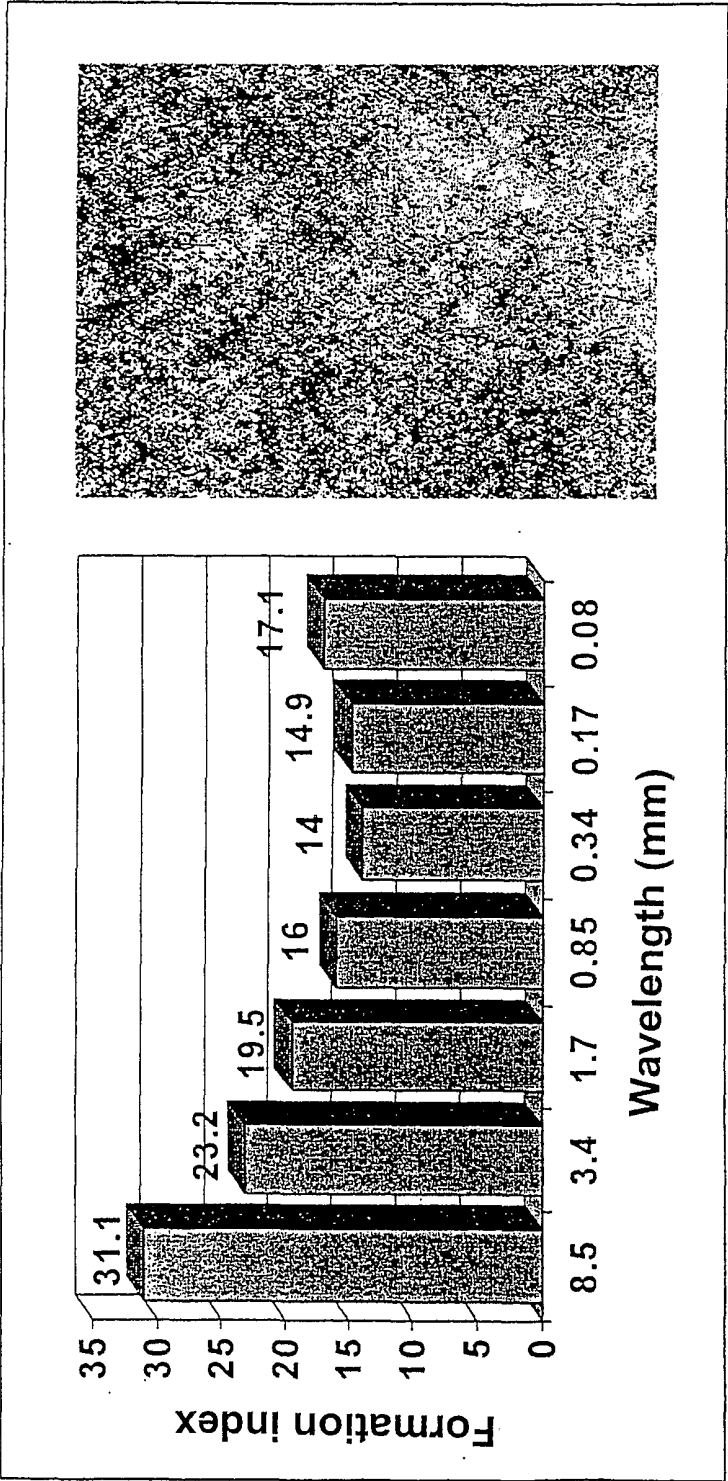Testimage without background
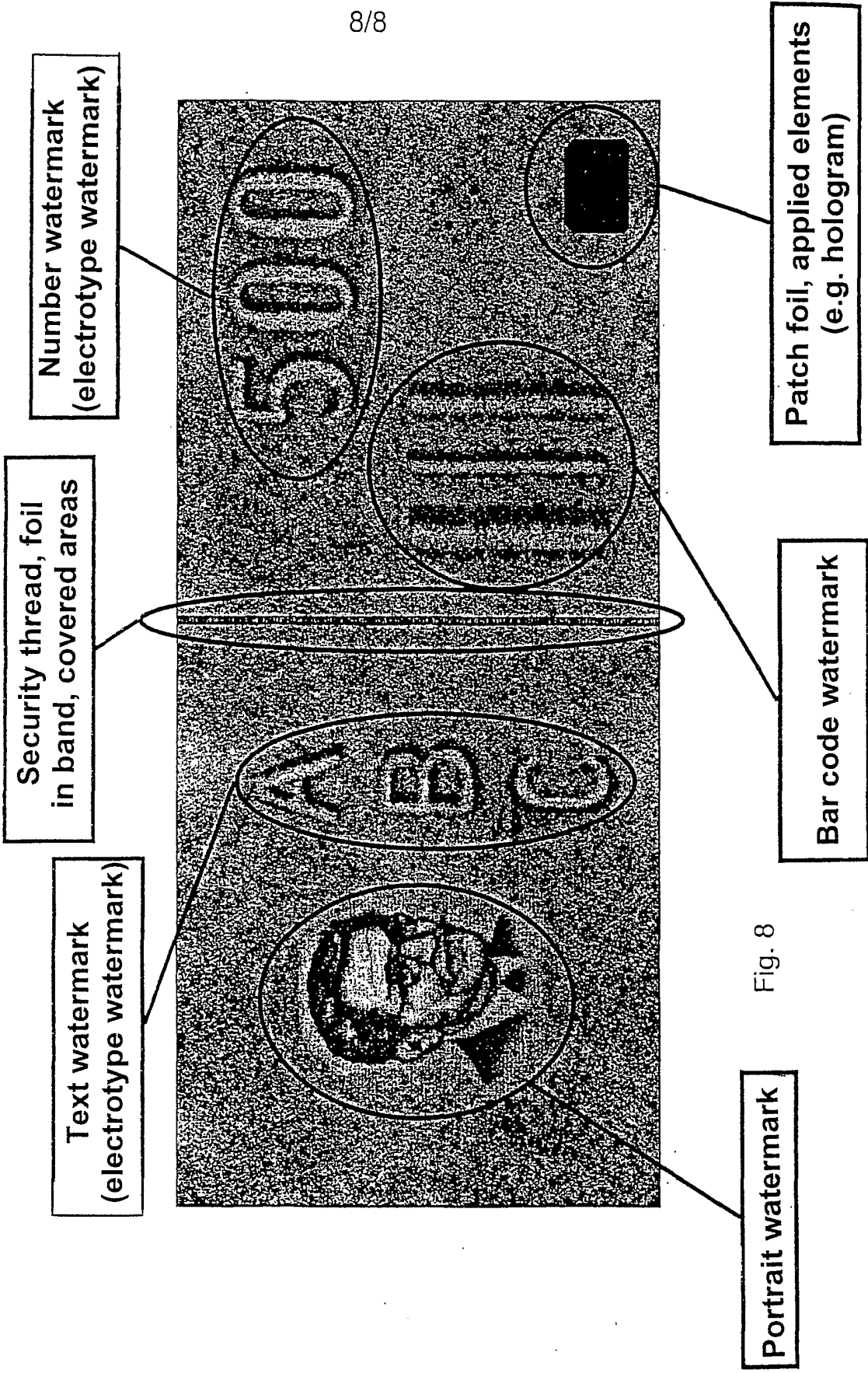
Fig. 3

16

Reference

22

Fig. 4
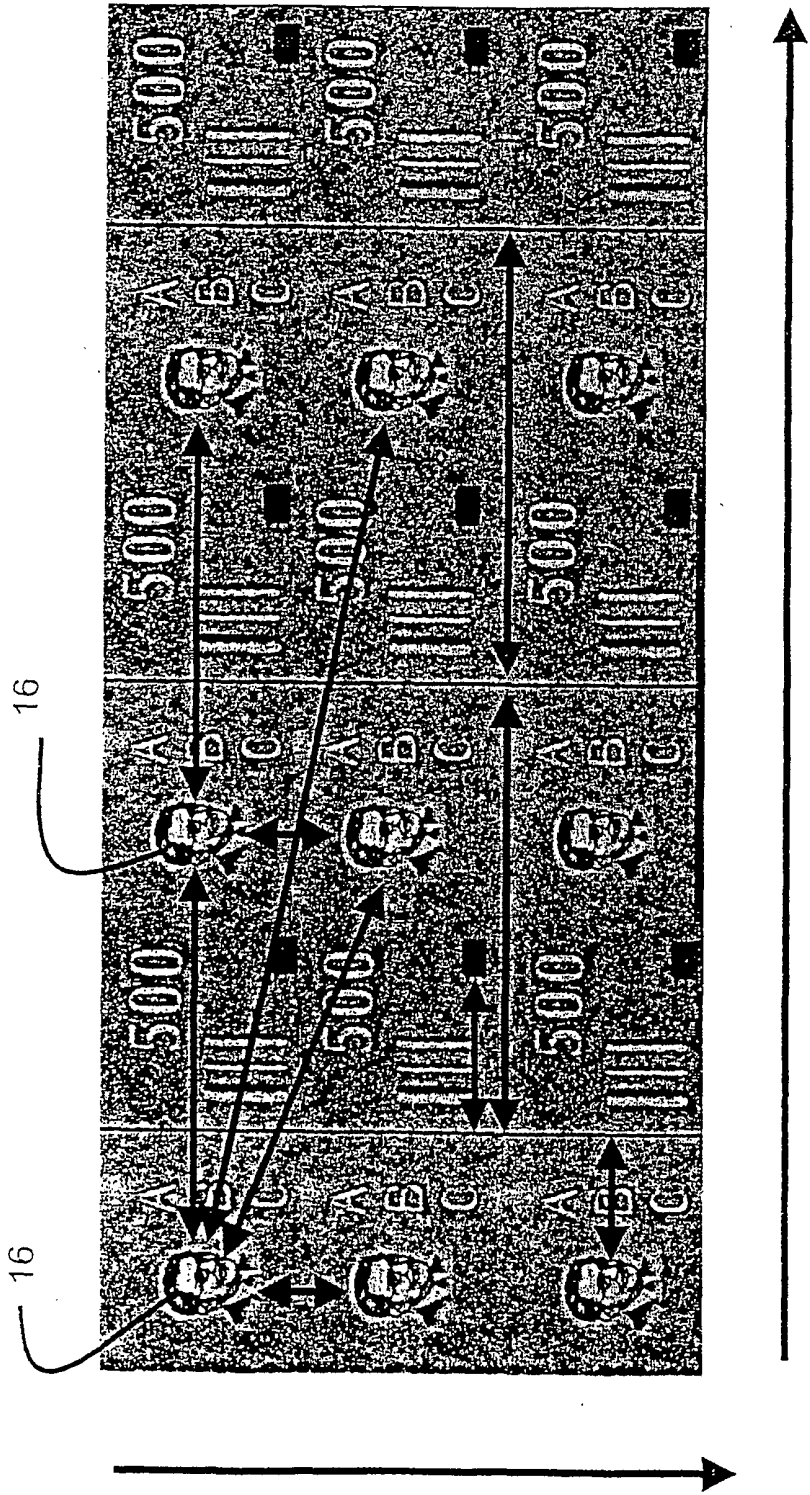
Fig. 5
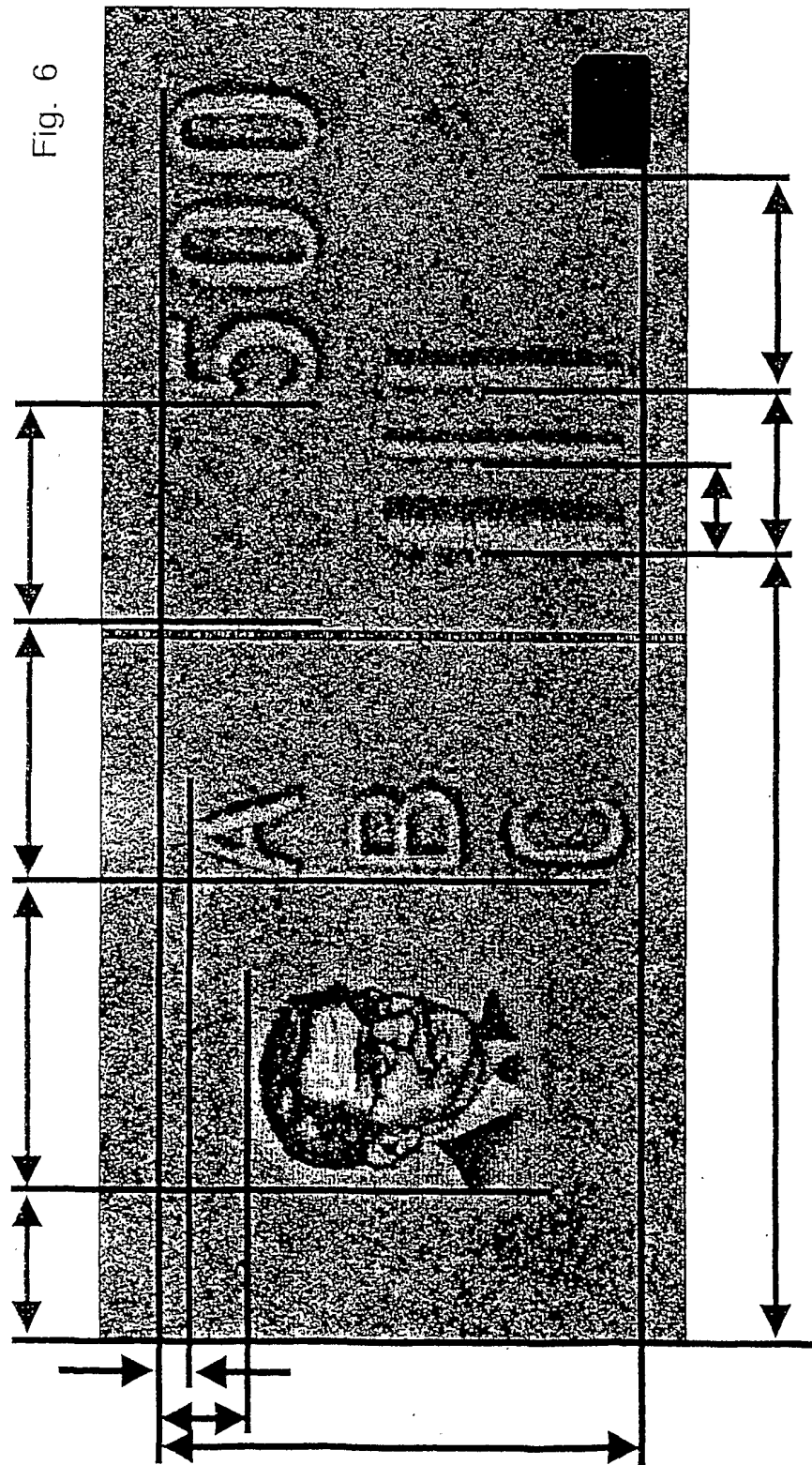
Fig. 6

Fig. 7

Number watermark
(electrotype watermark)

Patch foil, applied elements
(e.g. hologram)

Security thread, foil
in band, covered areas

Bar code watermark

Text watermark
(electrotype watermark)

Portrait watermark

Fig. 8

1

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G07D 7/00
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)

IPC7: G07D

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

SE,DK,FI,NO classes as above

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

EPO INTERNAL, WPI DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan, abstract of JP 11-351962 A (FUJI ELECTRIC CO LTD), 24 December 1999 (24.12.99), see abstract, figures	1,27
X		14-19,39-45
A		20-26,46-52
	--	
X	EP 0881603 A1 (SANYO ELECTRIC CO., LTD.), 2 December 1998 (02.12.98), page 6, figure 3	1,27
X		14-19,39-45
A		20-26,46-52
	--	

X	Further documents are listed in the continuation of Box C.	X	See patent family annex.

* 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

Date of the actual completion of the international search	Date of mailing of the international search report
3 Sept 2001	0 6 -09- 2001
Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM	Helene Eliasson / JA A
Facsimile No. +46 8 666 02 86	Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5915518 A (HOPWOOD ET AL), 29 June 1999 (29.06.99), column 2, line 61 - line 63; column 5 - column 7	1,27
X		14-19,39-45
A		20-26,46-52
	--	
X	US 5947255 A (SHIMADA ET AL), 7 Sept 1999 (07.09.99), claim 1	1,27
X		14-19,39-45
A		20-26,46-52
	--	
A	EP 0867842 A1 (G.D. SOCIETA' PER AZIONI), 30 Sept 1998 (30.09.98), see claims	1,14-27, 39-52
	--	
A	US 5729623 A (OMATU ET AL), 17 March 1998 (17.03.98), column 15, figure 11, abstract	1,14-27, 39-52
	--	
A	Patent Abstracts of Japan, abstract of JP 11-98344 A (MITSUBISHI ELECTRIC CORP), 9 April 1999 (09.04.99)	1,14-27, 39-52
	--	

Form PCT/ISA/210 (continuation of second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Intern(l application No.
PCT/ ᴐᴜ01/01077

Box I	Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **2-13 , 28-38**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

... / ...

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II	Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July1998)

Claims 2-13 and 28-38 do not comply with the requirements in Article 6. These claims are not clear and concise and do not define the matter for which protection is sought in such a way that a meaningful search can be carried out. Claims 2-13 are dependent claims, referring to claim 1, and include only such features that lack coherence when related to claim 1. Dependent claims 28-38 also lack coherence when related to calim 27.

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
EP	0881603	A1	02/12/98	US	6157895 A	05/12/00
				CN	1209895 A	03/03/99
				JP	2816129 B	27/10/98
				JP	9204522 A	05/08/97
				US	6253158 B	26/06/01
				WO	9727566 A	31/07/97
				JP	9204553 A	05/08/97
				JP	9245172 A	19/09/97
				JP	9245215 A	19/09/97
				JP	10069558 A	10/03/98
				JP	10069559 A	10/03/98
US	5915518	A	29/06/99	AU	1324895 A	01/08/95
				CA	2179994 A	13/07/95
				CN	1141682 A	29/01/97
				EP	0738408 A	23/10/96
				GB	2291705 A	31/01/96
				GB	9414084 D	00/00/00
				JP	9507326 T	22/07/97
				WO	9519019 A	13/07/95
				GB	9500022 D	00/00/00
				US	5660439 A	26/08/97
				US	5810440 A	22/09/98
				US	5918960 A	06/07/99
US	5947255	A	07/09/99	EP	0802510 A	22/10/97
				JP	9282517 A	31/10/97
EP	0867842	A1	30/09/98	IT	1292830 B	11/02/99
				IT	BO970185 A	28/09/98
				JP	11066381 A	09/03/99
US	5729623	A	17/03/98	DE	4437067 A	11/05/95
				JP	7220087 A	18/08/95
				JP	7121719 A	12/05/95