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(54) Security thread reader

(57) A document, such as a banknote, may be provided with a security thread having one or more regions of magnetic material and one or more optically visible markings. A security thread reader is provided for detecting the presence of the security thread and the optically visible markings. The security thread reader comprises a magnetic field detector for determining the presence and location of the security thread, a controller for setting a specified target area of the document to include an area of the document in which the security thread is present, an optical scanner for generating an image of the specified target area, and an image processor for identifying the optically visible markings within the scanned image corresponding to the security thread. In this way a document or banknote can be identified and authenticated automatically.

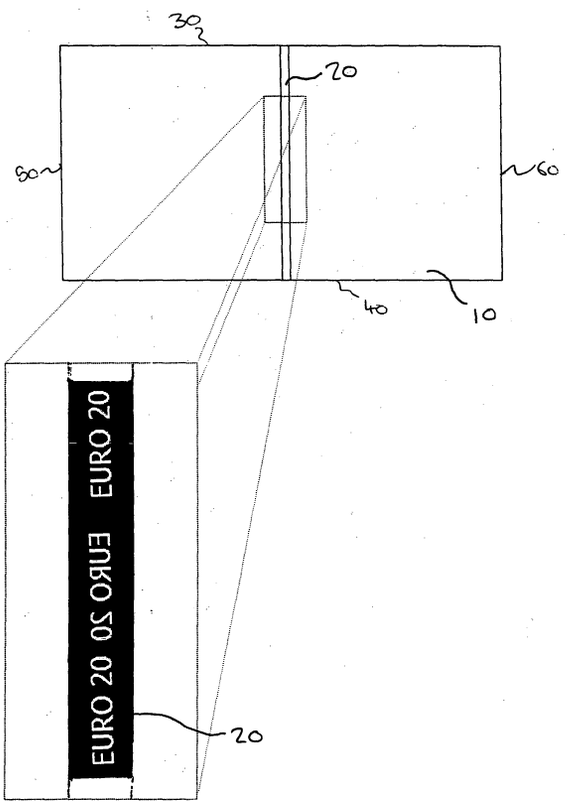

Fig. 1

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Description

[0001] The present invention relates to a security thread reader and a method of detecting a security thread within a document. More particularly, this invention relates to a security thread reader and a method for detecting the presence of a security thread in a document in which the security thread has one or more regions of magnetic material and one or more optically visible markings.

[0002] Counterfeiting of documents, most notably of currency, is a problem experienced throughout the world. Governments worldwide have invested heavily in the development of increasingly advanced methods of protecting their national currencies, and numerous protection mechanisms applicable equally to currency and other types of documents have resulted from these developments. For example, the Euro banknote includes several security features, which taken in combination form a significant impediment to a counterfeiter in producing an identical copy of an authentic banknote. For instance, the Euro banknotes are printed on a pure cotton paper, giving them a unique feel when handled. Some areas on the face of the banknotes are printed in relief so that they can be identified by touch. Other security features are discernible by sight, in some cases by viewing light transmitted through the banknote, and in other cases specifically when the banknote is viewed at a particular orientation to a light source. In particular, the Euro banknote provides a watermark, the watermark more particularly including a picture and characters indicative of the value of the banknote, which is visible when the banknote is held between the viewer and a light source. The Euro banknote also includes a security thread, which is visible, again visible when the banknote is held between the viewer and a light source, as a dark line running between opposite edges of the banknote. Certain denominations of Euro currency also provide a foil hologram patch which shows a particular motif and the value of the banknote when the banknote is tilted, and a colour-shifting ink which causes the value numerals printed on the banknote to change colour when the banknote is tilted.

[0003] Security threads may be incorporated into a paper substrate of the banknotes during the manufacturing process. For instance, in the Euro banknotes a security thread is manufactured by forming a metal layer of aluminium on a polyester substrate, and then stripping off or by demetallising some parts of the aluminium to form recessed characters or negative transparent scripts. These scripts are readable by visually inspecting the banknotes when held in front of a backlight. An alternative format of security thread may be provided using an insulator-metal transition (IMT) process by which a combination of magnetic and metallic materials can be deposited on a discontinuous basis.

[0004] A challenge arises in providing automated systems which are able to detect and verify these sophisticated security features. Measures which improve security are highly advantageous.

[0005] One aspect of the invention provides a security thread reader for detecting the presence of a security thread in a document, the security thread having one or more regions of magnetic material and one or more optically visible markings, the security thread reader comprising:

a magnetic field detector operable to detect the magnetic material within the security thread and to determine, based on this detection, one or more areas within the document at which the security thread is present;

a controller operable to set a specified target area of the document to include at least a portion of the one or more areas within the document at which it has been determined that the security thread is present;

an optical scanner operable to generate an image of the specified target area; and

an image processor operable to process an area of the scanned image corresponding to the specified target area of the document to identify the optically visible markings within the security thread.

[0006] In a document, the security thread itself may be relatively narrow compared to the dimensions of the document itself. Accordingly, the markings or script provided on the security thread may also be relatively small, which in turn requires the optical resolution of an optical reader arranged to discern the markings or script present on the security thread to be relatively high. The invention recognises that a high resolution image generated for the entire document, which will generally be required where optical techniques are being used to detect the presence of a security thread within a banknote, may comprise a disadvantageously large quantity of data. The need to handle this large quantity of image data would be likely to result in higher data storage and image processing demands and/or slower operation. For instance, a larger image data buffer may be required to store the image data while image processing takes place, and the image processor may require increased processing power to perform the necessary image processing on the large volume of data.

[0007] Additionally, the invention further recognises that there may be other markings present on the non security thread portions of the document which may confuse the image processor, resulting in inaccurate or spurious results. Accordingly, it is desirable to constrain the operation of the processor to the area of the security thread to improve reliability.

[0008] The reduction in size of the area to be scanned also enables the use of smaller, lighter, simpler and potentially cheaper scan heads of the optical scanner.

[0009] Although the type of document to which the present invention is applicable may be any document

having a security thread, the present invention is particularly advantageous when applied to banknotes having a security thread. For instance, the methods described herein could be applied to currency counting machines, vending machines, ticket machines or paying-in cash-points.

[0010] While it may be possible to provide a magnetic field detector capable of magnetically scanning a document for a magnetic thread in which the magnetic field detector remains static relative to the document, preferably either or both of the magnetic field detector and the document are moved relative to the other during the magnetic scanning operation. This enables one or more smaller, lighter, simpler and potentially cheaper sensors to be provided and positioned close to the document enabling weaker magnetic activity to be observed.

[0011] Similarly, while it may be possible to provide an optical scanner capable of optically scanning a document in which the optical scanner remains static relative to the document, such as a large scale Charge Couple Device (CCD) arrangement, preferably either or both of the optical scanner and the document are moved relative to the other during the optical scanning operation. This enables a smaller optical scanner to be located closer to the document to provide a high resolution image of a designated portion of the document.

[0012] To alleviate problems of stringing, an anti-stringing mechanism can be provided in which if the relative motion between either of the magnetic field detector or the optical scanner and the document is reversed then a transaction associated with the document is cancelled. The reversal in relative motion may cause, and be detected as a result of, a second detection of the security thread by the magnetic field detector. Alternatively, because the reversal in relative motion will cause an inversion of the scanned image of the optically visible markings if the optical scanning process in operation at the time when the document is being retracted, the image processor can detect the reversal of relative motion by detecting the inversion of the optically visible markings. Whichever method is used to detect the reversal of relative motion, a user will be unable to retract a document from the security thread reader without invalidating the transaction.

[0013] In assessing the presence, position and authenticity of a document, quantities such as the length, thickness and magnetic strength of the security thread can be measured by the magnetic field detector. For instance, a magnetic thickness value indicative of the cross sectional dimensional characteristics of the security thread can be ascertained, the magnetic thickness value being determined as a function of the signal amplitude of the magnetic field detector. While it can be appreciated that various types of magnetic field detector may be suitable for use with the present invention, preferably the magnetic field detector comprises one or more Hall-effect sensors. Hall-effect sensors are particularly suitable due to their small size, low cost and high sensitivity.

[0014] The one or more regions of magnetic material may include one or more of several different types of magnetic material, including ferromagnetic material.

[0015] Security threads in banknotes or other documents may not be visible using light reflected from the document if the security thread is embedded below the surface of the document. The security threads in such documents can only be viewed when the document is held in front of a light source such as a backlight. Accordingly, for such documents the optical scanner should include a light emitting element for emitting light and a light receiving element for receiving light, the light emitted from the light emitting element being transmitted through the document before being received by the light receiving element. To obtain a very high resolution image and to accordingly improve the likelihood of the image processor correctly identifying the optically visible markings within the security thread, the light emitting element should preferably provide substantially coherent light, for instance laser light. Whilst this laser light feature is preferred, it is not essential.

[0016] A number of image processing operations may be suitable for identifying the optically visible markings. For instance the image processor may comprise an optical character recognition (OCR) function for this purpose. Alternatively, the image processor may comprise a pattern matching function.

[0017] Another aspect of the invention provides a method of detecting the presence of a security thread in a document, the security thread having one or more regions of magnetic material and one or more optically visible markings, the method comprising the steps of:

detecting the magnetic material within the security thread;
determining, based on the result of the detection step, one or more areas within the document at which the security thread is present;
setting a specified target area of the document to include at least a portion of the one or more areas within the document at which it has been determined that the security thread is present;
generating an image of the specified target area; and
processing an area of the scanned image corresponding to the specified target area of the document to identify the optically visible markings within the security thread.

[0018] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 schematically illustrates an example banknote comprising a security thread;
Figure 2 is a schematic block diagram of a security thread reader according to an embodiment of the

present invention;

Figure 3 schematically illustrates the operation of a magnetic field detector and an expected output of the magnetic field detector in accordance with an embodiment of the invention;

Figures 4A and 4B are schematic flow diagrams illustrating the operation of a security thread reader according to an embodiment of the present invention;

Figure 5 is a schematic flow diagram illustrating the operation of a security thread reader according to an embodiment of the invention in which an anti-stringing mechanism is provided.

[0019] Referring to Figure 1, a banknote suitable for use with an embodiment of the present invention is illustrated. The banknote 10 is provided with a security thread 20 which crosses from an edge 30 of the banknote 10 to an opposite edge 40 of the banknote 10. In the present case, as is the case with existing currency, the security thread 20 crosses the shortest dimension of the banknote 10, although the embodiments of the invention described hereinafter may be adapted to operate on banknotes having an alternative security thread position, such as a thread running from an edge 50 to an edge 60. The security thread 20 may be fixed to a surface of the banknote 10, or more preferably may be either wholly or partially embedded within the banknote 10. The security thread 20 may be constructed in a number of ways and consist of a number of different materials, including at least some magnetic material. The magnetic material may exhibit any type of magnetism that either generates a sufficiently strong magnetic field to be detected (either without an external influence, or with an external influence such as an electric field or another magnetic field) or which perturbs an external magnetic field sufficiently for the perturbation of the external magnetic field to be detected.

[0020] Figure 1 further illustrates an expanded view of the security thread 20. The example security thread 20 shown is exemplary of that which is visible on a 20 Euro note. It can be seen that the security thread 20 is provided with the markings "EURO 20". A left-to-right mirror image of this marking is also provided such that the marking "EURO 20" can be recognised when the banknote 10 is held up in front of a light source irrespective of the face of the banknote 10 being viewed. The security thread 20 illustrated is relatively difficult to counterfeit at least partly due to the level of detail provided in the markings on the security thread 20.

[0021] The functional arrangement of a security thread reader 100 according to an embodiment of the present invention is schematically illustrated in the block diagram of Figure 2. The security thread reader 100 comprises a magnetic field detector 110 and an optical scanner 140. The magnetic field detector 110 performs the function of locating the security thread 20 within a banknote 10. The magnetic field detector 110 will produce a characteristic analog output signal in the presence of the magnetic material present within the security thread 20. An analog-to-digital converter 120 is provided to convert the analog output signal generated by the magnetic field detector 110 into a corresponding digital signal. This corresponding digital signal will be passed to a processor 170 via an input/output device 130. The processor 170 includes decision logic 180, which may be either hardware or software based and which uses the digitised output signal from the magnetic field detector to determine whether a security thread is present within the banknote 10, and if it is so present then to determine its location on the banknote 10. The decision logic 180 will use this determined position to control optical scanning and image processing functions of the security thread reader 100. The decision logic 180 may comprise a database of characteristic signals which can be compared to the detected magnetic signals to determine whether the detected magnetic signal meets matches one or more stored magnetic signals. The result of this comparison can be used to assist in determining the presence of the security thread 20 and potentially to determine the nature, for instance type or denomination, of the banknote 10.

[0022] The optical scanner 140 performs the function of optically scanning the banknote 10, and in particular the security thread 20 within the banknote 10, to generate a digital image. If the optical scanner provided were to provide an analog rather than a digital output, an analog-to-digital converter would be provided to digitise the analog output. The digital output data is then passed to an image buffer 160 via an input/output device 150. The image buffer 160 will store image data corresponding to at least a portion of the banknote 10. The image data within the image buffer 160 is available to the processor 170. In order to detect optically visible markings which include character data, such as text, the processor 170 also includes an optical character recognition (OCR) module 190 which can identify the presence of the character data within the image data stored in the image buffer 160. In an alternative embodiment which may be more suitable where abstract or picture based markings are provided on the magnetic strip rather than character-based markings, a pattern recognition module may be provided instead of the OCR module to determine the presence of predetermined markings within the image data stored in the image buffer 160. In either case the markings can be compared against a database of markings and/or criteria in order to identify the authenticity and characteristics such as the type or denomination of the banknote 10.

[0023] The optical scanner 140 may be a single head or multi-head scanner and may for instance comprise a CMOS array, and may user either non-coherent or coherent light, such as laser light. The use of laser light in an optical scanner is particularly advantageous where a high-resolution image is required.

[0024] The processor 170 acts as a controller to con-

trol the operation of the optical scanner 140 and the image processing functions of the processor 170. Specifically, the processor 170 will ensure that an image area to be processed includes the security thread 20. Preferably, areas of the banknote 10 remote from the security thread 20 will not be processed, resulting in a reduction in the data handling requirements of the security thread reader 100. Four main arrangements of the security thread reader 100 are envisaged, although alternative arrangements are also envisaged.

A) The magnetic field detector 110 initially locates the position of the security thread 20, and the optical scanner 140 subsequently scans only the portion of the document identified by the magnetic field detector 110 as having the security thread 20 embedded therein.

B) The magnetic field detector 110 passes across the banknote 10 with the optical scanner 140 following behind it at a predetermined distance. When the magnetic field detector 110 locates the security thread 20, the optical scanner commences scanning a predetermined time later, when the optical scanner 140 has reached the position at which the security thread 20 has been located.

C) The optical scanner 140 scans the banknote 10 and the image buffer 160 buffers the most recently acquired data. The magnetic field detector 110 follows behind the optical scanner 140 at a predetermined distance. When the magnetic field detector 110 locates the security thread 20, the optical scanner 140 ceases scanning the banknote 10 and a portion of the image buffer 160 corresponding to the detected position of the security thread is processed by the processor 170.

D) The optical scanner 140 scans the entire banknote 10 (either independently from or in synchronisation with the magnetic field detector), but the processor 170 only processes image data designated by the decision logic 180 as corresponding to the position of the security thread 20.

[0025] Figure 3 schematically illustrates the relative motion of a magnetic field detector 210 across the banknote 10 of Figure 1. As with Figure 1, the four edges of the banknote 10 are labelled as edges 30, 40, 50 and 60. In the present embodiment the magnetic field detector 210 passes across the face of the banknote 10 from the edge 50 towards the edge 60 in the direction of the arrows. Clearly it would be equally valid for the magnetic field detector 210 to pass across the banknote 10 from the edge 60 to the edge 50. It will be appreciated that the motion of the magnetic field detected 210 is relative motion with respect to the banknote 10. Embodiments in which the banknote 10 is stationary and the magnetic field detector 210 is in motion and alternative embodiments in which the magnetic field detector 210 is stationary and the banknote 10 is in motion are equally valid, and each have their own advantages depending on the particular application to which the apparatus is being applied. Additionally, other embodiments in which both the banknote 10 and the magnetic field detector 210 move can also be envisaged.

[0026] Although it will be appreciated that the magnetic field detector 210 could consist of only a single magnetic field detecting element, in the present embodiment an array of magnetic field detecting elements 210a, 210b, 210c and 210d make up the magnetic field detector 210. By providing an array of magnetic field detecting elements, a larger portion of the banknote 10 can be investigated without providing a single element with a longer and more complex scan path across the surface of the banknote 10. The magnetic field detecting elements 210a, 210b, 210c and 210d may be either independent from each other, or could be connected in series or parallel. The magnetic field detecting elements 210a, 210b, 210c and 210d may be used, in addition to detecting the presence of the security thread, to determine the length of the security thread, this length being compared with a database to identify the type and denomination of the banknote 10.

[0027] The particular method used to detect the presence of the magnetic material within the security thread 20 will depend at least in part on the nature of the magnetic material. For strongly magnetic materials, the magnetic field generated by the magnetic material may be observed directly using a magnetic sensor. For a less strongly magnetic material it may be necessary or advantageous to induce the magnetic material to generate a magnetic field, for instance by the application of an electric field or an external magnetic field to the security thread 20. Alternatively, the magnetic field detector could also be provided with a magnetic field generator, with the generated magnetic field being continuously monitored for perturbations. In this way, the presence or movement of the magnetic material within the generated magnetic field would perturb the generated magnetic field in a characteristic way which would be recognised by the magnetic field detector. In the Figure 3 embodiment, the security thread 20 comprises magnetic material which provides a strong enough magnetic field for direct sensing of the magnetic field to be possible.

[0028] A number of different kinds of magnetic field based sensors exist which could be applied to the present invention. For instance, the presence of magnetic material in a security thread could be detected using resonant inductive circuits or capacitative circuits similar to those used in the reading heads of a tape recorder.

[0029] Preferably, the magnetic material within the security thread 20 is detected using one or more Hall effect sensors. Hall effect sensors comprise one or more semiconductor platelets in which an electric current is passed through from one edge to an opposite edge. A Hall voltage is generated across the plate in a direction transverse to the current flow when an external magnet-

ic field acts perpendicularly to the direction of the current through the semiconductor platelet. The Hall voltage generated is dependent on the magnetic flux density perpendicular to the plane of the Hall plate. The Hall plate and associated evaluation circuitry can be integrated onto a single silicon chip, for instance using CMOS technology to form a robust and compact sensor unit.

[0030] Referring to Figure 3, the magnetic field detector 210 comprises four magnetic field detecting elements 210a, 210b, 210c and 210d arranged during a magnetic scan operation in a line across the width of the banknote 10 from the edge 30 to the edge 40. Each of the magnetic field detecting elements 210a, 210b, 210c and 210d comprises a hall effect sensor as described above. As the magnetic field detecting elements 210a, 210b, 210c and 210d traverse the banknote 10 from the edge 50 to the edge 60, the Hall voltage output V_{HALL} from each of the elements 210a, 210b, 210c and 210d is monitored. In the absence of a magnetic field, the magnetic field detecting elements 210a, 210b, 210c and 210d will generate a small residual voltage V_0 known as an offset voltage which is due to influences such as the structural properties and the temperature of the material. The decision logic 180 described above with reference to Figure 2 is configured to consider the security thread 20 to be present only if the Hall voltage V_{HALL} exceeds a predetermined threshold voltage V_{THRESH}. The decision voltage may also require the Hall voltage V_{HALL} to exceed the threshold voltage V_{THRESH} for at least a predetermined minimum distance of the banknote 10 to reduce the likelihood of false detection of the security thread 20 as a result of background electrical or magnetic fluctuations. The lower portion of Figure 3 graphically illustrates the V_{HALL} output signal as a function of the position of one of the magnetic field detecting elements 210a with respect to the banknote 10. The V_{HALL} output signal may differ from one element to another element as a result of, for example a discontinuity in the security thread 20 or demagnetisation of part of the magnetic material within the security thread 20.

[0031] It can be seen from Figure 3 that when the magnetic field detecting element 210a moves close to the security thread 20, an increase in magnetic activity associated with the presence of the security thread 20 results in an increase in the Hall output voltage V_{HALL} of the magnetic field detecting element 210a. The Hall output voltage V_{HALL} will reach a maximum value when the magnetic field detecting element 210a is at its closest to the security thread 20, and will then fall back to its original level as the element moves away from the security thread 20. Therefore, if a security thread 20 is present in the banknote 10, the Hall output voltage V_{HALL} should exceed the threshold voltage V_{THRESH} while the magnetic field detecting element 210a is proximate the security thread 20.

[0032] The steps involved in the operation of the security reader 100 in an example embodiment of the invention will now be described with reference to Figures 4A and 4B. Referring to Figure 4A, at a step S1 the security thread reader 100 is initialised by specifying in advance a threshold voltage V_{THRESH} and a minimum time period τ for which the Hall voltage V_{HALL} must exceed the threshold voltage V_{THRESH} for the security thread 20 to be considered as present within the banknote 10. The Current Position, CP along the scanning track of the magnetic field detecting elements 210a, 210b, 210c and 210d and a counter, t are both initialised to zero.

[0033] At a step S2, magnetic scanning of the banknote 10 commences and relative motion between the magnetic field detecting elements 210a, 210b, 210c and 210d begins, with the Current Position, CP of the magnetic field detecting elements 210a, 210b, 210c and 210d being incremented in accordance with the relative motion.

[0034] At a step S3, the measured Hall voltage V_{HALL} of the magnetic field detecting elements 210a, 210b, 210c and 210d is compared to the threshold voltage V_{THRESH}. If the Hall voltage V_{HALL} is below the threshold voltage V_{THRESH} then the scanning step S2 continues and no further action is taken. If the Hall voltage V_{HALL} is above the threshold voltage V_{THRESH} then it is considered that the security thread 20 may have been encountered and the process moves on to a step S4.

[0035] At the step S4 a counter is started and a counter value, t begins incrementing. Also at the step S4, a variable STStart, corresponding to a possible start position of the security thread 20, is set to the current position CP of the magnetic field detecting elements 210a, 210b, 210c and 210d.

[0036] At a step S5 the magnetic scan process continues and at a step S6 the Hall voltage V_{HALL} is again compared to the threshold voltage V_{THRESH}. At the step S6, if the Hall voltage V_{HALL} is above the threshold voltage V_{THRESH} then the magnetic scan process continues and no further action is taken. If the Hall voltage V_{HALL} is below the threshold voltage V_{THRESH} then the process moves on to a step S7.

[0037] At the step S7 the counter which was started at the step S4 is stopped and the counter value, t is thus frozen. Also at the step S7, a variable STEnd, corresponding to a possible end position of the security thread 20, is set to the current position CP of the magnetic field detecting elements 210a, 210b, 210c and 210d.

[0038] At a step S8, the frozen value of the counter value t is compared to the minimum time period τ which was set earlier in the step S 1. If the counter value t is less than the minimum time period τ then it is considered that the magnetic thread has not been detected and the process moves on to a step S9, where the counter value t is reset to zero. Following the step S9, the process returns back to the step S2 where the security thread reader continues to magnetically scan the banknote 10 for the security thread 20. However, if at the step S8 it is determined that the counter value t is greater than or

equal to the minimum time period τ then it is considered that the security thread 20 has been detected and that its location within the banknote 10 is now known. The process then moves on to a step S10, which is illustrated in Figure 4B.

[0039] Although in the present embodiment a time counter is used, it will be appreciated that because the time is simply a function of the distance moved by the magnetic field detecting elements 210a, 210b, 210c and 210d across the banknote 10, and because the relative motion is being tracked to identify the current position of elements 210a, 210b, 210c and 210d and thus the position of the security thread, this information could be used instead of the time counter.

[0040] At the step S10, an optical scan area is designated. In this embodiment, the optical scan area is set as a strip of the banknote 10 bounded by the edges 30 and 40 of the banknote and by the positions STStart and STEnd designated by the magnetic thread detection process in steps S1 to S9. This optical scan area should correspond to the position of the security thread 20 within the banknote 10.

[0041] At a step S11, the area designated in the step S10 is optically scanned to generate image data corresponding to the security thread 20 of the banknote 10. The image data generated is stored to an image buffer in a step S12.

[0042] At a step S 13, the buffered image data is processed using a technique such as optical character recognition (OCR) or pattern matching to identify the markings present on the security thread 20.

[0043] The method described above with reference to Figures 4A and 4B can be applied to a banknote reader such as a vending machine or ticket machine. With banknote readers within this field of technology it is highly desirable to provide anti-stringing safeguards. "Stringing" is the term applied to the practice of withdrawing a banknote from a banknote reader after validation of the transaction has taken place but before the banknote has been fully and irretrievably stored into the machine. This results in the user both retaining the banknote and also obtaining the result of the transaction. Methods of anti-stringing include attaching string or an adhesive tape to the banknote prior to its insertion into the banknote reader and then pulling back on the string or tape between the time of validation of the transaction and the storage of the banknote.

[0044] Figure 5 schematically illustrates an embodiment of the invention in which an anti-stringing mechanism is provided. In this embodiment of the invention, the steps S1 to S13 as described above with reference to Figures 4A and 4B are carried out to obtain an identification of the markings present on a security thread 20 within a banknote 10. In a step S14 this identification is used to determine the authenticity (and denomination) of the banknote 10. If the banknote 10 is determined not to be authentic, then the process moves on to step S 15 where the transaction is terminated. At this time the banknote 10 could either be returned to the user or confiscated. Additionally the banknote reader comprising the security thread reader could conduct a predetermined course of action such as alerting the proprietor of the banknote reader that a potentially counterfeit banknote has been detected.

[0045] If the banknote 10 is determined to be authentic then the process moves on substantially simultaneously to steps S16, S17 and S18. At the step S16 the transaction is validated. At the step S 17 the banknote reader initiates storage of the banknote 10. At the step S 18 the magnetic field detecting elements 210a, 210b, 210c and 210d measure the magnetic flux from a portion of the banknote 10 at which they are currently located. Specifically, the magnetic field detecting elements 210a, 210b, 210c and 210d will be positioned such that the security thread 20 would need to pass by them in the event that the banknote were to be retracted from the banknote reader. Note that the magnetic scanning in the step S18 does not include system driven relative motion between the banknote and the magnetic field detecting elements 210a, 210b, 210c and 210d as was the case with steps S2 and S5 in Figure 4A. Relative motion between the banknote 10 and the magnetic field detecting elements 210a, 210b, 210c and 210d in step S 18 will result only from a user retracting the banknote or from the banknote finally being stored into the banknote reader. In the latter case the security thread will not pass by the magnetic field detecting elements 210a, 210b, 210c and 210d because it will be travelling into rather than out of the banknote reader.

[0046] At a step S19 the measured Hall voltage V_{HALL} of the magnetic field detecting elements 210a, 210b, 210c and 210d is compared to the threshold voltage V_{THRESH}. If the Hall voltage V_{HALL} is below the threshold voltage V_{THRESH} then the scanning step S 19 continues and no further action is taken. If the Hall voltage V_{HALL} is above the threshold voltage V_{THRESH} then it is considered that the security thread 20 may have been encountered and the process moves on to a step S20. At the step S20 the magnetic scan process continues and at a step S21 the Hall voltage V_{HALL} is again compared to the threshold voltage V_{THRESH}. At the step S21, if the Hall voltage V_{HALL} is above the threshold voltage V_{THRESH} then the magnetic scan process continues and no further action is taken. If the Hall voltage V_{HALL} is below the threshold voltage V_{THRESH} then it is considered that the security thread has been encountered and that stringing is therefore taking place. In this event the process will move on to the step S15 and the transaction will be terminated.

[0047] The steps S18 to S21 will continue until either the security thread 20 is detected and the transaction therefore invalidated or until the banknote has been finally stored after the step S 17. As such, it is not possible to retract the banknote without termination of the transaction occurring. In this way, the stringing problem identified above is addressed.

[0048] Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims.

Claims

1. A security thread reader for detecting the presence of a security thread in a document, the security thread having one or more regions of magnetic material and one or more optically visible markings, the security thread reader comprising:

   a magnetic field detector operable to detect the magnetic material within the security thread and to determine, based on this detection, one or more areas within the document at which the security thread is present;
   a controller operable to set a specified target area of the document to include at least a portion of the one or more areas within the document at which it has been determined that the security thread is present;
   an optical scanner operable to generate an image of the specified target area; and
   an image processor operable to process an area of the scanned image corresponding to the specified target area of the document to identify the optically visible markings within the security thread.

2. A security thread reader according to claim 1, wherein the document is a banknote.

3. A security thread reader according to claim 1 or claim 2, wherein either or both of the magnetic field detector and the document are moved relative to the other.

4. A security thread reader according to any preceding claim, wherein either or both of the optical scanner and the document are moved relative to the other.

5. A security thread reader according to claim 3 or claim 4, wherein if the relative motion between either of the magnetic field detector or the optical scanner and the document is reversed then a transaction associated with the document is cancelled.

6. A security thread reader according to claim 5, wherein the reversal in relative motion results in, and is detected as a result of, a second detection of the security thread by the magnetic field detector.

7. A security thread reader according to claim 5, wherein reversal in relative motion results in an inversion of the scanned image of the optically visible markings, the image processor detecting the reversal of relative motion by detecting the inversion of the optically visible markings.

8. A security thread reader according to any preceding claim, wherein the magnetic field detector determines the length of the security thread.

9. A security thread reader according to any preceding claim, wherein the magnetic field detector determines a magnetic thickness value indicative of the dimensional characteristics of the security thread, the magnetic thickness value being determined as a function of the signal amplitude of the magnetic field detector.

10. A security thread reader according to any preceding claim, wherein the magnetic field detector comprises one or more Hall-effect sensors.

11. A security thread reader according to any preceding claim, wherein the one or more regions of magnetic material comprise a ferromagnetic material.

12. A security thread reader according to any preceding claim, wherein the optical scanner includes a light emitting element for emitting light and a light receiving element for receiving light, the light emitted from the light emitting element being transmitted through the document before being received by the light receiving element.

13. A security thread reader according to claim 12, wherein the light emitted from the light emitting element is substantially coherent.

14. A security thread reader according to any preceding claim, wherein the image processor comprises an optical character recognition (OCR) function for identifying the optically visible markings.

15. A method of detecting the presence of a security thread in a document, the security thread having one or more regions of magnetic material and one or more optically visible markings, the method comprising the steps of:

   detecting the magnetic material within the security thread;
   determining, based on the result of the detection step, one or more areas within the document at which the security thread is present;
   setting a specified target area of the document to include at least a portion of the one or more areas within the document at which it has been

determined that the security thread is present;
generating an image of the specified target area; and
processing an area of the scanned image corresponding to the specified target area of the document to identify the optically visible markings within the security thread.

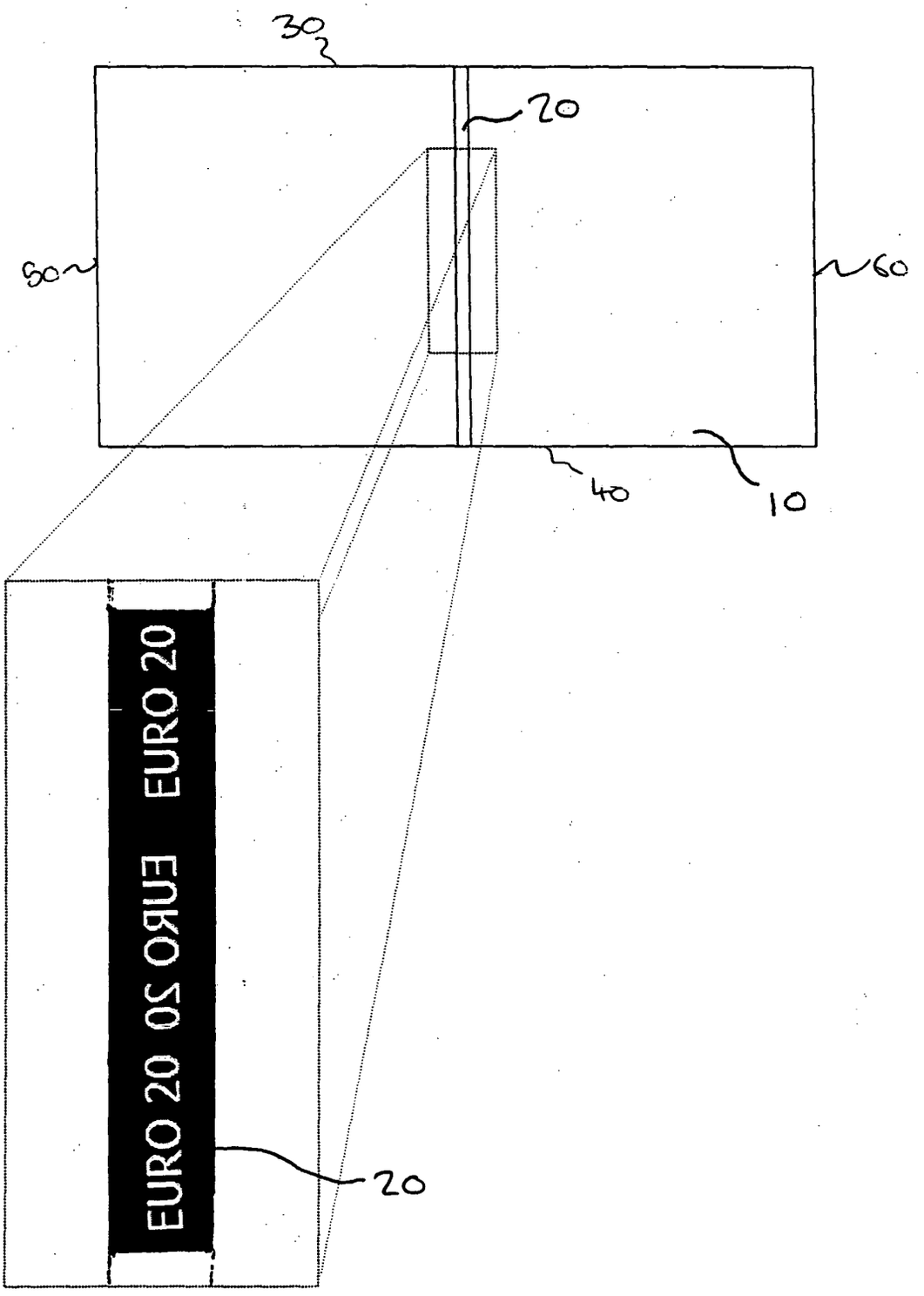

Fig. 1

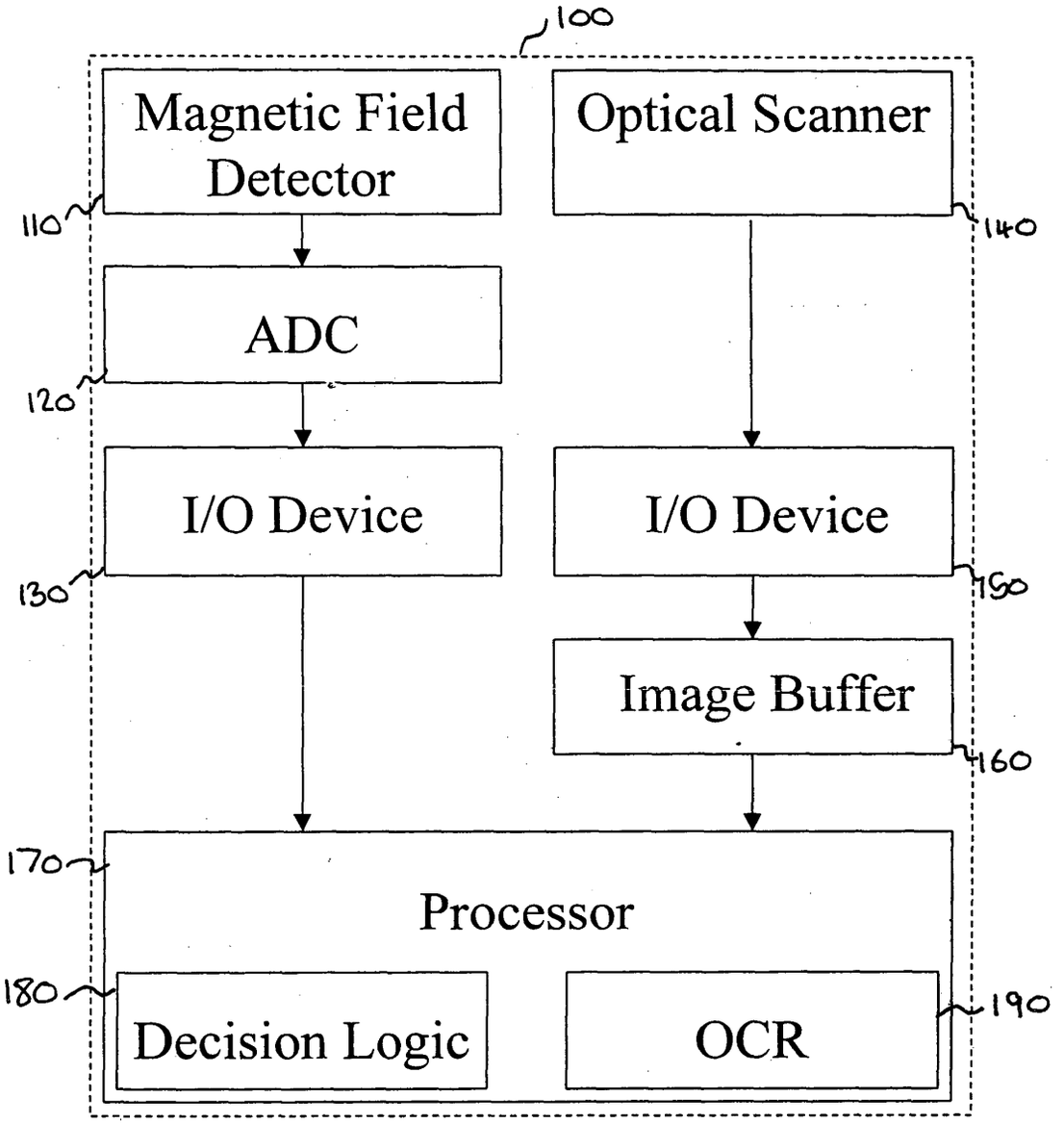
100
Magnetic Field Detector
110
Optical Scanner
140
ADC
120
I/O Device
130
I/O Device
150
Image Buffer
160
170
Processor
180
Decision Logic
OCR
190

Fig. 2

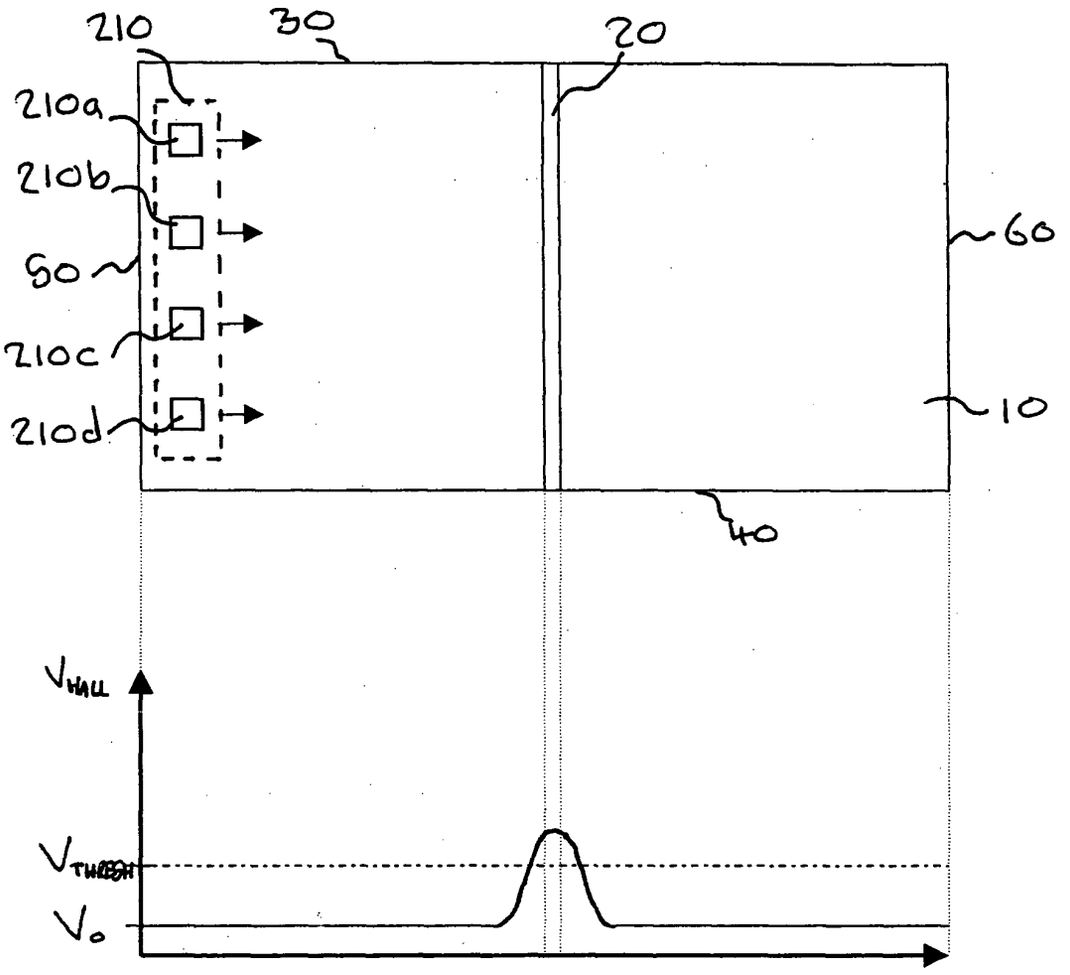

Fig. 3

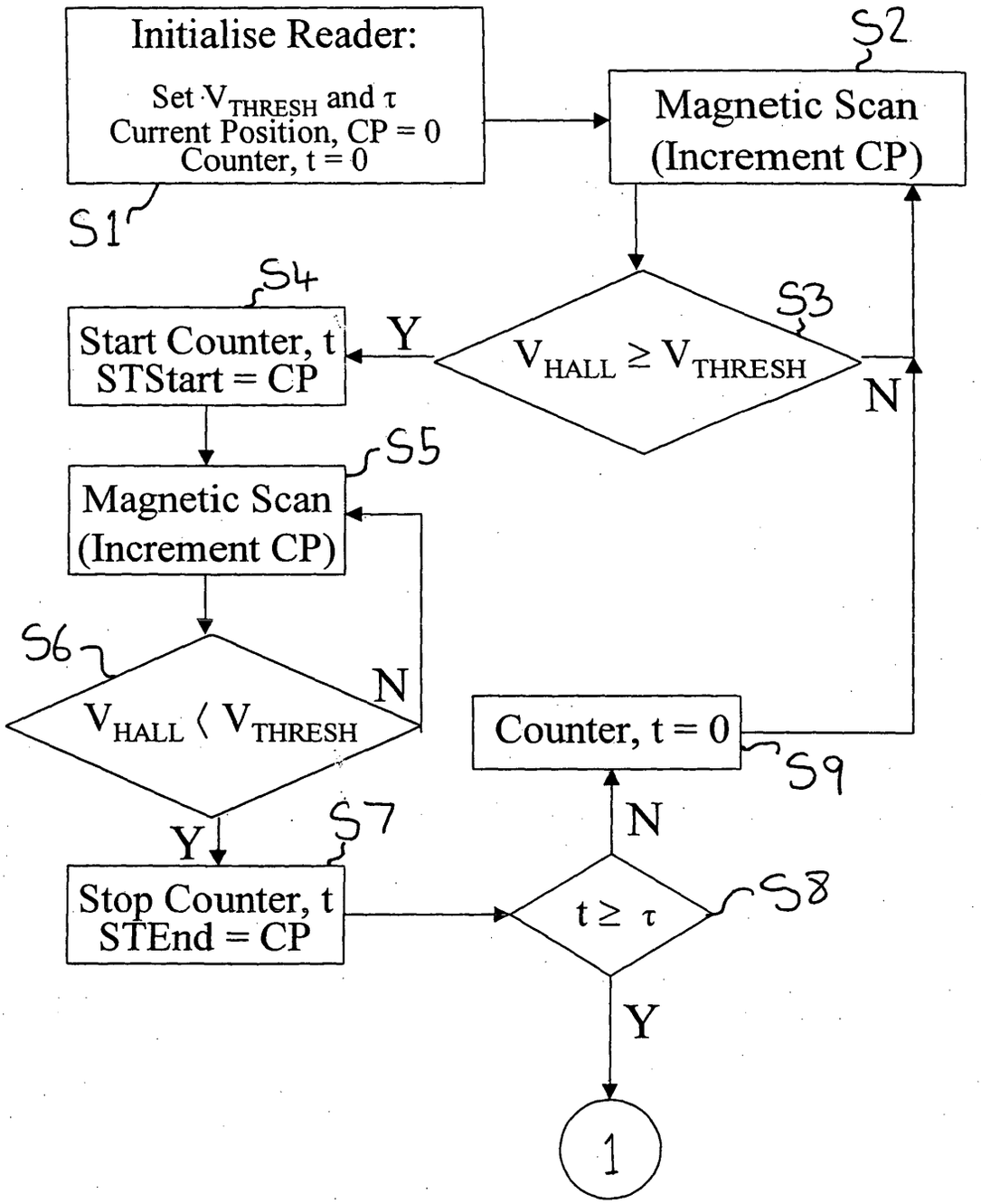
Initialise Reader:
Set V_{THRESH} and τ
Current Position, CP = 0
Counter, t = 0
S1
Magnetic Scan
(Increment CP)
S2
$V_{HALL} \geq V_{THRESH}$
S3
Y
N
Start Counter, t
STStart = CP
S4
Magnetic Scan
(Increment CP)
S5
$V_{HALL} < V_{THRESH}$
S6
N
Y
Stop Counter, t
STEnd = CP
S7
$t \geq \tau$
S8
N
Y
Counter, t = 0
S9
1

Fig. 4A

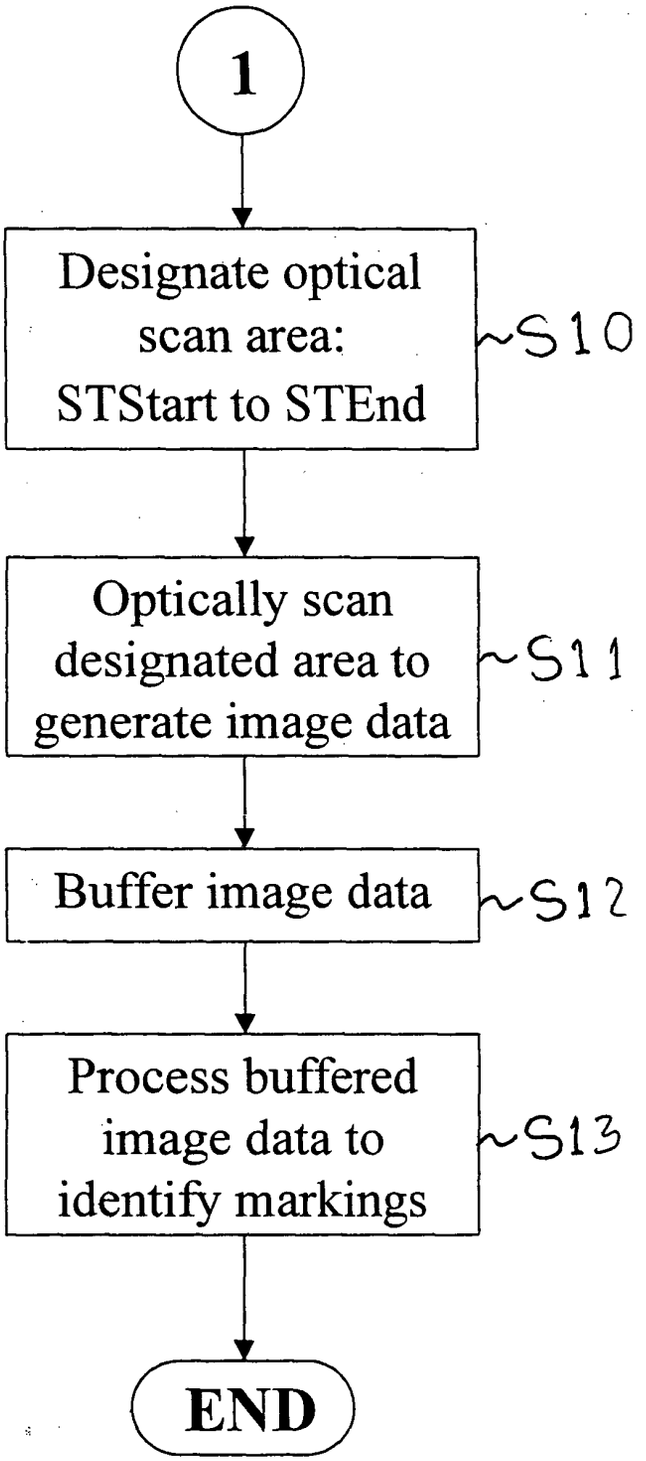
1
Designate optical scan area: STStart to STEnd
S10
Optically scan designated area to generate image data
S11
Buffer image data
S12
Process buffered image data to identify markings
S13
END

Fig. 4B

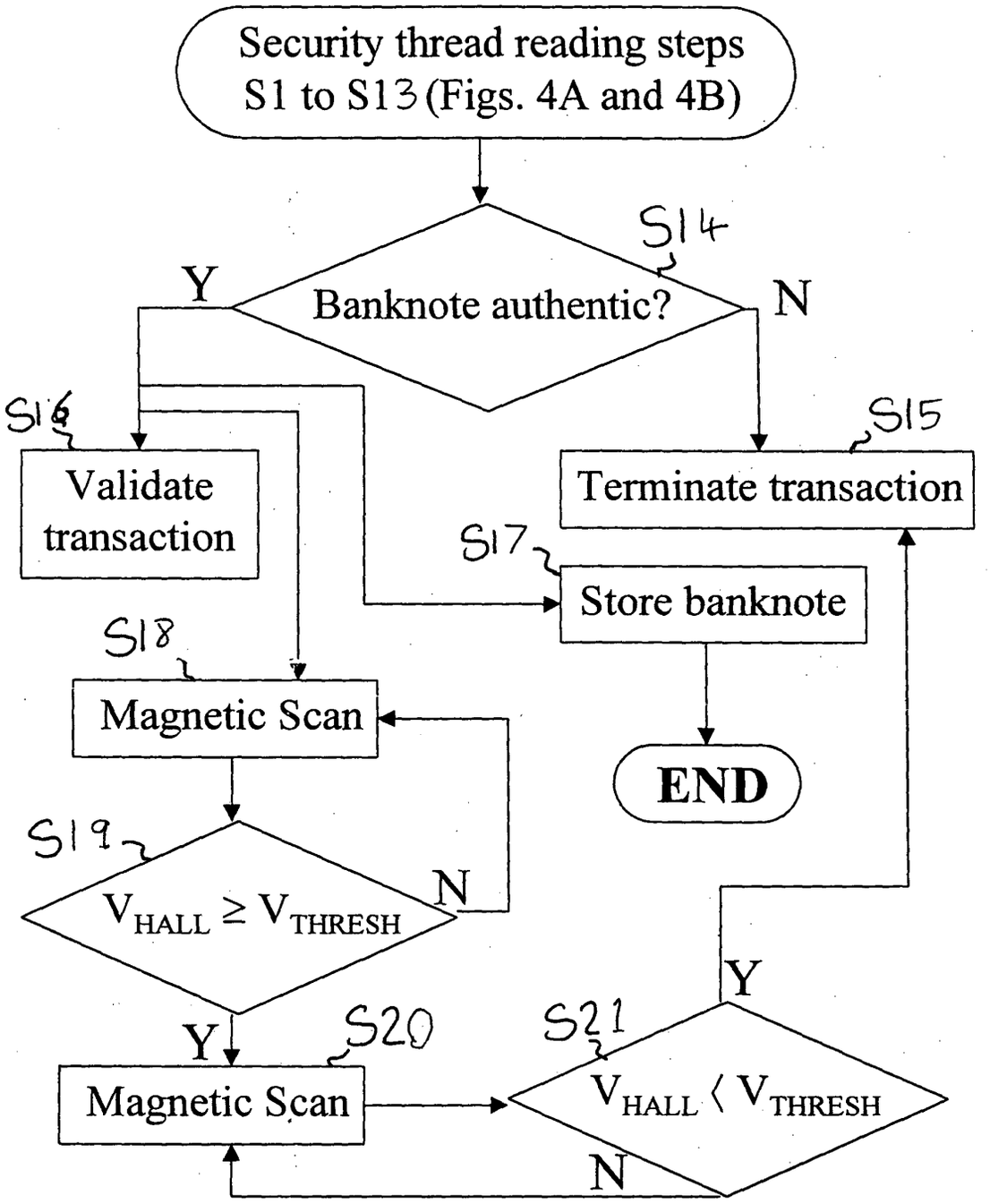
Security thread reading steps S1 to S13 (Figs. 4A and 4B)
S14
Banknote authentic?
Y
N
S16
Validate transaction
S15
Terminate transaction
S17
Store banknote
S18
Magnetic Scan
END
S19
$V_{HALL} \geq V_{THRESH}$
N
Y
S20
Magnetic Scan
S21
$V_{HALL} < V_{THRESH}$
Y
N

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 1891

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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