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(54) **Title**: AUTHENTICATION APPARATUS AND METHOD

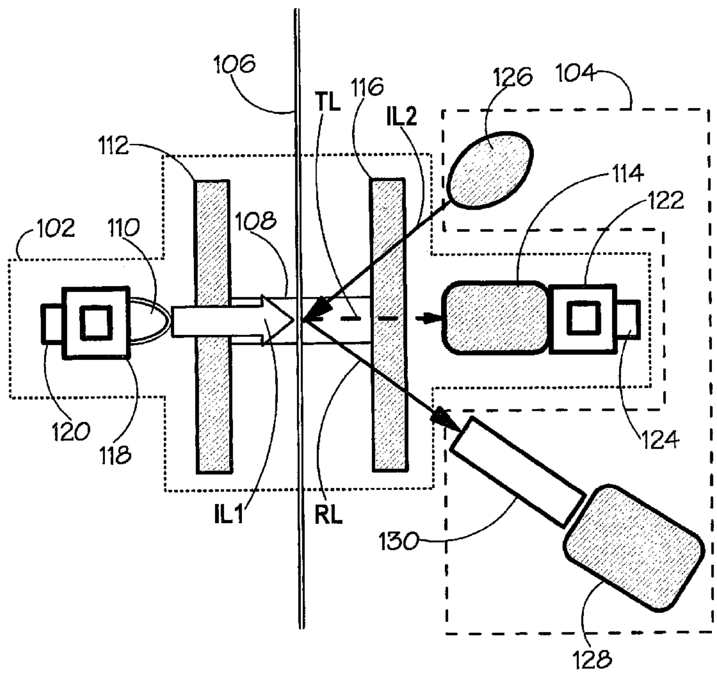

FIG.4.

(57) **Abstract**: An authentication apparatus operative to determine the authenticity of an item comprising a film substrate responsive to detection that a portion of said item located in a measuring region of said apparatus has a predetermined birefringence characteristic, said apparatus comprising: an item detection arrangement operative to determine if at least a portion of an item is located in a measuring region of said authentication apparatus; and an optically-based birefringence measuring apparatus, wherein said authentication apparatus is operative to compare a measured birefringence characteristic with a predetermined birefringence characteristic and to produce an authenticity signal indicative of authenticity or otherwise of said item based upon said comparison.

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Authentication Apparatus and Method

The present invention relates to an authentication apparatus and method, and particularly, but not exclusively, to an authentication apparatus for and method of authenticating an item comprising a polymer film.

Polymer films are increasingly being used as substrates in fields where security, authentication, identification and anti-counterfeiting are important. Polymer-based products in such areas include for example bank notes, important documents (e.g. ID materials such as for example passports and land title, share and educational certificates), films for packaging high-value goods for anti-counterfeiting purposes, and security cards.

Polymer-based secure materials have advantages in terms of security, functionality, durability, cost-effectiveness, cleanliness, processability and environmental considerations. Perhaps the most notable amongst these is the security advantage. Paper-based bank notes, for example, can be relatively easy to copy, and there is lower occurrence of counterfeits in countries with polymer-based bank notes compared to paper-based bank notes. Polymer-based bank notes are also longer-lasting and less-easily torn.

Security materials based on polymer films are amenable to the incorporation of a variety of visible and hidden security features. Since the introduction of the first polymer bank notes approximately 25 years ago, security features have included optically variable devices (OVD), opacification features, printed security features security threads, embossings, transparent windows and diffraction gratings. Aside from complicated security features there is also the more immediate advantage that the high temperatures used in copying machines will often cause melting or distortion of polymer base-material if counterfeiters attempt simply to copy secure materials (e.g. bank notes) using such machines.

However, standalone apparatus suitable for the authentication of security documents at points of sale is only in limited use at the present time. Points of sale may have a UV light source for detecting a fluorescent ink on a bank note, or a pen which does not mark authentic bank notes. These devices do not provide a high technical hurdle to counterfeiters. Points of sale may also have electronic apparatus which authenticates a credit or debit card using a tamper-resistant electronic circuit embedded in the card. However, this apparatus is complex and expensive, requires time to process and a telecommunications link to a remote server, and is not suitable for use in the authentication of bank notes during routine cash transactions.

More sophisticated apparatus for checking the authenticity of bank notes is in common use by credit institutions and professional cash handlers for checking bank notes which are to be returned to circulation, but such apparatus is expensive, particularly as it is generally necessary to check for the presence of multiple security features to authenticate a bank note. Cash receiving machines have less sophisticated authentication apparatus as they have to be kept to a relatively low cost.

A variety of polymers may be used as secure substrates. Amongst these is polypropylene film. The three main methods of manufacturing polypropylene film are the stenter method, the cast method and the bubble method.

In the cast and stenter methods, polymer chips are typically placed in an extruder and heated so that an extrudate is forced out of a slit die onto a chilled roller to form a film (in the case of the cast method) or a thick polymer ribbon (in the case of the stenter method). In the stenter method, the thick polymer ribbon is then reheated and then stretched lengthways (termed the "machine direction") and widthways (termed the "transverse direction") to form a film.

In the bubble method, the polymer is extruded not through a slit die but through an annular die, to form a relatively thick extrudate, in the form of a hollow cylinder or "drainpipe" shape through which air is blown. The annular die is at the top of an apparatus which is typically the equivalent of several storeys high (for example 40 to 50 metres). The extrudate moves downwards and is heated sequentially so that it is expanded to form a bubble. The bubble is then slit into two half-bubbles, each of which may be used individually as "monoweb" films; or alternatively the two halves may be nipped and laminated together to form a double thickness film (or the bubble may be collapsed to form a double thickness film). Typically there are three concentric annuli at the die, so that the hollow cylinder is an extrudate of three layers. For example, there may be a core layer of polypropylene with a terpolymer skin layer on one side and another terpolymer skin layer on the other side. In this case the monoweb would consist of three layers with polypropylene in the middle and the double web would consist of five layers because the layer in the middle would be the same skin layer (terpolymer) of each half-bubble. Many other possible arrangements and components are possible, for example in terms of the number of annuli, type of skin layer, type of core layer, etc.

Thus the bubble method results in a thin film (for example 10 to 100 microns thick) by forming a bubble whereas the stenter method results in a thin film by stretching the material. The bubble method results in homogeneously stretched film which is different to and for some purposes advantageous over stenter film. Biaxially Oriented Polypropylene (BOPP) film is made by the bubble process by Innovia Films Ltd., Wigton, UK. In addition to polypropylene, other polymers (e.g. LLDPE, polypropylene/butylene copolymers) may also be formed as thin films using the bubble process.

Previous authentication apparatus and methods make use of known sheets of security document substrate which are permeable to electromagnetic radiation, for example, transparent in the visible region of the electromagnetic spectrum. It is known to create security documents, such as banknotes, by printing opaque inks onto sheets of transparent plastics substrate material, leaving a transparent window. The resulting window provides an overt security feature which is conspicuous to the human eye. It is known to print, etch or embed additional optical security features, such as optically variable devices formed by diffraction gratings, onto or into the resulting transparent windows, to provide additional overt security features. It is known to provide automatic authentication apparatus which can determine authenticity from the presence or absence of these additional optical security features, but such apparatus is typically complex and expensive.

WO 2009/133390 discloses a method of authenticating a polymer film comprising measuring the birefringence of a core layer therein.

Birefringence, or double refraction, is a property of materials caused by differences in the refractive indices of the material for the two different polarisations, s- and p-, and between the two axes of its surface place.

A birefringent material, when presented with polarised light, splits the light into ordinary and extraordinary rays which are both retarded by transmission through the birefringent material, but to different degrees. After transmission through a second polariser at 90° with respect to the polarised light, the two rays recombine and interfere with one another destructively or constructively. The effect generated is of variable transmission in the form of a sine wave as the birefringent material is rotated from the minima (0° with respect to the polarisers) to the maxima (45° with respect to the polarisers).

Birefringence is induced in transparent polymer films in three ways: crystal orientation, polymer chain orientation and crystal lattice deformation.

Refractive index is proportional to the density of a material; polymeric materials exist in two forms, crystalline and amorphous, both of which exist in a known proportion within a particular polymer type – polypropylene can be between 35% and 50% crystalline depending on its molecular weight range and its stereo-chemistry. During the bubble process crystallisation occurs as the molten cast tube (1mm thick) is quenched using chilled water; cooling is rapid and temperature gradients occur across the thickness of the film giving some directionality to crystallisation. Crystalline areas form throughout the cast tubes that are then pulled during the stretching process into their final shape within the finished polymer. Birefringence is caused by differences in the lengths of the various dimensions of the crystalline regions and their orientation within the polymer; as the bubble polymer is stretched equally in both machine and transverse directions, this is expected to average out producing a low birefringence; however uneven distribution of crystalline areas causes variance of birefringence over distances of 1 – 3mm.

Refractive index is also affected by the orientation of the polymer chains within the material; this has the largest effect on the overall birefringence which is proportional to the ratio between the machine direction and transverse direction stresses during stretching.

Finally, lattice deformation is theoretically a cause of birefringence but is unlikely to be significant in a soft, low melting point material such as polypropylene.

The resulting effect of the birefringence of a material manifests itself as a rotation of the polarisation angle of light being transmitted through the material; the effect is initiated via an interfacial interaction and propagated through the birefringent material; the degree of birefringence observed is a product of the initial interfacial interaction (i.e. the angle of incidence) and the subsequent path length through the material.

As noted above, the birefringent effect is a product of the thickness of the film and the degree to which the refractive indices differ between the two axes. The effect is visible if the film is placed between two crossed polarisers and rotated through 90° between a minima (equivalent to no change in transmission from the crossed polarisers) to a maxima at 45° where potentially as much light is transmitted as would be through a single polariser.

Birefringence in films is induced by orientation differences in production between the machine and the transverse direction; the resulting films have two axes at 90° to one another at which points the birefringence is at its minimum value, with 45° from either axis being the maximum. As a result of the nature of film processing in reels and sheets, every material produced by every known process will have the same properties including the polarisers.

Because of the universality of the orientation of polymers, a single measurement of birefringence at 45° is sufficient to determine the maximum value of any film and any printed product from that film. The polarisers themselves will also conform to this; therefore in the manufacture of a device such as this the specification for the polarisers should be that they should be cut at 45° from a master polariser sheet.

The method and apparatus disclosed in WO 2009/133390 involves the use of a pair of spinning polarisers that are at oriented at 90° to one another. The polarisers are operative to rotate at the same rate, and the apparatus is operative to measure the intensity of the light that passes through a sample placed between the polarisers.

Figs. 1 to 3 show components of apparatus for different methods of observing birefringence as disclosed in WO 2009/133390.

With reference to Figure 1, a first method of observing birefringence is via the use of crossed polarisers. Linear polarisers allow one type of either s- or p- polarised light to pass through them, so that when a second linear polariser is presented and twisted 90° relative to the first, the remaining light made from a single polarised type is filtered out; this technique is referred to as using cross polarisers. Birefringent materials effectively rotate the axis of polarisation and so, when placed between two crossed polarisers will affect how much light is permitted to pass through them. Rotating the birefringent material whilst between the crossed polarisers causes the intensity of light to vary as the angles of birefringence alters. Thin polymer films operate on the first order of birefringence and will tend to rotate light between 0° and 90°; a fully birefringent material will vary from no enhancement in transmission between the polarisers to eliminating the effect of the first polariser by rotating light to pass through the second. This behaviour forms the basis of one method of measuring the birefringence of the films; the sample is typically placed between two motorised cross polarising filters which then rotate through 360° whilst maintaining the same rotationary configuration with respect to one another, light passes from a source through the filter/sample/filter and its intensity is measured using a photodiode. The intensity measured will follow two 180° cycles the maximum and minimum values of which will be related to the birefringence of that film.

With reference to Fig. 2, a second method for the measurement of birefringence is to use two circular-shaped linear polarising filters that are composed of sectors of material, each having its own polarisation angle which is related to the angular position of the sector on the circular optic. If two of these optics are differentiated by their s- and p- orientations, then the combination of both will act as cross polarisers for each sector. A single light source can be used to illuminate a sample placed between two such polarisers and the transmitted light from each sector can be fed into an optical fibre which in turn has the intensity transmitted measured using a photodiode. In this way, the birefringent behaviour of the film can be measured in a single measurement without rotating the polarisers – the resolution of such a measurement will depend on the angular size of each of the sectors – for example sectors as large as 20° would give eighteen measurements and would be more than sufficient for the finding of the maximal and the minimal transmissivities.

With reference to Fig. 3, a third method for the measurement of the birefringence is the use of a quartz wedge. In this instance, the birefringent material is placed between a polarising filter and a calibrated quartz wedge whilst light is shone through towards an inspection system that measures the positions of fringes on the wedge.

To differentiate between the designated genuine film and others, the above-described birefringence measurement method may be employed to allow the user to eliminate other types of film, i.e. designated counterfeit films: BOPP film made by the stenter process is oriented more in the transverse direction than the machine direction, and so is considerably more birefringent than BOPP films made by the double bubble process. Birefringence can be controlled precisely using the double bubble process and so can provide a unique signature that can eliminate films.

The method of WO 2009/133390 allows a film to be securitized as is. The particular inherent characteristics of the film are observed using the disclosed method, and there is no need to add any further security or identifying features. This identification allows authentication for security purposes and also allows the film's origin to be determined.

The films referred to herein are generally sheet-form materials, and may be provided as individual sheets, or as a web material which may subsequently be processed (by die cutting for example) to provide sheet or article form materials. When referring to "film" in this specification it is intended, unless expressly provided otherwise, to include films in sheet, article or in web form.

The method of WO 2009/133390 is suitable for authenticating items containing films made by the bubble process. The bubble process results in films which have balanced orientation, well-defined and uniform thicknesses and other properties (high tensile strength, low elongation, high gloss and clarity, good puncture and flex-crack resistance, resistance to oils and greases, good water-impermeability) which define a "signature" of the film which indicate that it has been prepared by the bubble process.

In order to differentiate between films (e.g. BOPP films and others) the overall thickness of the film, as well as the thickness of individual layers, for example a laminating layer, may be measured. This allows determination of particular characteristics which are dependent on particular processes, for example a particular bubble process. Additionally, or alternatively, the unique birefringent signature of the film may be assessed and used to determine whether the film was made by a particular process and accordingly whether it is, for example, a genuine bank note or counterfeit. Birefringence depends on the anisotropy of the material and films made by bubble process have different anisotropies and hence different birefringent properties to films made by other processes. Furthermore the precise conditions used in the bubble process will affect the birefringent signature.

Thus WO 2009/133390 recognises that, rather than needing to add security or identification features, the inherent properties of films made by particular processes, such as the bubble process, are unique and act as a signature.

Actual counterfeit film is more likely to be bought rather than made by the counterfeiter. There are several sources that can be broken into three main groupings:

1. Cast or blown films - cast films are made by extruding polymer through a die onto a chilled roller. Blown films are made by extruding a polymer through a circular die and inflating a bubble in the semi-molten state. Cast films & blown films are typically either non or slightly oriented and so have inferior dimensional stability (i.e. they can easily be stretched), poorer optics and thickness control.

2. Mono oriented films – mono oriented films are made by extruding through a die and stretching in the machine direction. Mono oriented films are highly oriented, they have poorer optics and poor transverse direction dimensional stability.

3. Biaxially oriented films - biaxially oriented films are commercially available from Innovia Films Limited and from a number of other suppliers. Commercial grades of BOPP from many suppliers are generally made by the stenter process where PP is extruded through a slot die onto a chill roller, stretched in the machine direction over heated rollers and stretched in the transverse direction in a tenter frame. These films are anisotropic in nature unlike BOPP made by the double bubble process, which is stretch oriented evenly in all directions.

There exists the possibility that a counterfeiter may be aware of the above-described birefringence effect. In order to deceive systems employing the above-described method, the counterfeiter may produce counterfeit items by printing on film at 45° to the film's sheet edge or reel edge. Whilst the difficulty of doing this may effectively rule out any industrial process, the danger might remain for a knowledgeable and determined counterfeiter.

The above described birefringence measurement methods may require a relatively lengthy amount of time to make appropriate measurements. In practice this may be greater than one second, thereby effectively ruling out high speed measurements. Also, there is the issue of item placement and measurement area. Transparent or "window" regions of items may be small and partially covered with print. Thus, in the particular field of banknote authentication, an automatic alignment to a particular denomination may be possible, but this might become awkward in manual use. This is further complicated by the size of the measurement area: large areas can be more accurate but will be more likely to accidentally incorporate some of the printed areas of the window.

The above described birefringence measuring method may be useful for authenticating films which form part of security documents. However, in some instances, those security documents may comprise film substrates where at least a portion of the film substrate is printed upon. To ensure that a correct birefringence measurement for the film substrate itself is taken, the measurement should be made on the unprinted or "window" region of the film, i.e. an item authentication region of the item. A birefringence measurement performed on a printed area of the film substrate may result in a "false positive", because the birefringence measurement reading for the printed region may be of a similar level to that of a genuine film. Therefore, it is important that that the birefringence measurement is performed on the unprinted or "window" region (i.e. directly on the film substrate) of the item rather than on a printed region to avoid such "false positives" and to obtain an accurate birefringence measurement of the film substrate. A non-window area could be mistaken for an area of low birefringence or air when placed between two polarisers, because in both situations transmission is low between the crossed-polarisers.

As may be appreciated, the need to ensure that it is the window region (or item authentication region) of the item upon which birefringence measurement is performed, rather than on a printed region, may require some manipulation of the item on the part of a user. The user may need to move the item within the measuring apparatus until the window region of the item is located in a measuring region where the birefringence measurement method can be performed. This may prove time consuming whilst the user manipulates the item to properly locate the window in the measuring region.

It may be desirable to implement a birefringence measurement method for the authentication of items using machine feeding apparatus. This may potentially increase the speed at which items can be authenticated.

The present invention has been devised with the foregoing considerations in mind.

According to an aspect of the present invention, there is provided an authentication apparatus operative to determine the authenticity of an item comprising a film substrate responsive to detection that a portion of the item located in a measuring region of the apparatus has a predetermined birefringence characteristic, the apparatus comprising: an item detection arrangement operative to determine if at least a portion of an item is located in a measuring region of the authentication apparatus; and an optically-based birefringence measuring apparatus, wherein the authentication apparatus is operative to compare a measured birefringence characteristic with a predetermined birefringence characteristic and to produce an authenticity signal indicative of authenticity or otherwise of the item based upon the comparison, the apparatus further comprising a control means operative to control output of the authenticity signal from the apparatus responsive to determination, by the item detection arrangement, of presence or otherwise of the at least a portion of the item in the measuring region.

This may allow the apparatus to output an authenticity signal only when a portion of an authentic or genuine item is located in the measuring region. The operation of the item detector arrangement may serve to reduce power consumption of the apparatus: the authenticity signal may be output by the apparatus only when an item is present. Otherwise, no signal is output.

Optionally, the item detection arrangement may comprise an item detection emitter located, and operative, to illuminate with electromagnetic radiation an item detection region of the apparatus, and an item detection detector, located, and operative, to receive at least one of: electromagnetic radiation reflected from the item detection region; and electromagnetic radiation transmitted through the item detection region, wherein the item detection detector is further operative to provide a signal indicative of presence or otherwise of an item in the item detection region, and further wherein the item detection arrangement is operative to determine that the at least a portion of the item is located in the measuring region responsive to receipt of the item detection detector signal indicating presence of an item in the item detection region.

The item detection emitter may be operative to emit white-light and/or infra-red light, and the item detection detector may be operative to detect white-light and/or infra-red light.

Further optionally, the apparatus may be operative to differentiate between item film substrates made by a bubble process and item film substrates made by a different process.

The optically-based birefringence measuring apparatus may comprise a birefringence measurement emitter located, and operative, to illuminate the measuring region of the apparatus with electromagnetic radiation; a first polariser located between the birefringence measurement emitter and a first side of the measuring region so that electromagnetic radiation emitted by the birefringence measurement emitter passes therethrough; a birefringence measurement detector located on a second side of the measuring region, and operative to receive electromagnetic radiation transmitted through the measuring region from the birefringence measurement emitter; and a second polariser located between the second side of the measuring region and the birefringence measurement detector so that electromagnetic radiation transmitted through the measuring region passes therethrough, the second polariser oriented so as to effect polarisation in a direction transverse to that of the first polariser; wherein the birefringence measurement detector is operative to output a signal corresponding to a measured birefringence characteristic.

The output signal output by the birefringence measurement detector corresponding to a measured birefringence characteristic may be proportional to an intensity of transmitted electromagnetic radiation received.

Optionally, the birefringence measurement detector may be operative to communicate the output signal corresponding to a measured birefringence characteristic to a processor which is operative to compare a value of the output signal with the predetermined birefringence characteristic.

Further optionally, the predetermined birefringence characteristic may comprise one of: a first range of values corresponding to expected birefringence measurement detector output signal values if an opaque or semi-opaque region of the item is located in the measuring region; a second range of values corresponding to expected birefringence measurement detector output signal values if a transparent or semi-transparent region of the item is located in the measuring region; and a third range of values corresponding to expected birefringence measurement detector output signal values if no item is present in the measuring region.

The birefringence measurement emitter may comprise a light source. Optionally, the light source may comprise a white light emitting LED.

The birefringence measurement detector may comprise a photodetector. Optionally, the photodetector may comprise a photodiode. Further optionally, the photodiode may be suitable for detecting white light.

The birefringence measurement emitter may be slidably mounted on a rail or rod. Optionally, the birefringence measurement emitter may be attached to the rail or rod by an attachment which is slidable relative to the rail or rod, and which attachment may comprise a fixing element (e.g. a locking screw) to allow a position of the birefringence measurement emitter to be fixed relative to the rail or rod.

The birefringence measurement detector may be slidably mounted on a rail or rod. Optionally, the birefringence measurement detector may be attached to the rail or rod by an attachment which is slidable relative to the rail or rod, and which attachment may comprise a fixing element (e.g. a locking screw) to allow a position of the birefringence measurement detector to be fixed relative to the rail or rod.

Optionally, the item detection arrangement may comprise an optically-based reflectance measuring apparatus for determining if an item authentication region is located in the measuring region, wherein the reflectance measuring apparatus may comprise: a reflectance measurement emitter operative to illuminate the measuring region of the apparatus with electromagnetic radiation; and a reflectance measurement detector located and operative to receive electromagnetic radiation reflected from the measuring region of the apparatus and operative to output a signal corresponding to a measured characteristic of the electromagnetic radiation reflected from the measuring region and indicative of presence or otherwise of an item authentication region in the measuring region, wherein the reflectance measuring apparatus is operative to compare a measured reflection characteristic with a set of predetermined reflection characteristics and to determine presence or otherwise of the item authentication region in the measuring region based upon the comparison, and further operative to provide to the control means a signal indicative of the determination for controlling output of the authenticity signal from the control means.

This may allow the apparatus to output an authenticity signal only when an item authentication region of an item is located in the measuring region. At all other times, another signal type may be output by the apparatus. For example, the signal may comprise a signal indicating that no sample is present or, for example, a signal indicating that the region of the item which is located in the measuring region is not the authentication region (e.g. a non-window region or printed region of the item)).

Optionally, the output signal output by the reflectance measurement detector corresponding to a measured reflection characteristic may be proportional to an intensity of reflected electromagnetic radiation received.

Optionally, the reflectance measurement detector may be operative to communicate the output signal corresponding to a measured reflection characteristic to a processor which is operative to compare a value of the output signal corresponding to the measured reflection characteristic with the predetermined reflection characteristic, which may comprise a pre-defined value indicative of presence of an item authentication region of the item in the measuring region, and the processor operative to implement the determination that the item authentic region is present or absent in the measuring region based upon the comparison and operative to provide to the control means the signal indicative of the determination.

Optionally, if the comparison of the predetermined reflection characteristic with the output signal output by the reflectance measurement detector corresponding to a measured reflection characteristic indicates that the item authentication region is located in the measuring region, the processor is operative to output a determination signal to the control means indicative of presence of the item authentication region in the measuring region, wherein responsive to receipt thereof, the control means is operative to output the authenticity signal indicative of authenticity or otherwise of the item based upon the comparison of the predetermined birefringence characteristic with the output signal output by the birefringence measurement detector corresponding to a measured birefringence characteristic.

Optionally, the predetermined reflection characteristic may comprise one or more of: a first range of values corresponding to expected reflectance measurement detector output signal values if an opaque or semi-opaque region of the item is located in the measuring region; a second range of values corresponding to expected reflectance measurement detector output signal values if a transparent or semi-transparent region of the item is located in the measuring region; and a third range of values corresponding to expected reflectance measurement detector output signal values if no item is present in the measuring region.

Optionally, the reflectance measurement detector may have associated therewith a shade, the shade including at least one aperture, wherein the aperture may be located with respect to the reflectance measurement detector to permit electromagnetic radiation reflected from the at least a portion of the item to be received by the reflectance measurement detector.

Optionally, the shade may comprise a tube, and in which the aperture may comprise the hollow portion of the tube. Further optionally, the aperture may comprise a tubular region in the shade. The reflectance measurement detector may be located at an end of the tube, or within the tube, or at an end of, or within, the tubular region of the shade.

Optionally, the reflectance measurement emitter has associated therewith a shade, the shade including an aperture, wherein the aperture is located with respect to the reflectance measurement emitter to permit electromagnetic radiation emitted from the reflectance measurement d emitter to be directed toward the measuring region of the apparatus.

Optionally, the shade may comprise a tube, and in which the aperture may comprise the hollow portion of the tube. Further optionally, the aperture may comprise a tubular region in the shade. The reflectance measurement emitter may be located at an end of the tube, or within the tube, or at an end of, or within, the tubular region of the shade.

Optionally, the reflectance measurement emitter is operative to emit coherent electromagnetic radiation. Further optionally, the reflectance measurement emitter may comprise at least one LED. The at least one LED may be operative to emit light in the infra-red range of the electromagnetic spectrum and/or may comprise a white light emitter source. Yet further optionally, the reflectance measurement emitter may comprise at least one strip electromagnetic radiation source.

Optionally, the reflectance measurement detector may comprise at least one photodiode. Further optionally, the at least one photodiode may be operative to detect light in the infra-red range of the electromagnetic spectrum. Yet further optionally, the reflectance measurement detector may comprise at least one line-scan camera and/or may comprise at least one spectrometer and a CCD or CMOS image sensor.

Optionally, the reflectance measurement emitter may comprise at least one of: a plurality of LEDs; a plurality of white light emitter sources; and a plurality of strip electromagnetic radiation sources; and the reflectance measurement detector may comprise at least one of: a plurality of photodiodes; a plurality of line-scan cameras; and a plurality of spectrometers and CCD or CMOS image sensors; wherein each one of the plurality of LEDs is paired with a corresponding one of the plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image sensors, wherein each one of the plurality of white light emitter sources may be paired with a corresponding one of the plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image sensors, and wherein each one of the plurality of strip electromagnetic radiation sources may be paired with a corresponding one of the plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image sensors.

Optionally, at least one of the plurality of LEDs may be operative to emit light in the infra-red range of the electromagnetic spectrum. Further optionally, at least one of the plurality of photodiodes may be operative to detect light in the infra-red range of the electromagnetic spectrum.

The apparatus optionally may include a transport path, of which a part may comprise the measuring region, and along which item transport path the item may be conveyable.

The item may comprise a banknote.

The opaque or semi-opaque region may comprise a printed region of the banknote and/or the transparent or semi-transparent region of the item may comprise an unprinted or window region (item authentication region) of the banknote.

According to another aspect of the present invention, there is provided a banknote counting apparatus comprising the authentication apparatus which includes any one or more of the above-described features, the banknote counting apparatus further comprising a note counting device operative to maintain a count of banknotes conveyed through the apparatus, and the note counting device further operative to receive the authenticity signal indicative of authenticity or otherwise of the item from the authentication apparatus, wherein the note counting device is operative to alter a note count only when the signal indicates that an item in the measuring region is authentic.

Optionally, upon receipt of the signal indicating that the item in the measuring region is authentic, the note counting device may be operative to alter the note count. Further optionally, the note counting device may be operative to alter the note count by incrementing the count.

According to another aspect of the present invention, there is provided a method of authenticating an item comprising a film substrate, the method comprising detecting if a portion of an item located in a measuring region of an authentication apparatus has a predetermined birefringence characteristic, and further comprising the steps of: determining, by an item detection arrangement, if at least a portion of an item is located in a measuring region of the authentication apparatus; comparing a measured birefringence characteristic, obtained by an optically-based birefringence measuring apparatus, with a predetermined birefringence characteristic; producing an authenticity signal indicative of authenticity or otherwise of the item based upon the comparison; controlling, by way of a control means, output of the authenticity signal from the apparatus responsive to determination, by the item detection arrangement, of presence or otherwise of the at least a portion of the item in the measuring region.

Optionally, the method may comprise illuminating with electromagnetic radiation, by way of an item detection emitter forming part of the item detection arrangement, an item detection region of the apparatus, and receiving, by way of an item detection detector forming part of the item detection arrangement, at least one of: electromagnetic radiation reflected from the item detection region; and electromagnetic radiation transmitted through the item detection region, and further comprising providing a signal indicative of presence or otherwise of an item in the item detection region and, responsive to receipt of an item detection detector signal indicating presence of an item in the item detection region, determining, by the item detector arrangement, that the at least a portion of the item is located in the measuring region.

Optionally, the method may differentiate between item film substrates made by a bubble process and item film substrates made by a different process.

Optionally, the method may comprise illuminating, with a birefringence measurement emitter, the measuring region of the apparatus with electromagnetic radiation; locating a first polariser between the birefringence measurement emitter and a first side of the measuring region so that electromagnetic radiation emitted by the birefringence measurement emitter passes therethrough; locating a birefringence measurement detector on a second side of the measuring region; receiving, at the birefringence measurement detector, electromagnetic radiation transmitted through the measuring region from the birefringence measurement emitter; locating a second polariser between the second side of the measuring region and the birefringence measurement detector so that electromagnetic radiation transmitted through the measuring region passes therethrough; orienting the second polariser so as to effect polarisation in a direction transverse to that of the first polariser; outputting, from the birefringence measurement detector, a signal corresponding to a measured birefringence characteristic.

Optionally, the method may comprise communicating the output signal corresponding to a measured birefringence characteristic to a processor; and comparing, in the processor, a value of the output signal with the predetermined birefringence characteristic.

Optionally, the predetermined birefringence characteristic may comprise one of: a first range of values corresponding to expected birefringence measurement detector output signal values if an opaque or semi-opaque region of the item is located in the measuring region; a second range of values corresponding to expected birefringence measurement detector output signal values if a transparent or semi-transparent region of the item is located in the measuring region; and a third range of values corresponding to expected birefringence measurement detector output signal values if no item is present in the measuring region.

Optionally, the method may comprise: determining, by way on an optically-based reflectance measuring apparatus of the item detection arrangement, if an item authentication region of an item is located in the measuring region, the determining step implemented by: illuminating, by way of a reflectance measurement emitter of the reflectance measuring apparatus, the measuring region of the apparatus with electromagnetic radiation; receiving, by way of a reflectance measurement detector of the reflectance measuring apparatus, electromagnetic radiation reflected from the measuring region of the apparatus; outputting, from the reflectance measurement detector, a signal corresponding to a measured characteristic of the electromagnetic radiation reflected from the measuring region and indicative of presence or otherwise of an item authentication region in the measuring region; comparing, in the reflectance measuring apparatus, a measured reflection characteristic with a set of predetermined reflection characteristics; and determining presence or otherwise of the item authentication region in the measuring region based upon the comparison; and providing, to the control means, a signal indicative of the determination for controlling output of the authenticity signal from the control means.

Optionally, the method may comprise communicating the output signal corresponding to a measured reflection characteristic to a processor which is operative to compare a value of the output signal corresponding to the measured reflection characteristic with the predetermined reflection characteristic, which may comprise a pre-defined value indicative of presence of an item authentication region of the item in the measuring region, and the processor operative to implement the determination that the item authentication region is present or absent in the measuring region based upon the comparison and operative to provide to the control means the signal indicative of the determination.

Optionally, if the comparison of the predetermined reflection characteristic with the output signal output by the reflectance measurement detector corresponding to a measured reflection characteristic indicates that the item authentication region is located in the measuring region, outputting, from the processor to the control means, a determination signal indicative of presence of the item authentication region in the measuring region, wherein responsive to receipt thereof, outputting, from the control means, the authenticity signal indicative of authenticity or otherwise of the item based upon the comparison of the predetermined birefringence characteristic with the output signal output by the birefringence measurement detector corresponding to a measured birefringence characteristic.

The predetermined reflection characteristic may comprise one or more of: a first range of values corresponding to expected reflectance measurement detector output signal values if an opaque or semi-opaque region of the item is located in the measuring region; a second range of values corresponding to expected reflectance measurement detector output signal values if a transparent or semi-transparent region of the item is located in the measuring region; and a third range of values corresponding to expected reflectance measurement detector output signal values if no item is present in the measuring region.

The opaque or semi-opaque region may comprise a printed region of a banknote and/or the transparent or semi-transparent region of the item may comprise an unprinted or window region (item authentication region) of the banknote.

Optionally, the method may comprise providing a transport path in the authentication apparatus, of which a part of the transport path may comprise the measuring region, and conveying the item along the transport path.

According to another aspect of the present invention, there is provided a banknote counting method comprising any one or more of the method steps described above, the banknote counting method further comprising maintaining, using a note counting device, a count of banknotes conveyed through the apparatus; receiving, at the note counting device, from the authentication apparatus, the authenticity signal indicative of authenticity or otherwise of the item; and altering a note count only when the authenticity signal indicates that an item in the measuring region is authentic.

Optionally, the method may further comprise altering the note count upon receipt of an authenticity signal indicating that an item in the measuring region is authentic. Further optionally, the method may comprise altering the note count by incrementing the count.

One or more specific embodiments in accordance with aspects of the present invention will be described, by way of example only, and with reference to the following drawings.

Figs. 1 to 3 schematically illustrate components of known apparatus for implementing different methods of observing birefringence;

Figs. 4 schematically illustrates a top-view of an authentication apparatus in accordance with one or more embodiments of the present invention;

Fig. 5 schematically illustrates a side view of an authentication apparatus in accordance with one or more embodiments of the present invention;

Fig. 6 schematically illustrates a circuit diagram for the authentication apparatus in an illustrative embodiment;

Fig. 7 schematically illustrates the authentication apparatus in an optional arrangement;

Figs. 8a and 8b schematically illustrates the authentication apparatus in another optional arrangement;

Fig. 9a schematically illustrates a top view of the authentication apparatus in a further optional arrangement;

Fig. 9b schematically illustrates a side view of the authentication apparatus in a further optional arrangement;

Fig. 9c illustrates a graph of an output signal response of birefringence measuring apparatus of the authentication apparatus of Fig. 9a.

Figs. 10a, 10b and 10c schematically illustrate detector arrangements of the reflectance measuring apparatus forming part of the authentication apparatus according to one or more embodiments of the present invention;

Fig. 11 illustrates a graph plotting intensity of radiation received at a detector dependent upon an angle of incident radiation and an area of the detector;

Fig. 12 illustrates a graph plotting angle of incidence of illuminating radiation versus reflectivity of the illuminating radiation from an item surface;

Fig. 13 illustrates a profile of intensity of reflected radiation received by a detector of a reflectance measuring apparatus when a banknote is passed through an authentication apparatus according to one or more embodiments of the present invention;

Fig. 14 schematically illustrates a top view of an emitter-detector-item arrangement of the reflectance measuring apparatus for use in an optional arrangement of the authentication apparatus of one or more embodiments of the present invention;

Fig. 15 schematically illustrates a top view of an emitter-detector-item arrangement of the reflectance measuring apparatus for use in an optional arrangement of the authentication apparatus of one or more embodiments of the present invention; and

Fig. 16 schematically illustrates a perspective view of an emitter-detector-item arrangement of the reflectance measuring apparatus for use in an optional arrangement of the authentication apparatus of one or more embodiments of the present invention.

Figs. 4 and 5 illustrate an authentication apparatus 100 which comprises a birefringence measuring apparatus 102 and a reflectance measuring apparatus 104.

The authentication apparatus 100 is operative to measure birefringence and reflectance characteristics of an item 106 (e.g. a banknote). In particular, the authentication apparatus 100 is operative to measure birefringence and reflectance characteristics of a portion of the item 106 located in a measuring region 108 of the authentication apparatus 100.

The birefringence measuring apparatus 102 comprises a first emitter 110, or birefringence measurement emitter (optionally an LED operative to emit white-light), a first polariser 112, a first detector 114, or birefringence measurement detector (optionally a photodiode operative to detect white light), and a second polariser 116.

The elements of the birefringence measuring apparatus 102 are arranged such that the first emitter 110 and first polariser 112 are located on a first side of the measuring region 108, and the first detector 114 and the second polariser 116 are located on a second side of the measuring region 110 (i.e. opposite the first emitter 110 and first polariser 112).

First emitter 110 is operative to illuminate the measuring region 108 with electromagnetic radiation (denoted by dotted arrow IL in the figure), and first detector 114 is oriented and operative to receive electromagnetic radiation (denoted by dotted arrow TL in the figure) which is transmitted through a portion of the item 106 located in the measuring region 108. The illuminating electromagnetic radiation IL1 passes through first polariser 112 prior to irradiating a portion of the item 106 located in the measuring region 108. After passing through the portion of the item 106 located in the measuring region 108, the transmitted electromagnetic radiation TL passes through second polariser 116 before being received by first detector 114.

In the illustrated arrangement, the measuring region 108 is located in a first plane. The first polariser 112 is spaced from the first plane and is located in a second plane on a first side of the measuring region 108. The second plane is substantially parallel to the first plane. Similarly, the second polariser 116 is spaced from the first plane and is located in a third plane on a second side of the measuring region 108. It is located opposite the first polariser 112, and the third plane is substantially parallel to the first and second planes. The arrangement of transmission orientations of the first and second polarisers 112, 116 is such that they comprise crossed polarisers. That is, the first polariser 112 is arranged such that a transmission orientation thereof is about +45° to a transmission orientation of the portion of the item 106 located in the measuring region 108. The second polariser 116 is arranged such that a transmission orientation thereof is about -45° to the transmission orientation of the portion of the item 106 located in the measuring region 108. Alternatively, the transmission orientation of the first polariser 112 may be such that it is about -45° to a transmission orientation of the portion of the item 106 located in the measuring region 108 and the transmission orientation of the second polariser 116 may be such that it is about +45° to the transmission orientation of the portion of the item 106 located in the measuring region 108.

Thus, in the illustrated arrangement, the illuminating electromagnetic radiation IL1 emitted by first emitter 110 will be polarised by the first polariser 112, irradiate the portion of the item 106 located in the measuring region 108, pass through the item 106, continue as transmitted electromagnetic radiation TL to the second polariser 116 (i.e. crossed polariser) and pass therethrough, and continue for reception by the first detector 114. The first detector 114 responsive to detection of transmitted electromagnetic radiation TL incident thereon, outputs a signal proportional to the intensity of received transmitted electromagnetic radiation TL to a processing means (not shown).

The processing means, upon receiving an output signal from the first detector 114, is operative to compare a value of the received signal with a set of pre-defined values stored in a database (not shown). These pre-defined values may correspond to expected transmitted electromagnetic radiation values when one or more of: a printed region of an item is located in the measuring region 108; an unprinted region of an item (e.g. a window region or item authentication region) is located in the measuring region 108 (where the film substrate of the item is genuine); an unprinted region of an item (e.g. a window region) is located in the measuring region 108 (where the film substrate of the item is not genuine); and no banknote is located in the measuring region 108.

The first emitter 110 is slidably mounted on a rail or rod 118. The first emitter 110 may be fixed at a particular position along a length of said rail or rod 118 by way of fixing screw 120. This arrangement allows the position of the first emitter 110 relative to the measuring region 108 to be altered. Similarly, first detector 114 is slidably mounted on a rail or rod 122. The first detector 114 may be fixed at a particular position along a length of said rail or rod 122 by way of fixing screw 124. Again, this arrangement allows the position of the first detector 114 relative to the measuring region 108 to be altered.

An item 106 comprising a film that is highly oriented will give rise to a high reading from the first detector 114 (because a large amount of electromagnetic radiation will be transmitted, i.e. the intensity of the transmitted electromagnetic radiation TL will be relatively high). However, a balanced film will give rise to a zero-value or low reading from the first detector 114 because the behaviour of the electromagnetic radiation through the first and second crossed polarisers will be largely unaltered.

Films having a balanced orientation (e.g. BOPP films) will produce a low birefringence signal at the first detector 114. Such a signal may be substantially the same as that corresponding to a printed area of film or no film at all in the measuring region 108. On the other hand, when a stenter or other oriented film is located in the measuring region 108, the first detector 114 will produce a high birefringence signal that will be different from all the above situations.

The birefringence measuring apparatus 102 is therefore capable of operating on the basis of a "item is authentic" result all the time until an item comprising a false piece of film is encountered, at which point an alarm and/or visual alert may be activated: in other words it will find a negative but not identify a positive.

To counter this, the authentication apparatus 100 includes the reflectance measuring apparatus 104.

The reflectance measuring apparatus 104 comprises a second emitter 126, or reflectance measurement emitter (optionally an LED operative to emit electromagnetic radiation in the infra-red region of the electromagnetic spectrum), a second detector 128, or reflectance measurement detector (optionally a photodiode operative to detect electromagnetic radiation in the infra-red region of the electromagnetic spectrum), and a shade 130 associated with the second detector 128. The shade 130 serves to protect the second detector 128 from stray light so as to prevent false readings caused by stray light being incident upon the second detector 128 from sources other than the second emitter 126.

The reflectance measuring apparatus 104 is configured such that the second emitter 126 and second detector 128 are oriented to face the measuring region 108. Second emitter 126 is operative to illuminate the measuring region 108 with electromagnetic radiation (denoted by arrow IL2 in the figure), and second detector 128 is oriented and operative to receive electromagnetic radiation (denoted by arrow RL in the figure) reflected from the portion of the item 106 located in the measuring region 108.

In an optional arrangement, the authentication apparatus 100 may comprise a path along which an item may be conveyed. The measuring region 108 forms part of this path. Thus, in this particular arrangement, the item may be conveyed along the path from one side of the authentication apparatus 100 to the other and, during its transit, pass through the measuring region 108. That is, in this optional arrangement, the item to be authenticated may be moved relative to the authentication apparatus 100 or vice versa. Such an optional arrangement will be described in more detail in relation to Fig. 7. In another optional arrangement, authentication measurement may take place when an item is static. That is, the item may be introduced to an item location region (of which the measuring region 108 forms part) of the authentication apparatus 100, where the item is held until an authentication measurement has taken place. Such an optional arrangement will be described in more detail in relation to Figs. 8a and 8b.

In operation, the item 106 is introduced into the authentication apparatus 100 such that a portion of the item 106 will be located in the measuring region 108. At that time, illuminating electromagnetic radiation IL2 from second emitter 126 is incident upon the portion of the item 106 located in the measuring region 108. At least a portion of the illuminating electromagnetic radiation IL2 incident upon the item 106 in the measuring region 108 will be reflected by the portion of the item 106 in the measuring region 108. This reflected electromagnetic radiation RL is reflected toward second detector 128. As it nears the second detector 128, it will pass through an aperture of shade 130 and is then detected by second detector 128. The second detector 128, responsive to detection of reflected electromagnetic radiation RL incident thereon, outputs a signal proportional to the intensity of received reflected electromagnetic radiation RL to the processing means (not shown).

The processing means, upon receiving an output signal from the second detector 128, is operative to compare a value of the received signal with a set of pre-defined values stored in a database (not shown). These pre-defined values may correspond to expected reflected electromagnetic radiation values when one or more of: a printed region of an item is located in the measuring region 108; an unprinted region of an item (e.g. a window region) is located in the measuring region 108 (where the film substrate of the item is genuine); an unprinted region of an item (e.g. a window region) is located in the measuring region 108 (where the film substrate of the item is not genuine); and no banknote is located in the measuring region 108.

The processing means may be arranged to transmit an output signal to one or more visual or audio alert systems based upon output signals received from said first detector 114 and second detector 128.

Therefore, in an optional arrangement, if no item is present in the measuring region 108, the processing means may issue an output signal to control a visual alert system to display a first visual alert (e.g. a red light) and an audio alert system to output a first audio alert (e.g. a buzzer). If a printed region of an item is present in the measuring region 108, the processing means may issue an output signal to control a visual alert system to display a first visual alert (e.g. a red light) and an audio alert system to output a first audio alert (e.g. a buzzer). If a window region of an item is present in the measuring region 108 and where the film substrate forming the item is genuine (as determined by the birefringence measuring apparatus), the processing means may issue an output signal to control a visual alert system to display a second visual alert (e.g. a green light) and an audio alert system to be silent. If a window region of an item is present in the measuring region 108 and where the film substrate forming the item is non-genuine (as determined by the birefringence measuring apparatus), the processing means may issue an output signal to control a visual alert system to display a first visual alert (e.g. a red light) and an audio alert system to output a first audio alert (e.g. a buzzer).

This apparatus 100 may be implemented in, for example, a banknote counting system. The processing means may be operative to output a signal to a counting device only when the signals received from the birefringence measuring apparatus 102 and the reflectance measuring apparatus 104 are indicative that a window region of the item 106 is located in the measuring region 108, and that the film substrate forming the window region is authentic. However, no signal may be output when the signals received from the birefringence measuring apparatus 102 and the reflectance measuring apparatus 104 are indicative that a window region of the item 106 is located in the measuring region 108, but that the film substrate forming the window region is not authentic. That is, a count made by the counting device may be altered only when a genuine window region is registered in the measuring region 108.

In the illustrated arrangement of Figs 4 and 5, the first emitter 110 comprises a light emitting diode (LED) which is operative to emit white light and the first detector 114 comprises a photodiode operative to detect white light.

Further, the second emitter 126 comprises an LED which is operative to emit electromagnetic radiation at wavelengths corresponding to the infra-red (IR) region of the electromagnetic spectrum. Optionally, the LED is operative to emit electromagnetic radiation with wavelengths about 890nm.

The second detector 128 in the illustrated arrangement comprises a photodiode operative to detect electromagnetic radiation at wavelengths corresponding to the IR region of the electromagnetic spectrum and, optionally, to detect electromagnetic radiation with wavelengths between about 880nm and 1140nm.

Of course, in further optional arrangements, the second emitter 126 and second detector 128 may be operative to emit and detect electromagnetic radiation at other wavelengths in the electromagnetic spectrum.

In the arrangement where the LED of the second emitter 126 is operative to emit electromagnetic radiation having wavelengths of about 890nm, the photodiode of the second detector 128 is operative to generate a voltage of approximately 350mV max upon the detection of light between 880nm and 1140nm.

The sensitivity of reflectance measuring apparatus 104 is dependent upon the angle of the second emitter 126 and second detector 128 to one another, the distance and angle of the measuring region 108 relative to the second emitter 126 and second detector 128, the levels of ambient light and the size of the shade 130.

The shade 130 in the illustrated arrangement comprises a tubular element (optionally a black tube). The second detector 128 may be located at, or near, one end of the tubular element on a first side of the shade 130 (or (or within the tubular element near a first side of the shade 130). The tubular element is located and oriented relative to the second emitter 126 and measuring region 108 such that reflected electromagnetic radiation RL reflected from the measuring region 108 enters the tubular element at a mouth portion thereof. After entering the tubular element via mouth portion, the reflected electromagnetic radiation RL travels along tubular element to the second detector 128. The length and diameter of the tube determine the angle range of incident electromagnetic radiation that is admitted to the second detector 128 (i.e. the longer and narrower the tube is, the narrower the angle range of incident electromagnetic radiation that is admitted). An arrangement such as this can differentiate between a polymer window, a printed surface and air due to differences in the gloss of each of these materials.

With the gloss measurement (i.e. the measurement performed by the reflectance measuring apparatus 104) in place, the authentication apparatus 100 now has the information that the birefringence is either low or high and that there is the presence or absence of a window. Optionally, the reflective gloss system is positioned on the opposite side of the polarisation system from the first emitter 110, to reduce or inhibit the impact of light leakage from the first emitter 110 into the infra-red detector (light is only permitted through the films when there is a highly birefringent film between them, at this point light leakage into the infra-red detector is unimportant because there will actually be a window present).

The width of the spacing between the reflectance measuring apparatus 104 and the item to be authenticated will affect the accuracy of the window presence detection system (i.e. reflectance measuring apparatus 104). There may be a trade-off between the minimum practical width of the item slit, to ensure the flattest possible reading and the range of angles accepted by the second detector (the wider the range accepted, the greater the danger of false signals).

An issue of consequence for component placement is the vertical position and size of the first emitter, 110, first detector 114, second emitter 126 and second detector 128. Item windows (e.g. banknote windows) are not always in the same place vertically and, whilst a swiping system (e.g. as illustrated in Fig. 7) would take into account the horizontal placement of the window, the vertical placement of the window in the item would need to be taken into account also. To counter this, in an optional arrangement, two or more positions of the item surface could be measured and/or the emitters and detectors could be movable. As is illustrated in Figs. 4 and 5, the emitters and detectors are mounted on rails 118, 122. To allow flexibility of the authentication apparatus 100 where it is to be used to authenticate items such as, for example, banknotes (where the window region locations in notes may be different for different denominations or where window region locations in notes may be different for different countries), the rail system could allow an initial adjustment to be made to the specified height, and then the emitters and detectors could be fixed at that height.

Optionally, multiple emitters and detectors may be mounted on the same rail and/or longer detector arrays and emitter sources could be employed.

Fig. 6 is a schematic circuit diagram for the authentication apparatus 100. Features such as, for example, capacitors, resistors, etc. are omitted to aid clarity.

The circuit comprises a power source 131 which is operative to power the first emitter 110, second emitter 126 and processor 132.

First detector 114 and second detector 128 are coupled to the processor 132 (optionally a microcontroller) so that output signals output by these devices are received by the processor 132. An output signal from first detector 114 is fed into gate 2 of the processor 132 and an output signal from second detector 128 is fed into gate 1 of the processor 132.

Either one, or both, detectors 114, 118 optionally may have coupled between the output(s) thereof and the processor 132 a variable resistor. This may provide a means to control the level of signal from the optical systems, thus allowing for calibration of the apparatus.

An alert system 134 is coupled to the processor 132. The alert system comprises a visual alert element (i.e. a green LED 136 and a red LED 138 in the illustrated arrangement), and an audio alert element (i.e. a buzzer 140 in the illustrated arrangement). These are coupled to gates 3, 4 and 5 of the processor 132. Of course, other elements may be used in addition to, or in place of those illustrated in an alert system in other optional arrangements.

Table 1 below summarises the inputs and outputs which describe the behaviour of the elements of the illustrated circuit when the apparatus is used in relation to banknotes.

Table 1. Summary of circuit element behaviour

Condition	Detector		Gate					Result
	First detector 144 (birefringence)	Second detector 128 (reflectance, i.e. window detection)	1	2	3	4	5	
No note	low	low	0	0	1	1	0	Red light and buzzer
Non-window (e.g. printed region)	low	high	0	0	1	1	0	Red light and buzzer
Authentic window	low	medium	1	0	0	0	1	Green light
Non-authentic window (i.e. counterfeit film)	high	medium	1	1	1	1	0	Red light and buzzer

The presence of a window results in a reflective signal between that of no window and the presence of a note in intensity. Thus, the reflectance measuring apparatus must be able to differentiate between the three states (i.e. no note, window region of note, or printed region of note present in measuring region) to enable the authentication apparatus to function to output a signal only when a window region of a note is present in the measuring region. This may be useful as a mechanism to control power use of the apparatus, i.e. the presence of a window region of a note acts as a switch to turn on the apparatus to conduct a birefringence measurement. Otherwise, the apparatus may remain (or revert) to a standby mode.

The operation of the authentication apparatus may be summarised as follows. Electromagnetic radiation signals (e.g. light signals) are measured from when the authentication apparatus is turned on. When an item (e.g. banknote) edge enters the measuring region, there is likely to be a fluctuation or change in the measurement readings being taken by the reflection measuring apparatus. There is likely to be a further fluctuation or change when a window region of the item passes through the measuring region. When this occurs, the birefringence measurement performed at that time is noted. If the birefringence measurement is relatively low, the authentication apparatus indicates that the item is authentic. However, if the birefringence measurement is relatively high, the authentication apparatus indicates that the item is counterfeit. Thus, an item will be deemed genuine, once a window has been detected in the measuring region, and the birefringence measurement performed, and the birefringence measurement value is indicative that the note is authentic. Failure to detect any window may result in no output being generated by the authentication apparatus.

Fig. 7 illustrates a device 142 which may be suitable for authenticating banknotes. The device 142 includes the authentication apparatus 100 in any one or more of the arrangements described above. The device 142 may be suitable as a portable hand-held device.

The device 142 comprises a substantially U-shaped unit with a slot 144 through which banknotes may be conveyed (e.g. "swiped"). Optionally, the slot depth is 40mm (approximately half the size of larger denomination polymer film substrate banknotes in circulation in one or more countries). As the window region of the banknote passes the birefringence measuring apparatus of the authentication apparatus located inside the device 142, the signal output by the authentication apparatus is conveyed to an illumination device which is operative to illuminate the device with either a green or red light depending on the birefringence reading of the window. For example, if the banknote is formed from an authentic polymer film, the device 142 may be illuminated with green light. However, if the banknote is formed from a non-authentic polymer film, the device 142 may be illuminated with red light.

The dimensions of the device 142 may depend upon the size of the electronics and power source that are required to allow the device to function. However, a required dimension is that of the slot height. The slot 144 must be of sufficient depth so that, as a banknote is conveyed through the slot, the window of the banknote passes between the upstanding portions of the device 142 either side of the slot 144 (and thus between the elements of the birefringence measuring apparatus and the reflectance measuring apparatus). Another required dimension will be that of the slot width, which should be a compromise between a narrow enough slot to maintain banknote flatness during passage through the slot 144 for an accurate result and a wide enough slot to allow ease of passage of the banknote through the slot 144. Optionally, a slot width of between about 0.5 – 1mm may be employed. Further optionally, the slot 144 may comprise curved entry and/or exit points to assist insertion of a banknote end into the slot 144 and/or to assist removal of the banknote from the slot 144.

Figs. 8a and 8b illustrate another optional authentication apparatus arrangement. In this arrangement, the authentication apparatus may be suitable for banknote authentication when the banknote is static.

In this arrangement, there is provided a positioning bund 146 which comprises a surface for receiving the banknote thereon. The positioning bund 146 comprises a note template 148 provided thereon. For example, the note template 148 may be engraved into the surface of the positioning bund 146 such that a recessed region is formed in the surface of the positioning bund 146. This recessed region may be of similar dimensions to a banknote and is shaped to receive a banknote therein.

Therefore, in use, the banknote 150, comprising one or more printed surface features 152 and a window region 154 is placed on the note template 148 of the positioning bund 146 and guided into position (see arrow A) using raised edges formed at the edge of the recessed region. Elements of the authentication apparatus are located above and below the positioning bund so as to take measurements of a portion of the banknote 150 located in the measurement region 108 of the positioning bund 146. The measurement region 108 is located with respect to the positioning bund 146 so as to be coincident with the window region of a banknote when such a banknote is located on the positioning bund 146. The reflectance measuring apparatus of the authentication apparatus detects when a window region of a banknote is in place in the measuring region 108 and the authentication apparatus is then operative to perform birefringence measurement on the window region 154.

To enable the illustrated arrangement to be suitable for different denominations and/or different currencies (which are likely to be of different sizes), a series of banknote outline templates could be provided (e.g. engraved) on the positioning bund. A user could hold a banknote against the appropriate banknote outline. This could be done, for example, by using raised edges at the top and either left or right of the positioning bund 146 to guide the note into position (depending on where the windows are more consistently positioned).

Different sizes and positions of windows could be accommodated, in optional arrangements, by providing multiple birefringence measurement positions.

Figs. 9a and 9b illustrate top and side views of an authentication apparatus according to another optional arrangement. This arrangement may be suitable for a moving system, i.e. one where an item (e.g. a banknote) is moved relative to the authentication apparatus (or vice versa).

In the illustrated arrangement, there is shown an banknote 150 being conveyed in a direction indicated by arrow B relative to a birefringence measuring apparatus 102, and through a measuring region 108. In the illustrated arrangement, the birefringence measuring apparatus 102 comprises an array of birefringence measuring elements across the measuring region width. These sensors birefringence measuring elements are operative to indicate whether birefringence of a portion of the banknote 150 in the measuring region 108 is high or otherwise. The illustrated arrangement further comprises a note detector arrangement 156 located adjacent to the birefringence measuring apparatus 102. This note detector arrangement 156 is operative to emit, from an emitter 158, or array of emitters (item detection emitters) an electromagnetic radiation beam toward the banknote transport path. A detector 160, or array of detectors (item detection detector) are located, and operative, to receive electromagnetic radiation from said electromagnetic radiation beam transmitted across said banknote transport path and/or reflected from said transport path. Therefore, when a banknote enters the region of the banknote transport path illuminated by the electromagnetic radiation beam emitted by the emitter 158 of the note detector arrangement 156, the presence of the banknote is detected by the note detector arrangement 156. That is, when a banknote is present in the transport path, the electromagnetic radiation beam emitted by emitter 158 may be reflected by the banknote and received at a detector located to receive reflected electromagnetic radiation, or the beam may be attenuated as it passes through the banknote, and a detector located to receive transmitted electromagnetic detection may detect a decrease in the transmitted electromagnetic radiation being received (due to presence of the banknote in the beam). Thus, the note detector arrangement 156 may be operative to detect presence or otherwise of the banknote 150 by reflection of the irradiating electromagnetic radiation beam when the banknote 150 is present and/or by a reduction in the intensity of the transmitted irradiating electromagnetic radiation beam (due to presence of the banknote in the beam). Therefore, when a banknote 150 cuts the irradiating electromagnetic radiation beam, the note detector arrangement 156 detects the presence of the banknote 150. The note detector arrangement 156 is operative to control operation of the birefringence measuring apparatus 102 such that the birefringence measuring apparatus 102 performs measurements only when a banknote is present.

A reflectance measuring apparatus optionally may be present or may not be present. In an optional arrangement without the reflectance measuring apparatus, the birefringence measuring apparatus is operative to detect low/high birefringence readings at all times, but decisions are only made when the note detector arrangement presence sensor detects a note.

In such a “transmission only” arrangement, i.e. birefringence measurement but not reflectance measurement, the apparatus is operative to determine that a window is present in the measuring region by noting the signal of the detector(s) of the birefringence measurement apparatus. A background signal will result in a comparatively medium-level output signal from the detector(s). When a printed portion of a banknote is present in the measuring region (i.e. printed region blocks detector(s)), this will result in a comparatively low-level output signal from the detector(s). When a window region of a banknote is present in the measuring region (background signal plus birefringence), this will result in a comparatively high-level output signal from the detector(s) when a counterfeit banknote is present and a comparatively low-level output signal when an authentic window is present. Fig. 9c illustrates the detector(s) response when various portions of a counterfeit banknote are measured using the apparatus. As can be seen from Fig. 9c, when a printed portion of a banknote is present in the measuring region, the illuminating radiation emitted by the emitter(s) is blocked by the printed portion of the banknote and very little of the illuminating radiation is transmitted through the banknote to reach the detector(s). When a window region of the counterfeit banknote is present in the measuring region, the output signal from the detector(s) is comparatively high, and the apparatus is operative to output a signal that that the banknote is counterfeit.

In optional arrangements, there may be one or two or even a complete row of note detectors. They could be transmissive (as illustrated in Fig. 9b) or reflective. The electromagnetic radiation emitted by an emitter of the note detector arrangement may be white light or even a narrow band infra-red light.

Table 2 below illustrates a decision table for the elements of the authentication apparatus of the optional arrangement illustrated in Figs. 9a and 9b.

Table 2

Birefringence measuring apparatus output	Note detector arrangement output	Authentication apparatus output
High	No banknote present	No output
Low	No banknote present	No output
High	Banknote present	Fail (banknote counterfeit)
Low	Banknote present	Banknote authentic

The arrangement of Figs. 9a to 9c may be used in combination with the features of the arrangements illustrated in Figs. 7 or Figs. 8a and 8b, and as described above.

The parameters which may be relevant to a reflectance measuring apparatus forming part of an authentication apparatus according to one or more embodiments of the present invention will now be discussed. Since the reflectance measuring apparatus is operative to measure the reflected signal from a polymer surface, it is desirable that the reflections are be specular and from as narrow an angular range as possible to ensure that only reflections from film that is in the measurement region are accepted.

In the following description, any reference to "light" is intended to include electromagnetic radiation in both the "visible" part of the electromagnetic spectrum and also the "invisible" part of the electromagnetic spectrum.

Shade Aperture

In those arrangements in which the detector of the reflectance measuring apparatus is protected by a shade, the dimensions of a shade aperture should be considered. In some optional arrangements, the shade aperture may simply comprise a hole or slit in the shade. In other optional arrangements, the shade aperture may comprise a tube which, optionally, is composed of, or lined with, a non-reflective material.

The aperture width determines the amount of electromagnetic radiation rays collected at any angle, but is indiscriminate as to the origin of these rays and so does not help eliminate noise from ambient electromagnetic radiation sources or scatter.

The "set-back distance" (i.e. the distance between the second detector and the item-side of the shade aperture – the "aperture mouth") is related to the accuracy of the apparatus. A large distance between the aperture mouth and the second detector will mean that only very precisely angled light will travel the length of the aperture tube to the second detector.

The set-back distance may be limited by the physical constraints of the device inside which a detector such as this would be fitted.

The accuracy of the apparatus may also be dependent upon the aperture width. That is, accuracy of the apparatus may depend on the ratio of the aperture width to the set-back distance. Therefore, in larger devices in which a larger set-back distance can be employed, a larger aperture width may be used. However, for more constrained, smaller devices, in which the set-back distance may be small, a narrower aperture should be used. Consequently, this will mean a reduction in the rays collected and therefore sensitivity of the device.

The aperture of the shade is designed to exclude high angle light. It does this via the use of a narrow opening with the second detector offset, or "set-back" from the opening. There are two optional arrangements which may be suitable: a black tube, which will absorb stray radiation in its walls (i.e. an arrangement such as that illustrated in Fig. 4 and as described above); and an open space behind the aperture where high angle light will be propagated out of the range of the second detector.

These optional arrangements are illustrated schematically in Figs. 10a and 10b. The optional arrangements can be simplified (for the process of performing calculations) to the arrangement illustrated in Fig. 10c.

Referring to Fig. 10c, w is the aperture or tube width and l is the offset or "set-back" distance of the second detector from the aperture. The tube based design may be a more efficient one when the second detector is wider than the aperture/tube diameter. For an aperture design, if the second detector is wider than the aperture, then the range of light angles that are accepted by the second detector will be greater and for the following calculations, w would become the second detector width.

The exception to this is the accuracy of the device, which is proportional to the entrance width for the optical system.

The angle at which light entering the system is at its maximum intensity, θ_{max} is:

$$\theta_{max} = \tan^{-1}\left(\frac{w}{l}\right) \quad (1)$$

At angles higher than this, light rays that enter the optical system can reach only a fraction of the area of the second detector and so can be regarded as losing their intensity proportional to the angular area of the second detector they are incident upon.

This area, A_z, can be calculated by first setting an exclusion diameter, z, at the centre of the aperture's cross-sectional area. From z, the area of a central zone that cannot be accessed by higher angle light can be calculated and then subsequently subtracted from the overall slit angle to produce a result (which is effectively a ring with an inner diameter of z and an outer one of w).

The following equations show this:

$$\theta_z = \tan^{-1}\left(\frac{w+z}{l}\right) \qquad (2)$$

$$A_z = \frac{\pi}{4}[w^2 - z^2] \qquad (3)$$

where θ_z is the angle in question. If θ_z is plotted against A_z for an aperture of diameter = 2mm and a length of 10mm and normalise the result, the graph illustrated in Fig. 11 is obtained.

As can be seen, for a system such as this, incident light at less than about 11.5° will be accepted at its full intensity, which will decrease at higher angles, dropping to zero at about 22°.

From this, it is possible to determine the maximum angle of light that can be accepted by the system and when the efficiency of the system begins to decrease.

Incident Angle

In general, reflection of incident rays decreases slightly with increased incident angle until the Brewster angle is reached (44-54°), after which point reflection increases sharply. However, this is a gross simplification for semi-transparent materials such as BOPP films or pigment filled inks used in film coatings. In reality, such materials have many optical surfaces below the top physical one.

The presence of embedded materials such as pigments which often have substantially different absorbent and reflective properties will cause a material to have substantially different reflective properties across a series of angles.

The angle of incidence to be used for the gloss measurement can be determined by considering the theoretical reflectivity of a surface for the s and p polarisation states:

$$R_s = \left[\frac{\sin(\theta_t-\theta_i)}{\sin(\theta_t+\theta_i)}\right]^2 = \left[\frac{n_1\cos(\theta_i)-n_2\cos(\theta_t)}{n_1\cos(\theta_i)+n_2\cos(\theta_t)}\right]^2 \quad (4)$$

$$R_p = \left[\frac{\tan(\theta_t-\theta_i)}{\tan(\theta_t+\theta_i)}\right]^2 = \left[\frac{n_1\cos(\theta_t)-n_2\cos(\theta_i)}{n_1\cos(\theta_t)+n_2\cos(\theta_i)}\right]^2 \quad (5)$$

Where θ_i = incident angle, θ_t = transmitted angle, n_1 and n_2 = refractive index of media 1 and media 2 respectively.

For a randomly polarised material, the s and p reflections are averaged together to obtain a theoretical reflectivity for a typical light source. The graph illustrated in Fig. 12 illustrates a theoretical reflectivity of a hypothetical polypropylene surface with a refractive index of 1.49.

As can be seen from Fig. 12, the s polarisation state dominates the lower angles, with the p state reflecting very poorly until the Brewster angle ($\tan^{-1}(n_1/n_2) = 56.3^o$) is exceeded. The use of a non-polarised light source avoids the potential failure of the process at the Brewster angle, where the signal will be zero.

In experiments to determine the viability of the reflectance measuring apparatus of the authentication apparatus, the angles used were about 45^o to about 60^o. Using such angles, the reflectivity was between about 5% and about 9%.

As noted above, the reflectivity of the printed areas will be more complex due to the presence of pigmented material under the surface. Firstly, if the surface of the printed area is as flat as the non-printed area, then the overall reflectance could be calculated using equations (4) and (5) but with an additional value that takes into account the reflectivity of pigments under the surface of the ink. As pigments are generally small and well dispersed, this is taken to be a reasonable assumption.

Pigments are designed to absorb parts of the electromagnetic spectrum and reflect others. An ideal pigment will reflect as much light as it can whilst still maintaining its target colour – otherwise it will be quite dull. Conveniently, for the process performed by the apparatus of one or more embodiments of the present invention, both pigments in general and especially banknote pigments are dull. Coupled with this, pigments reflect light in all directions (otherwise it would not be possible to see them unless they are viewed at an angle equal to the incident angle of the ambient light in the environment). This means that, at any one angle, only a portion of the reflected light is seen. Add these two factors together and it means that a great deal of difference between the reflectivities of the printed and unprinted areas would not be expected, except at low angles (<30°) where pigment reflection will make the printed areas reflect more and at angles greater than the Brewster angle, when top surface (and bottom surface in the case of unprinted film) reflections are expected to dominate over pigment reflections making the unprinted areas more reflective..

In an experiment to measure gloss using the reflectance measuring apparatus forming part of the authentication apparatus according to one or more embodiments of the present invention, an Australian $50 banknote was passed through the measuring region of the reflectance measuring apparatus to mimic a banknote sorting system.

Fig. 13 illustrates the intensity profile detected when the Australian $50 banknote is passed through the reflectance measuring apparatus forming part of the authentication apparatus according to one or more embodiments of the present invention.

In the figure, the straight line X illustrates where the apparatus scanned the banknote, and the other line Y illustrates the voltage signal output by the second detector of the reflectance measuring apparatus.

The pigmented regions of the note reflect more (although not much more) than the window region Z, and are not affected much by the colour of the note (although the colours on this particular note are relatively plain). This experiment was conducted at an angle 60°, where a 9% reflectivity from the film would be expected. If the angle is reduced, then the importance of the pigment in the reflection will increase and vice versa.

It is clear from the graph that the edge of the note can be detected (i.e. the steep increase of the curve (denoted by Y_1) at the right-hand side of the figure). Also, the window region Z of the note can be detected – note the decrease in the voltage profile (denoted by Y_2) which is coincident with the location of the window region Z.

<u>Second detector "Stand-off" Distance/Divergence/Second detector signal</u>

Light from most sources is highly divergent (the exceptions being laser light and starlight) and therefore any ideal incident ray/reflected ray models quickly break up with increased distance of the second detector from the point of reflection. The centre of any divergent light source will still contain the ideal rays, but the greater the distance of the second detector from the point of reflection, the less intense the received reflected rays will be.

Therefore, it will be appreciated that increased divergence of illuminating rays and/or increased distance of the second detector from the point of reflection will decrease the signal strength of the reading from the second detector because the intensity of the received reflected rays will be less.

However, if a second detector is close to a surface (and thus, the point of reflection) then it will gather light from a broader range of angles. This may lead to the second detector receiving unwanted rays and thus affect the value of the signal output by the second detector.

Reflectance measuring apparatus forming part of the authentication apparatus according to one or more embodiments of the present invention may require the second detector to collect reflected rays from precise angles.

It will be appreciated from the above, therefore, that increasing the distance between the second detector and an item surface will increase its accuracy (because the likelihood of the second detector gathering light from a broader range of angles is reduced). However, increasing the distance between the second detector and an item surface will also reduce the intensity of reflected rays received by the second detector.

Additionally, decreasing divergence of the illuminating source (i.e. the second emitter) will also increase accuracy of the reflectance measuring apparatus as the decreased divergence may result in fewer stray reflections. Therefore, in an optional arrangement, the second emitter comprises a laser light source.

Photodiodes generate a voltage that is proportional to the intensity of light that falls upon them. The intensity of light (which must not be confused with radiant intensity) can be calculated from the irradiance of a light source which is given by:

$$I_o = \frac{P\pi d^2}{4} \qquad (6)$$

where I_o is the irradiance (W/mm^2) at the light source, P is the power of the light source (W) and d is the diameter of the light source (mm).

However, it is the irradiance at the second detector rather than the source (i.e. the second emitter) that is of interest. To establish this, the path length between the light source and the second detector (collectively the "probes") must be calculated. The relationship between path length, l_{path}, and stand-off distance, z_{probe}, is as follows:

$$l_{path} = \frac{2z_{probe}}{\cos\theta_{probe}} \quad (7)$$

where θ_{probe} is the angle at which the light source and the second detector are set relative to the surface (the angle between the two will be double this). This distance is the distance between light source and second detector.

The diameter of the beam at the second detector (e.g. photodiode), d_{photo}, can be calculated by the following:

$$d_{photo} = d + 2l_{path}\tan\theta_{div} \quad (8)$$

where d is the diameter of the light source and θ_{div} is the divergence of the light source (which will be quoted as part of the technical specification of the light source).

The intensity at the second detector can then be calculated as:

$$I_{div} = \frac{P\pi d_{photo}^2}{4} = \frac{P\pi(d+2l_{path}\tan\theta_{div})}{4} \quad (9)$$

The intensity drop between source and second detector can therefore be calculated by:

$$Intensity\ Drop = \frac{I_{div}}{I_0} = \frac{d_{photo}^2}{d^2} \qquad (10)$$

Any calculation of stand-off distance must therefore take into account the drop off in intensity from the light source to the second detector which is a product of the angles involved and the path lengths of the light. The limits of this will be determined by the light source intensity, the second detector sensitivity and the ambient light noise levels.

The light emitted by the light source has three separate conditions with respect to the second detector:

If $d_{photo} > w$, then the second detector is too far from the measuring region and useful low angle light is being lost.

If $d_{photo} = w$, then the second detector is at the correct distance from the measuring region.

If $d_{photo} < w$, then the second detector is too close to the measuring region and higher angle light than the second detector is designed to accept can find its way into the second detector.

Equations (7) and (8) can be rearranged to give equations (11) and (12) which show how the optimal stand-off distance, z_{probe}, can be calculated for a divergence angle and a device angle (11); and how the optimal device angle can be calculated for a stand-off distance and divergence angle (12):

$$z_{probe} = \frac{(w-d)\cos\theta_{probe}}{4\tan\theta_{div}} \qquad (11)$$

$$\theta_{probe} = \cos^{-1}\left(\frac{4\, z_{probe} \tan\theta_{div}}{(w-d)}\right) \qquad (12)$$

From (11), it may be appreciated that, the lower the light source divergence, the further the possible stand-off distance.

Resolution of the Edge Detection

Another consideration with the reflectance measuring apparatus forming part of the authentication apparatus according to one or more embodiments of the present invention may be the accuracy of the edge detection, which is a function of the size of w, i.e. the size of entrance aperture/tube diameter. In practice, the resolution of detection will be slightly smaller than the aperture size as the reflected light will diverge as it travels from the film to the aperture.

First, the path length must be calculated. This uses a similar equation to that shown in equation (7). However, this path length is from the surface of the film only and from the aperture to the film instead of from the film to the detector:

$$l_{reflected} = \frac{z_{aperture}}{\cos\theta_{probe}} \qquad (13)$$

where $l_{reflected}$ is the reflected path length and $z_{aperture}$ is the distance between the film surface and the aperture.

From this, it is possible to calculate the width of the ray, d_{res} that would be accepted by an aperture of $d_{aperture}$ width and over a path length of l_{ref}. The method is the reverse of equation (8), substituting in the new widths and path lengths that describe the reflected light:

$$d_{res} = d_{aperture} - 2l_{ref}\tan\theta_{div} \qquad (14)$$

The resolution would therefore be greater than the aperture – which could be considered as the minimum resolution of the system.

Wavelength

Wavelength of the illuminating rays may alter the behaviour of reflections with respect to surface roughening (i.e. altered interference).

In an optional arrangement, an IR emitter is used. This may improve accuracy of the apparatus because the second detector in such an arrangement is IR ray sensitive and so may be unaffected by interference from ambient light sources. However, in other optional arrangements, second emitters operative to emit electromagnetic radiation from other parts of the electromagnetic spectrum may be suitable. In such cases, the second detector may be protected from stray rays by, for example, a shade.

Item or Bank Note Angle

Although in the ideal situation, the angle of the item or banknote to the second detector will always be the same, in reality this will not always be the case. For example, the banknote may contain creases, or draughts may cause "flutter" of the note in the measuring region. Variations in note to second detector angle will alter the angle of the desired reflection. To counter this, the angular range of second detector acceptance can be increased (through shortening the set-back distance). However, this may decrease the accuracy of the device, so a suitable balance between these conflicting parameters will need to be achieved.

The variance in the reflectivity angle caused by the above-described example phenomena may be plus or minus a few degrees. Such a variance could be accounted for in an optional arrangement by employing an interpretation module in the apparatus to effectively remove second detector readings caused due to variance in reflectivity angle.

Fig. 14 schematically illustrates a top view of an emitter-detector-item arrangement of the reflectance measuring apparatus for use in an optional arrangement of the authentication apparatus of one or more embodiments of the present invention. To aid clarity, a birefringence measurement apparatus of the authentication apparatus is not shown.

The reflectance measuring apparatus 300 comprises a second emitter 302, second detector 304, processing means 306 electronically coupled to second detector 304 by signal line 308, and a shade 310 associated with the second emitter 302 and second detector 304. The shade 310 will be described in more detail later.

The reflectance measuring apparatus 300 is configured such that the second emitter 302 and second detector 304 are oriented to face a measuring region 311. Second emitter 302 is operative to illuminate the measuring region 311 with electromagnetic radiation (denoted by dotted arrow IL in the figure), and second detector 304 is oriented and operative to receive electromagnetic radiation (denoted by dotted arrow RL in the figure) reflected from a portion of an item located in the measuring region 311.

Optionally, the authentication apparatus may comprise a path along which an item may be conveyed. The measuring region 311 forms part of this path. Thus, in this particular arrangement, the item may be conveyed along the path from one side of the authentication apparatus to the other and, during its transit, pass through the measuring region 311.

In the illustrated arrangement, the item comprises a banknote 312.

The shade 310 in the illustrated arrangement comprises a main body element in which are provided a second emitter tube 314a and a second detector tube 314b. The second emitter 302 is located at, or near, one end of second emitter tube 314a on a first side of the shade 310. The second detector 304 is located at, or near, one end of second detector tube 314b on the first side of the shade 310. Illuminating electromagnetic radiation IL emitted by second emitter 302 travels through second emitter tube 314a and emerges from the second emitter tube 314a at a mouth portion thereof. The mouth portion is located on a second side of the shade 310. Second detector tube 314b is located and oriented within the shade 310 relative to the second emitter tube 314a and measuring region 311 such that reflected electromagnetic radiation RL reflected from the measuring region 311 enters second detector tube 314b at a mouth portion thereof. The mouth portion of the second detector tube 314b is located on a second side of the shade 310. After entering the second detector tube 314b via mouth portion, the reflected electromagnetic radiation RL travels along second detector tube 314b to second detector 304.

In operation, the banknote 312 will be conveyed along the path in a direction from the left-hand side to the right-hand side of the figure (i.e. as indicated by arrow C). The instance illustrated in Fig. 14 shows the banknote 312 with a portion thereof located in the measuring region 311. Illuminating electromagnetic radiation IL from second emitter 302 passes through second emitter tube 314a and exits the second emitter tube 314a from the mouth portion thereon. After exiting the second emitter tube 314a, the illuminating electromagnetic radiation IL is incident upon the portion of the banknote 312 located in the measuring region 311. At least a portion of the incident illuminating electromagnetic radiation IL will be reflected by the banknote 312. This reflected electromagnetic radiation RL is reflected toward mouth portion of second detector tube 314b, from where it enters second detector tube 314b and continues thereafter to second detector 304. The second detector 304, responsive to detection of reflected electromagnetic radiation RL incident thereon, outputs a signal proportional to the intensity of received reflected electromagnetic radiation RL via signal line 308 to processing means 306.

Processing means 306, upon receiving an output signal from the second detector 304, is operative to compare a value of the received signal with a set of pre-defined values stored in a database (not shown). These pre-defined values may correspond to expected reflected electromagnetic radiation values when one or more of: a printed region of a banknote is located in the measuring region 311; an unprinted region of a banknote (e.g. a window region) is located in the measuring region 311; no banknote is located in the measuring region 311. The processing means may use this signal, in conjunction with a signal received from the birefringence measuring apparatus (not shown) to output a signal indicative of whether or not the banknote is authentic or not.

As the banknote 312 continues its passage through the reflectance measuring apparatus300, the processing means 306 receives a number of readings from the second detector 304. Optionally, the birefringence measuring apparatus performs its measurement only when a window region is located in the measuring region 311 (i.e. the operation of the birefringence measurement may be based on the signal output by the reflectance measuring apparatus).

This apparatus 300 may form part of an authentication apparatus implemented in, for example, a banknote counting system. The processing means 306 may be operative to output a signal to a counting device only when a genuine banknote passes through the authentication apparatus.

In optional arrangement, the shade 310 may comprise an injection moulded part (optionally a single injection moulded part) which, further optionally, comprises an absorbent black pigmented polymer such as, for example, polyethylene, nylon or polypropylene.

The second emitter 302 may optionally comprise an LED and/or a laser of a number of different wavelengths. Optionally, the wavelength of the illuminating electromagnetic radiation IL may be in the IR region of the electromagnetic spectrum, e.g. about 890nm.

The second detector 304 may optionally comprise a photodiode configured to provide a broad spectrum second detector (e.g. operative to detect reflected rays having wavelengths in the range of about 400nm to about 1140nm). In a particular optional arrangement, the second detector may be operative to detect reflected rays having wavelengths in the range of about 880nm to about 1140nm.

Fig. 15 schematically illustrates a top view of an emitter-detector-item arrangement of the reflectance measuring apparatus for use in an optional arrangement of the authentication apparatus of one or more embodiments of the present invention. Again, to aid clarity, a birefringence measurement apparatus of the authentication apparatus is not shown.

Features similar to those illustrated in Fig. 14 are also illustrated in Fig. 15. In Fig. 15, the features common with those Fig. 8 are now designated with reference numerals of the type 4XX rather than 3XX. Thus, in Fig. 15, the reflectance measuring apparatus is denoted by reference number 400 (rather than 300), the second emitter, by reference number 402 (rather than 402) and so on.

The arrangement illustrated in Fig. 15 is similar to that of Fig. 14 except for the replacement of a single second emitter and single second detector with multiple second emitters and multiple second detectors. Thus, in Fig. 15, three second emitters 402a, 402b, 402c replace the single second emitter 302 of the arrangement illustrated in Fig. 14, and three second detectors 404a, 404b, 404c replace the single second detector 304 of the arrangement illustrated in Fig. 14.

A first one of the second emitters 402a is paired with a first one of the second detectors 404a, a second one of the second emitters 402b is paired with a second one of the second detectors 404b, and a third one of the second emitters 402c is paired with a third one of the second detectors 404c.

In view of the increase in the number of second emitters and second detectors compared with the arrangement illustrated in Fig. 14, consequent modifications are also required to the shade. Thus three second emitter tubes 414a, 414a' and 414a'' are provided in shade 410, along with three second detector tubes 414b, 414b', 414b''.

Illuminating electromagnetic radiation IL emitted by the first one of the second emitters 402a will travel along a first one of the second emitter tubes 414a and be incident upon a portion of the banknote 412 in the measuring region 411. Reflected electromagnetic radiation RL reflected from the banknote 412 in the measuring region 411 will travel toward a mouth of a first one of the second detector tubes 414b and, upon entering the first one of the second detector tubes 414b through the mouth thereof, will travel along the first one of the second detector tubes 414b to be received by the first one of the second detectors 404a.

Similarly, illuminating electromagnetic radiation IL emitted by the second one of the second emitters 402b will travel along a second one of the second emitter tubes 414a' and be incident upon a portion of the banknote 412 in the measuring region 411. Reflected electromagnetic radiation RL reflected from the banknote 412 in the measuring region 411 will travel toward a mouth of a second one of the second detector tubes 414b' and, upon entering the second one of the second detector tubes 414b' through the mouth thereof, will travel along second one of the second detector tubes 414b' to be received by the second one of the second detectors 404b.

Further, the third one of the second emitters 402c is operative to emit light into a third one of the second emitter tubes 414a". Rays reflected from the portion of the banknote 412 in the measuring region 411 due to incidence of illuminating electromagnetic radiation IL from the third one of the second emitter tubes 414a" will travel toward a mouth of the third one of the second detector tubes 414b" and, upon entering the third one of the second detector tubes 414b" through the mouth thereof, will travel along the third one of the second detector tubes 414b" to be received by the third one of the second detectors 404c.

Thus, in the illustrated optional arrangement, the reflectance measuring apparatus 400 comprises a multiple angle point analysis apparatus.

As described above, the second emitters are matched in their aperture paths with the second detectors. Although in this instance there are three angles shown for both second emitter and second detector, more could be used in other optional arrangements if appropriate.

The second emitters 402a, 402b, 402c are oriented so that illuminating electromagnetic radiation emitted therefrom is incident on the same part of the surface of the item being detected, i.e. the same point in the measuring region. It follows that the second detectors 404a, 404b, 404c should be similarly oriented in order to receive electromagnetic radiation reflected from the same part of the surface.

The processor 406 may be operative to perform analysis of multiple output signals received from the second detectors 404a, 404b, 404c.

In another optional arrangement, reflection measurement using multiple wavelengths could be applied to single or multiple angle measurements (i.e. the apparatus illustrated in Fig. 14 or 15 could be configured to make reflection measurements over a number of different wavelengths).

Possible configurations which could be based on the same geometry as the single wavelength measurement devices may comprise:

a) Colour second emitter to second detector: a single coloured second emitter replaces the second emitter in the arrangement of Fig. 14. However, if more than one colour was to be employed at a particular angle, this may prove problematic. There may be two solutions, namely:
    i. rotating the measurement around a circle: this maintains the angle and measures the same point of the note at the same time, but risks variation due to polarisation by reflection. The differences are not likely to be extreme and, if the same measurement orientation is used every time, the results will be consistent; and
    ii. delayed signals: measurement of points in a line could be measured in a cascading sequence by rows of parallel detection systems (point 1 is measured by station 1 at time 1, point 1 is measured by station 2 at time 2 whilst point 2 is being measured by station 1, etc.)
b) A white light emitter source may be used in conjunction with one or more of:
    i. a spectrometer in place of the photodiode second detector;
    ii. the functional components of a spectrometer located in the aperture tube (i.e. diffraction grating and a CCD second detector/CMOS); and
    iii. a digital camera.

Another optional arrangement of one or more embodiments of the present invention comprises a reflectance measuring apparatus operative to perform a full area scan. Such an arrangement is illustrated in Fig. 15. In this arrangement, there is provided a reflectance measuring apparatus 500 which comprises a strip electromagnetic radiation source 502 operative to emit illuminating electromagnetic radiation IL toward a banknote 506 located in the authentication apparatus. The incident electromagnetic radiation IL may be reflected by the note as reflected electromagnetic radiation RL toward a line-scan camera 504.

In this arrangement, the mode of operation is the same as described in other arrangements above, except that the second emitter/second detector combination of the earlier described arrangement is replaced with strip electromagnetic radiation source 502 and line-scan camera 504. The banknote 506 may be moved relative to the strip electromagnetic radiation source 502 and line-scan camera 504 or vice versa. Such an arrangement may be used to obtain a full map of the surface reflectivity at a particular illumination angle by taking measurements of the value of the reflected electromagnetic radiation RL using line-scan camera 504.

This map may optionally be monochrome or coloured (i.e. reflected electromagnetic radiation RL is collected by way of a colour camera or via a diffraction grating coupled to a 2D CMOS array). Further, the map may be built up from a series of measurements obtained by illuminating the banknote over a series of angles (e.g. similar to the arrangement illustrated in Fig. 15, but with the strip electromagnetic radiation sources and line-scan cameras effectively extending into/out of the plane of the paper).

In an optional arrangement, IR light just outside the visible spectrum may be used. In a further optional arrangement, one way of potentially reducing noise would be to employ a filter to filter out white light.

In all of the above-described "non-static" arrangements, a banknote may be moved relative to the authentication apparatus (i.e. moved along a transport path through the apparatus). However, in other optional "non-static" arrangements, the banknote may be stationary and the apparatus moved relative to the banknote.

In another optional arrangement, the emitter(s) and detector(s) of the birefringence measuring apparatus may be tilted or offset so that the optical path-length through the note increases.

In the above described arrangements, the polarisers of the birefringence measuring apparatus are "crossed". That is, a first polariser 112 is arranged such that a transmission orientation thereof is about ±45° to a transmission orientation of a portion of an item 106 located in a measuring region 108. A second polariser 116 is arranged such that a transmission orientation thereof is about ±45° to the transmission orientation of the portion of the item 106 located in the measuring region 108. That is, the transmission orientation of the first polariser 112 is at about 90° to that of the second polariser 116. In an optional arrangement, the transmission orientation of the first polariser 112 to that of the second polariser 116 may be 90°. However, in other optional arrangements, the transmission orientation of the first polariser 112 to that of the second polariser 116 may be non-perpendicular. For example, the transmission orientation of the first polariser 112 to that of the second polariser 116 may be about 89°. In such "non-perpendicular" arrangements, the amount of illuminating radiation which is allowed to pass through the polarisers increases compared with the "perpendicular" arrangements. This will affect the background levels of the detector(s) and may improve the ability of the apparatus to detect edges.

Insofar as embodiments of the invention described above are implementable, at least in part, using a software-controlled programmable processing device such as a general purpose processor or special-purposes processor, digital signal processor, microprocessor, or other processing device, data processing apparatus or computer system it will be appreciated that a computer program for configuring a programmable device, apparatus or system to implement the foregoing described methods and apparatus is envisaged as an aspect of the present invention. The computer program may be embodied as any suitable type of code, such as source code, object code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. The instructions may be implemented using any suitable high-level, low-level, object-oriented, visual, compiled and/or interpreted programming language, such as, Liberate, OCAP, MHP, Flash, HTML and associated languages, JavaScript, PHP, C, C++, Java, BASIC, Perl, Matlab, Pascal, Visual BASIC, JAVA, ActiveX, assembly language, machine code, and so forth. A skilled person would readily understand that term “computer” in its most general sense encompasses programmable devices such as referred to above, and data processing apparatus and computer systems.

Suitably, the computer program is stored on a carrier medium in machine readable form, for example the carrier medium may comprise memory, removable or non-removable media, erasable or non-erasable media, writeable or re-writeable media, digital or analog media, hard disk, floppy disk, Compact Disk Read Only Memory (CD-ROM), Company Disk Recordable (CD-R), Compact Disk Rewriteable (CD-RW), optical disk, magnetic media, magneto-optical media, removable memory cards or disks, various types of Digital Versatile Disk (DVD) subscriber identity module, tape, cassette solid-state memory.

As used herein any reference to “one embodiment” or “an embodiment” means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment.

As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

In addition, use of the “a” or “an” are employed to describe elements and components of the invention. This is done merely for convenience and to give a general sense of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

The scope of the present disclosure includes any novel feature or combination of features disclosed therein either explicitly or implicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigate against any or all of the problems addressed by the present invention. The applicant hereby gives notice that new claims may be formulated to such features during prosecution of this application or of any such further application derived therefrom. In particular, with reference to the appended claims, features from dependent claims may be combined with those of the independent claims and features from respective independent claims may be combined in any appropriate manner and not merely in specific combinations enumerated in the claims.

CLAIMS

1. An authentication apparatus operative to determine the authenticity of an item comprising a film substrate responsive to detection that a portion of said item located in a measuring region of said apparatus has a predetermined birefringence characteristic, said apparatus comprising: an item detection arrangement operative to determine if at least a portion of an item is located in a measuring region of said authentication apparatus; and an optically-based birefringence measuring apparatus, wherein said authentication apparatus is operative to compare a measured birefringence characteristic with a predetermined birefringence characteristic and to produce an authenticity signal indicative of authenticity or otherwise of said item based upon said comparison, said apparatus further comprising a control means operative to control output of said authenticity signal from said apparatus responsive to determination, by said item detection arrangement, of presence or otherwise of said at least a portion of said item in said measuring region.

2. An apparatus according to claim 1, wherein said item detection arrangement comprises an item detection emitter located, and operative, to illuminate with electromagnetic radiation an item detection region of said apparatus, and an item detection detector, located, and operative, to receive at least one of: electromagnetic radiation reflected from said item detection region; and electromagnetic radiation transmitted through said item detection region, wherein said item detection detector is further operative to provide a signal indicative of presence or otherwise of an item in said item detection region, and further wherein said item detection arrangement is operative to determine that said at least a portion of said item is located in said measuring region responsive to receipt of said item detection detector signal indicating presence of an item in said item detection region.

3. An apparatus according to claim 2, wherein said item detection emitter is operative to emit white-light and/or infra-red light.

4. An apparatus according to claim 2 or 3, wherein said item detection detector is operative to detect white-light and/or infra-red light.

5. An apparatus according to any one of the preceding claims, wherein said apparatus is operative to differentiate between item film substrates made by a bubble process and item film substrates made by a different process.

6. An apparatus according to any one of the preceding claims, wherein said optically-based birefringence measuring apparatus comprises a birefringence measurement emitter located, and operative, to illuminate said measuring region of said apparatus with electromagnetic radiation; a first polariser located between said birefringence measurement emitter and a first side of said measuring region so that electromagnetic radiation emitted by said birefringence measurement emitter passes therethrough; a birefringence measurement detector located on a second side of said measuring region, and operative to receive electromagnetic radiation transmitted through said measuring region from said birefringence measurement emitter; and a second polariser located between said second side of said measuring region and said birefringence measurement detector so that electromagnetic radiation transmitted through said measuring region passes therethrough, said second polariser oriented so as to effect polarisation in a direction transverse to that of the first polariser; wherein said birefringence measurement detector is operative to output a signal corresponding to a measured birefringence characteristic.

7. An apparatus according to claim 6, wherein said output signal output by said birefringence measurement detector corresponding to a

measured birefringence characteristic is proportional to an intensity of transmitted electromagnetic radiation received.

8. An apparatus according to claim 7, wherein said birefringence measurement detector is operative to communicate said output signal corresponding to a measured birefringence characteristic to a processor which is operative to compare a value of said output signal with said predetermined birefringence characteristic.

9. An apparatus according to any one of claims 6 to 8, wherein said predetermined birefringence characteristic comprises one of: a first range of values corresponding to expected birefringence measurement detector output signal values if an opaque or semi-opaque region of said item is located in said measuring region; a second range of values corresponding to expected birefringence measurement detector output signal values if a transparent or semi-transparent region of said item is located in said measuring region; and a third range of values corresponding to expected birefringence measurement detector output signal values if no item is present in said measuring region.

10. An apparatus according to any one of claims 6 to 9, wherein said birefringence measurement emitter comprises a light source.

11. An apparatus according to claim 10, wherein said light source comprises a white light emitting LED.

12. An apparatus according to any one of claims 6 to 10, wherein said birefringence measurement detector comprises a photodetector.

13. An apparatus according to claim 12, wherein the photodetector comprises a photodiode.

14. An apparatus according to claim 13, wherein the photodiode is suitable for detecting white light.

15. An apparatus according to any one of claims 6 to 14, wherein said birefringence measurement emitter is slidably mounted on a rail or rod.

16. An apparatus according to claim 15, wherein said birefringence measurement emitter is attached to the rail or rod by an attachment which is slidable relative to the rail or rod, and which attachment comprises a fixing element to allow a position of the birefringence measurement emitter to be fixed relative to the rail or rod.

17. An apparatus according to any one of claims 6 to 16, wherein said birefringence measurement detector is slidably mounted on a rail or rod.

18. An apparatus according to claim 17, wherein said birefringence measurement detector is attached to the rail or rod by an attachment which is slidable relative to the rail or rod, and which attachment comprises a fixing element to allow a position of the birefringence measurement detector to be fixed relative to the rail or rod.

19. An apparatus according to any one of the preceding claims, wherein said item detection arrangement comprises an optically-based reflectance measuring apparatus for determining if an item authentication region is located in said measuring region, wherein said reflectance measuring apparatus comprises: a reflectance measurement emitter operative to illuminate said measuring region of said apparatus with electromagnetic radiation; and a reflectance measurement detector located and operative to receive electromagnetic radiation reflected from said measuring region of said apparatus and operative to output a signal corresponding to a measured characteristic of said electromagnetic radiation reflected from said measuring region and indicative of presence

or otherwise of an item authentication region in said measuring region, wherein said reflectance measuring apparatus is operative to compare a measured reflection characteristic with a set of predetermined reflection characteristics and to determine presence or otherwise of said item authentication region in said measuring region based upon said comparison, and further operative to provide to said control means a signal indicative of said determination for controlling output of said authenticity signal from said control means.

20. An apparatus according to claim 19, wherein said output signal output by said reflectance measurement detector corresponding to a measured reflection characteristic is proportional to an intensity of reflected electromagnetic radiation received.

21. An apparatus according to claims 19 or 20, wherein said reflectance measurement detector is operative to communicate said output signal corresponding to a measured reflection characteristic to a processor which is operative to compare a value of said output signal corresponding to said measured reflection characteristic with said predetermined reflection characteristic, which comprises a pre-defined value indicative of presence of an item authentication region of said item in said measuring region, and said processor operative to implement said determination that said item authentic region is present or absent in said measuring region based upon said comparison and operative to provide to said control means said signal indicative of said determination.

22. An apparatus according to claim 21, wherein if said comparison of said predetermined reflection characteristic with said output signal output by said reflectance measurement detector corresponding to a measured reflection characteristic indicates that said item authentication region is located in the measuring region, said processor is operative to output a determination signal to said control means indicative of presence of said

item authentication region in said measuring region, wherein responsive to receipt thereof, said control means is operative to output said authenticity signal indicative of authenticity or otherwise of said item based upon said comparison of said predetermined birefringence characteristic with said output signal output by said birefringence measurement detector corresponding to a measured birefringence characteristic.

23. An apparatus according to any one of claims 19 to 22, wherein said predetermined reflection characteristic comprises one or more of: a first range of values corresponding to expected reflectance measurement detector output signal values if an opaque or semi-opaque region of said item is located in said measuring region; a second range of values corresponding to expected reflectance measurement detector output signal values if a transparent or semi-transparent region of said item is located in said measuring region; and a third range of values corresponding to expected reflectance measurement detector output signal values if no item is present in said measuring region.

24. An apparatus according to any one of claims 19 to 23, wherein the reflectance measurement detector has associated therewith a shade, said shade including at least one aperture, wherein said aperture is located with respect to the reflectance measurement detector to permit electromagnetic radiation reflected from said at least a portion of said item to be received by the reflectance measurement detector.

25. An apparatus according to claim 24, wherein the shade comprises a tube, and in which the aperture comprises the hollow portion of the tube.

26. An apparatus according to claim 25, wherein the reflectance measurement detector is located at an end of the tube, or within the tube.

27. An apparatus according to claim 24, wherein said aperture comprises a tubular region in the shade.

28. An apparatus according to claim 27, wherein said reflectance measurement detector is located at an end of, or within, the tubular region of the shade.

29. An apparatus according to any one of claims 19 to 28, wherein said reflectance measurement emitter has associated therewith a shade, said shade including an aperture, wherein said aperture is located with respect to the reflectance measurement emitter to permit electromagnetic radiation emitted from the reflectance measurement emitter to be directed toward the measuring region of said apparatus.

30. An apparatus according to claim 29, wherein said shade comprises a tube, and in which the aperture comprises the hollow portion of the tube.

31. An apparatus according to claim 30, wherein said reflectance measurement emitter is located at an end of the tube, or within the tube.

32. An apparatus according to claim 29, wherein said aperture comprises a tubular region in said shade.

33. An apparatus according to claim 32, wherein said reflectance measurement emitter is located at an end of, or within, said tubular region of said shade.

34. An apparatus according to any one of claims 19 to 33, wherein said reflectance measurement emitter is operative to emit coherent electromagnetic radiation.

35. An apparatus according to any one of claims 19 to 34, wherein said reflectance measurement emitter comprises at least one LED.

36. An apparatus according to claim 35, wherein said at least one LED is operative to emit light in the infra-red range of the electromagnetic spectrum and/or comprises a white light emitter source.

37. An apparatus according to any one of claims 19 to 36, wherein said reflectance measurement emitter comprises at least one strip electromagnetic radiation source.

38. An apparatus according to any one of claims 19 to 37, wherein said reflectance measurement detector comprises at least one photodiode.

39. An apparatus according to claim 38, wherein said at least one photodiode is operative to detect light in the infra-red range of the electromagnetic spectrum.

40. An apparatus according to any one of claims 19 to 39, wherein said reflectance measurement detector comprises at least one line-scan camera and/or comprises at least one spectrometer and a CCD or CMOS image sensor.

41. An apparatus according to any one of claims 19 to 40, wherein said reflectance measurement emitter comprises at least one of: a plurality of LEDs; a plurality of white light emitter sources; and a plurality of strip electromagnetic radiation sources; and said reflectance measurement detector comprises at least one of: a plurality of photodiodes; a plurality of line-scan cameras; and a plurality of spectrometers and CCD or CMOS image sensors; wherein each one of said plurality of LEDs is paired with a corresponding one of said plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image

sensors, wherein each one of said plurality of white light emitter sources is paired with a corresponding one of said plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image sensors, and wherein each one of said plurality of strip electromagnetic radiation sources is paired with a corresponding one of said plurality of photodiodes and/or plurality of line-scan cameras and/or plurality of spectrometers and CCD or CMOS image sensors.

42. An apparatus according to claim 41, wherein said at least one of the plurality of LEDs is operative to emit light in the infra-red range of the electromagnetic spectrum.

43. An apparatus according to claim 41 or 42, wherein said at least one of said plurality of photodiodes is operative to detect light in the infra-red range of the electromagnetic spectrum.

44. An apparatus according to any one of the preceding claims, wherein the apparatus includes a transport path, of which a part comprises the measuring region, and along which item transport path the item is conveyable.

45. An apparatus according to any one of the preceding claims, wherein said item comprises a banknote.

46. An apparatus according to claim 45, when dependent upon claim 9, or any one of claims 10 to 44 when directly or indirectly dependent upon claim 9, wherein the opaque or semi-opaque region comprises a printed region of said banknote and/or wherein the transparent or semi-transparent region of the item comprises an unprinted or window region of the banknote.

47. A banknote counting apparatus comprising the authentication apparatus of any one of the preceding claims, the banknote counting apparatus further comprising a note counting device operative to maintain a count of banknotes conveyed through the apparatus, and said note counting device further operative to receive the authenticity signal indicative of authenticity or otherwise of the item from said authentication apparatus, wherein the note counting device is operative to alter a note count only when the signal indicates that an item in the measuring region is authentic.

48. An apparatus according to claim 47, wherein upon receipt of the signal indicating that the item in the measuring region is authentic, the note counting device is operative to alter the note count.

49. An apparatus according to claim 48, wherein said note counting device is operative to alter the note count by incrementing the count.

50. A method of authenticating an item comprising a film substrate, the method comprising detecting if a portion of an item located in a measuring region of an authentication apparatus has a predetermined birefringence characteristic, and further comprising the steps of: determining, by an item detection arrangement, if at least a portion of an item is located in a measuring region of said authentication apparatus; comparing a measured birefringence characteristic, obtained by an optically-based birefringence measuring apparatus, with a predetermined birefringence characteristic; producing an authenticity signal indicative of authenticity or otherwise of said item based upon said comparison; controlling, by way of a control means, output of said authenticity signal from said apparatus responsive to determination, by said item detection arrangement, of presence or otherwise of said at least a portion of said item in said measuring region.

51. A method according to claim 50, comprising illuminating with electromagnetic radiation, by way of an item detection emitter forming part of said item detection arrangement, an item detection region of said apparatus, and receiving, by way of an item detection detector forming part of said item detection arrangement, at least one of: electromagnetic radiation reflected from said item detection region; and electromagnetic radiation transmitted through said item detection region, and further comprising providing a signal indicative of presence or otherwise of an item in said item detection region and, responsive to receipt of an item detection detector signal indicating presence of an item in said item detection region, determining, by said item detector arrangement, that said at least a portion of said item is located in said measuring region.

52. A method according to claims 50 or 51, wherein the method differentiates between item film substrates made by a bubble process and item film substrates made by a different process.

53. A method according to any one of claims 50 to 52, comprising illuminating, with a birefringence measurement emitter, said measuring region of said apparatus with electromagnetic radiation; locating a first polariser between said birefringence measurement emitter and a first side of said measuring region so that electromagnetic radiation emitted by said birefringence measurement emitter passes therethrough; locating a birefringence measurement detector on a second side of said measuring region; receiving, at said birefringence measurement detector, electromagnetic radiation transmitted through said measuring region from said birefringence measurement emitter; locating a second polariser between said second side of said measuring region and said birefringence measurement detector so that electromagnetic radiation transmitted through said measuring region passes therethrough; orienting said second polariser so as to effect polarisation in a direction transverse to that of the

first polariser; outputting, from said birefringence measurement detector, a signal corresponding to a measured birefringence characteristic.

54. A method according to claim 53, comprising communicating said output signal corresponding to a measured birefringence characteristic to a processor; and comparing, in said processor, a value of said output signal with said predetermined birefringence characteristic.

55. A method according to claims 53 or 54, wherein said predetermined birefringence characteristic comprises one of: a first range of values corresponding to expected birefringence measurement detector output signal values if an opaque or semi-opaque region of said item is located in said measuring region; a second range of values corresponding to expected birefringence measurement detector output signal values if a transparent or semi-transparent region of said item is located in said measuring region; and a third range of values corresponding to expected birefringence measurement detector output signal values if no item is present in said measuring region.

56. A method according to any one of claims 50 to, the method comprising: determining, by way on an optically-based reflectance measuring apparatus of said item detection arrangement, if an item authentication region of an item is located in said measuring region, said determining step implemented by: illuminating, by way of a reflectance measurement emitter of said reflectance measuring apparatus, said measuring region of said apparatus with electromagnetic radiation; receiving, by way of a reflectance measurement detector of said reflectance measuring apparatus, electromagnetic radiation reflected from said measuring region of said apparatus; outputting, from said reflectance measurement detector, a signal corresponding to a measured characteristic of said electromagnetic radiation reflected from said measuring region and indicative of presence or otherwise of an item

authentication region in said measuring region; comparing, in said reflectance measuring apparatus, a measured reflection characteristic with a set of predetermined reflection characteristics; and determining presence or otherwise of said item authentication region in said measuring region based upon said comparison; and providing, to said control means, a signal indicative of said determination for controlling output of said authenticity signal from said control means.

57. A method according to claim 56, comprising communicating said output signal corresponding to a measured reflection characteristic to a processor which is operative to compare a value of said output signal corresponding to said measured reflection characteristic with said predetermined reflection characteristic, which comprises a pre-defined value indicative of presence of an item authentication region of said item in said measuring region, and said processor operative to implement said determination that said item authentication region is present or absent in said measuring region based upon said comparison and operative to provide to said control means said signal indicative of said determination.

58. A method according to claim 57, wherein if said comparison of said predetermined reflection characteristic with said output signal output by said reflectance measurement detector corresponding to a measured reflection characteristic indicates that said item authentication region is located in the measuring region, outputting, from said processor to said control means, a determination signal indicative of presence of said item authentication region in said measuring region, wherein responsive to receipt thereof, outputting, from said control means, said authenticity signal indicative of authenticity or otherwise of said item based upon said comparison of said predetermined birefringence characteristic with said output signal output by said birefringence measurement detector corresponding to a measured birefringence characteristic.

59. A method according to any one of claims 56 to 58, wherein said predetermined reflection characteristic comprises one or more of: a first range of values corresponding to expected reflectance measurement detector output signal values if an opaque or semi-opaque region of said item is located in said measuring region; a second range of values corresponding to expected reflectance measurement detector output signal values if a transparent or semi-transparent region of said item is located in said measuring region; and a third range of values corresponding to expected reflectance measurement detector output signal values if no item is present in said measuring region.

60. A method according to any one of claims 50 to 59, wherein said item comprises a banknote.

61. A method according to claim 60, when dependent upon claim 55, or any one of Claims 56 to 59 when directly or indirectly dependent upon Claim 55, wherein the opaque or semi-opaque region comprises a printed region of said banknote and/or wherein the transparent or semi-transparent region of the item comprises an unprinted or window region of the banknote.

62. A method according to any one of claims 50 to 61, comprising providing a transport path in said authentication apparatus, of which a part of said transport path comprises said measuring region, and conveying said item along said transport path.

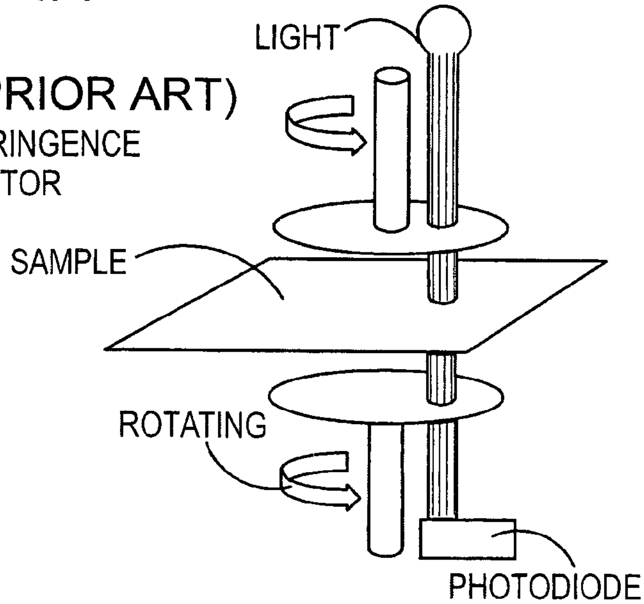
63. A banknote counting method comprising the method of any one of claims 50 to 62, the banknote counting method further comprising maintaining, using a note counting device, a count of banknotes conveyed through the apparatus; receiving, at the note counting device, from the authentication apparatus, said authenticity signal indicative of authenticity or otherwise of said item; and altering a note count only when the

authenticity signal indicates that an item in the measuring region is authentic.

64. A method according to claim 63, further comprising altering said note count upon receipt of an authenticity signal indicating that an item in the measuring region is authentic.

65. A method according to claim 64, comprising altering said note count by incrementing said count.

FIG.1. (PRIOR ART)
BIREFRINGENCE DETECTOR



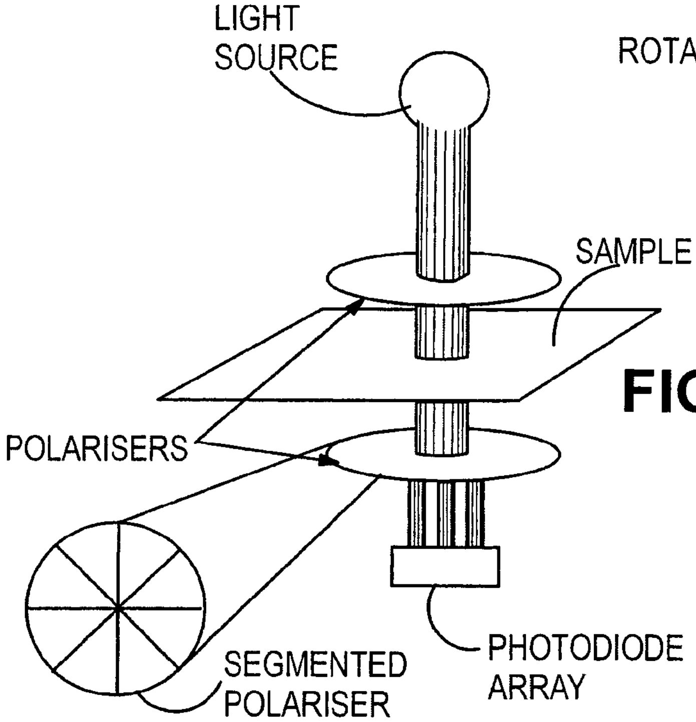


FIG.2. (PRIOR ART)
BIREFRINGENCE DETECTOR 2

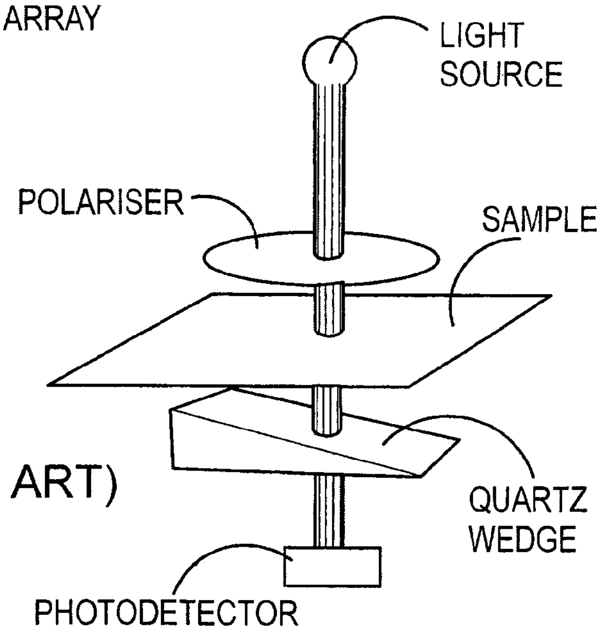


FIG.3. (PRIOR ART)
BIREFRINGENCE DETECTOR 3

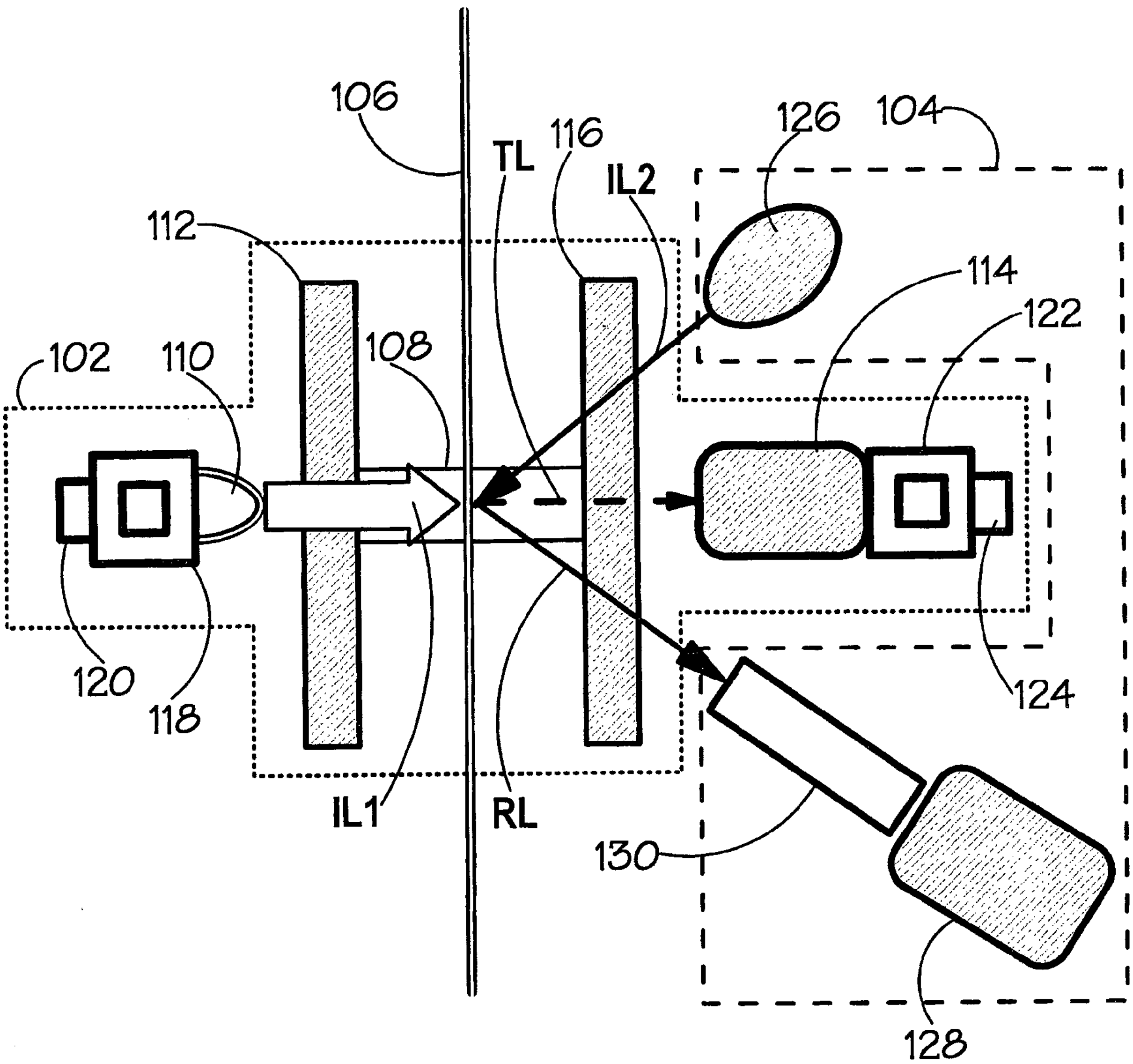

106
116
TL
IL2
126
104
112
114
122
102
110
108
120
118
124
IL1
RL
130
128

FIG.4.

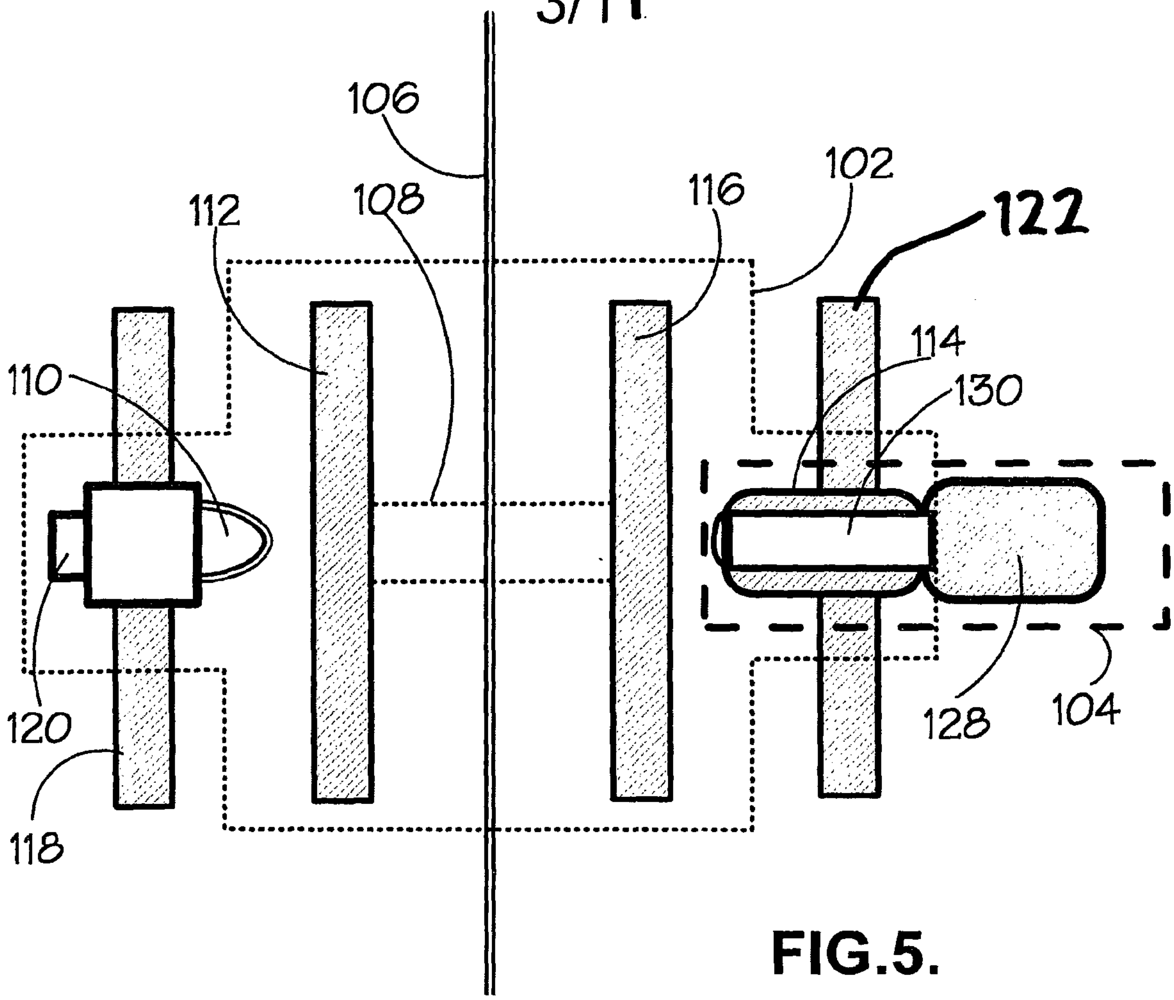


FIG.5.

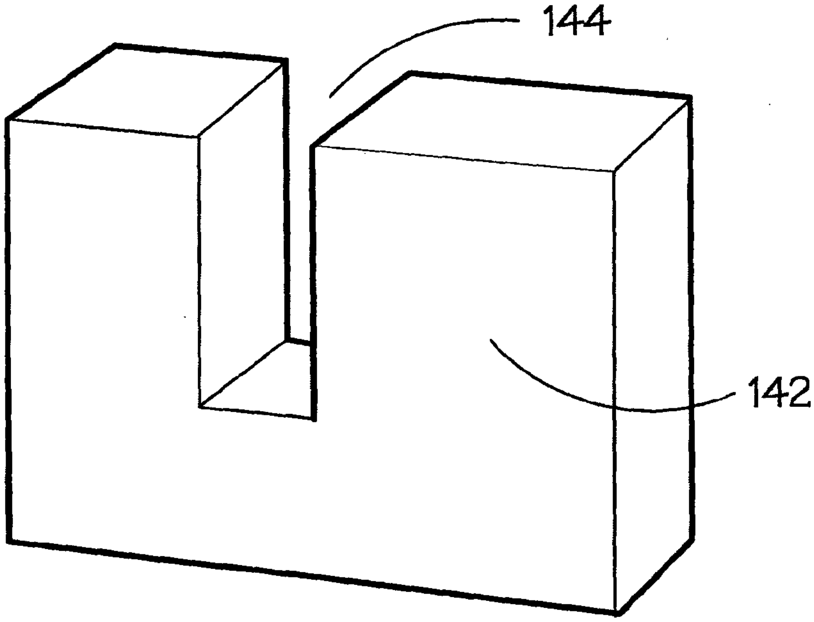


FIG.7.

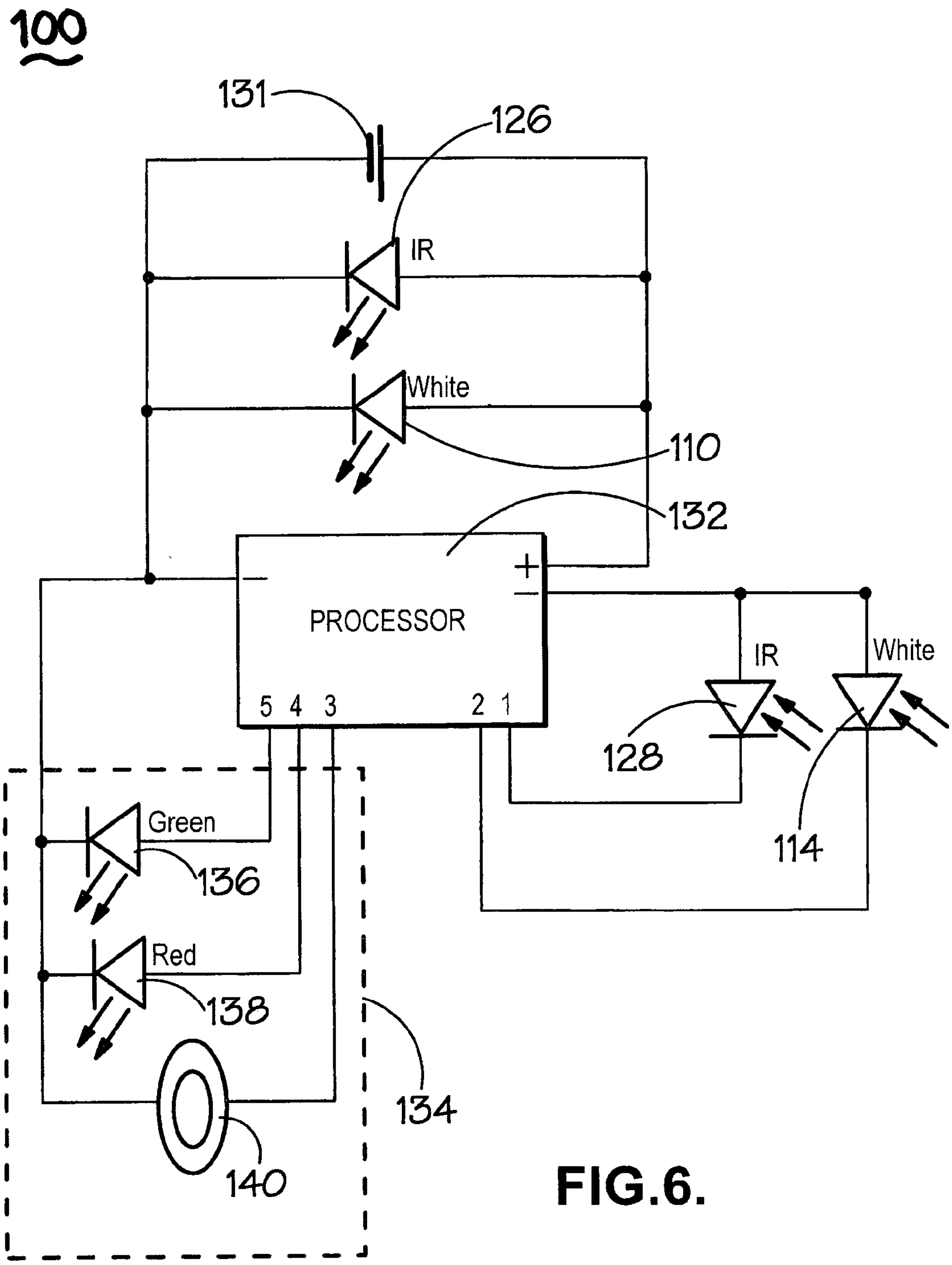

100
131
126
IR
White
110
132
PROCESSOR
+
−
5 4 3
2 1
IR
White
128
114
Green
136
Red
138
140
134

FIG.6.

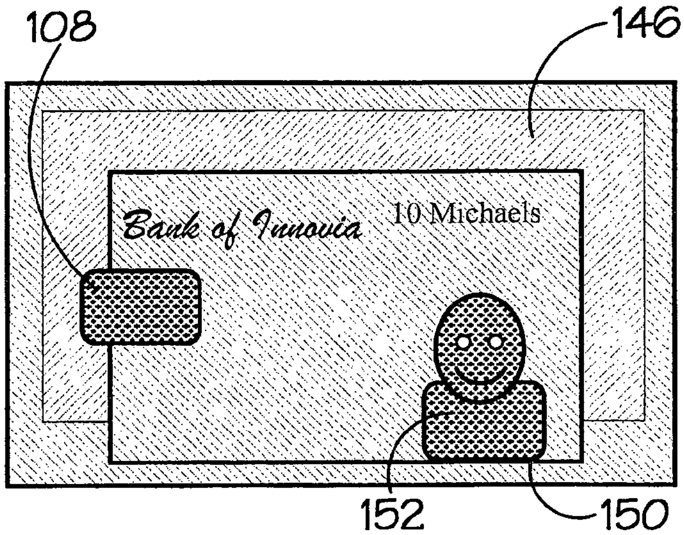

108
146
Bank of Innovia
10 Michaels
152
150

FIG.8a.

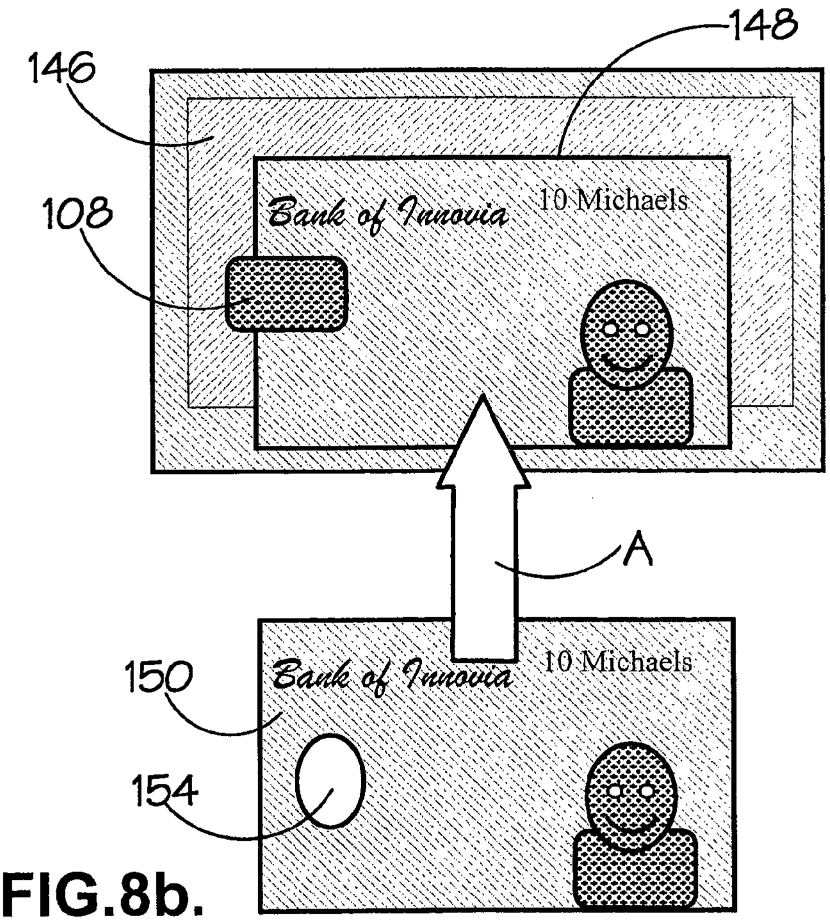
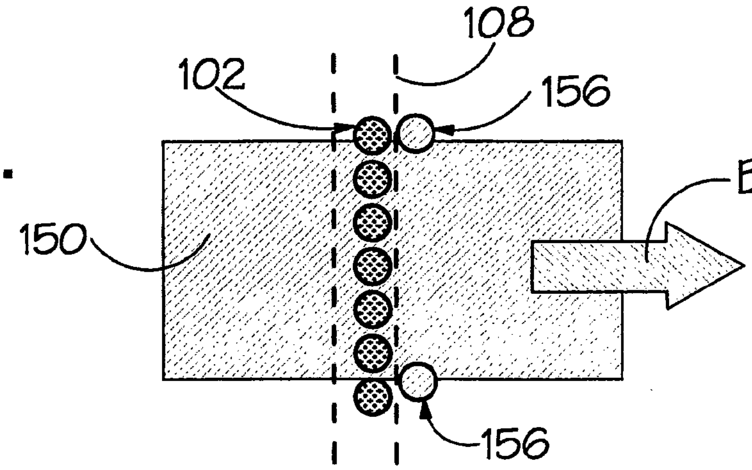

148
146
Bank of Innovia
10 Michaels
108
A
150
Bank of Innovia
10 Michaels
154

FIG.8b.

FIG.9a.



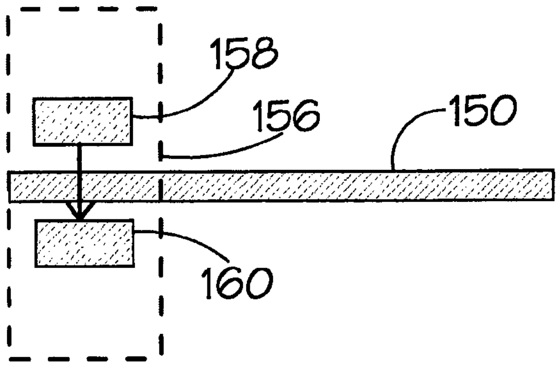
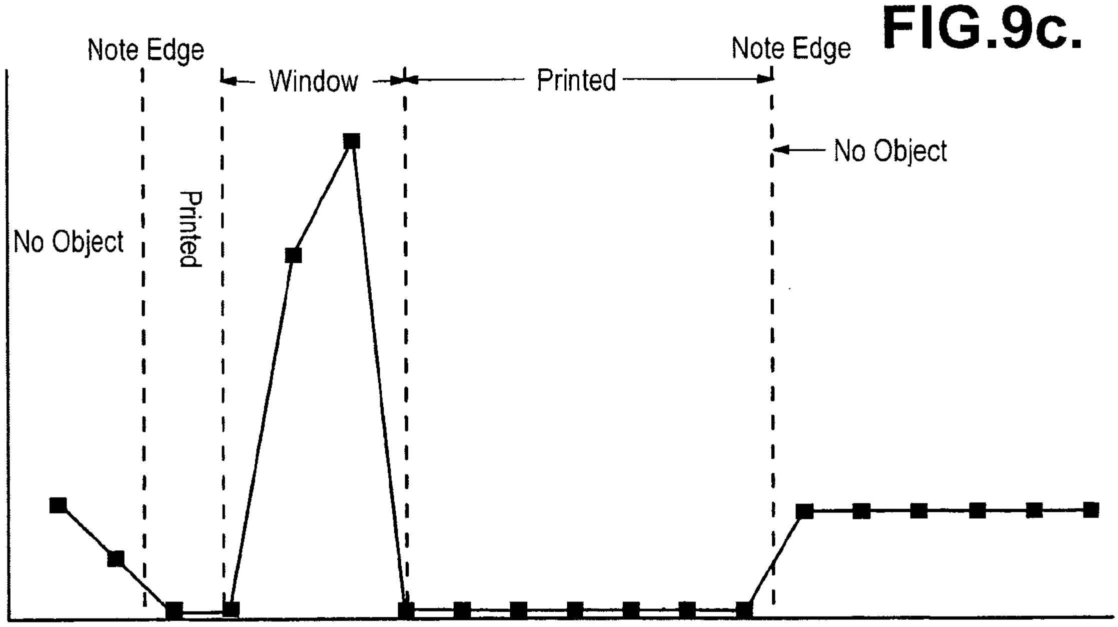


FIG.9b.

FIG.9c.



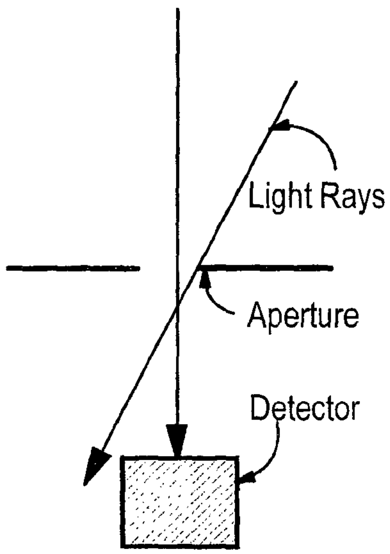


FIG.10a.

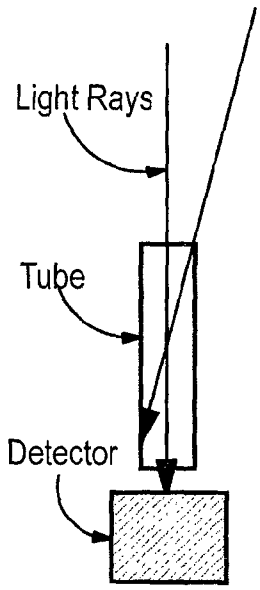


FIG.10b.

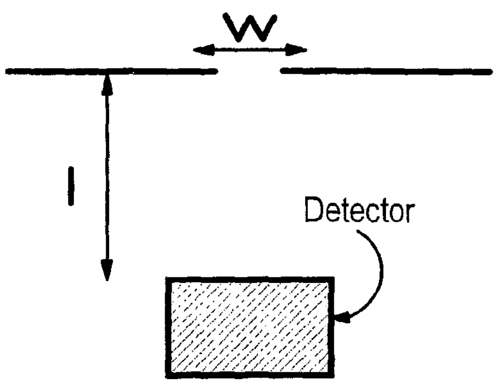


FIG.10c.

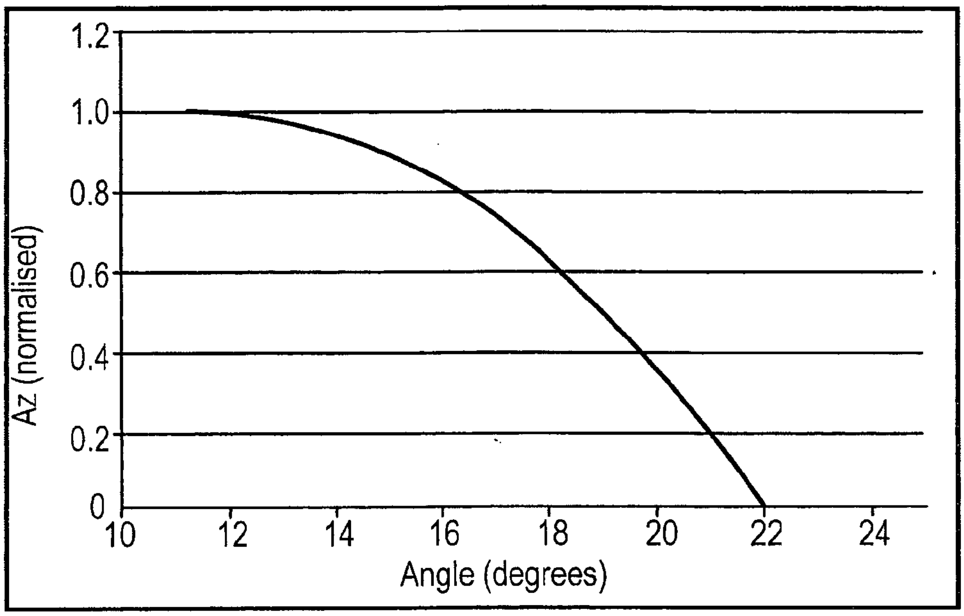

1.2
1.0
0.8
0.6
0.4
0.2
0
Az (normalised)
10
12
14
16
18
20
22
24
Angle (degrees)

FIG.11.

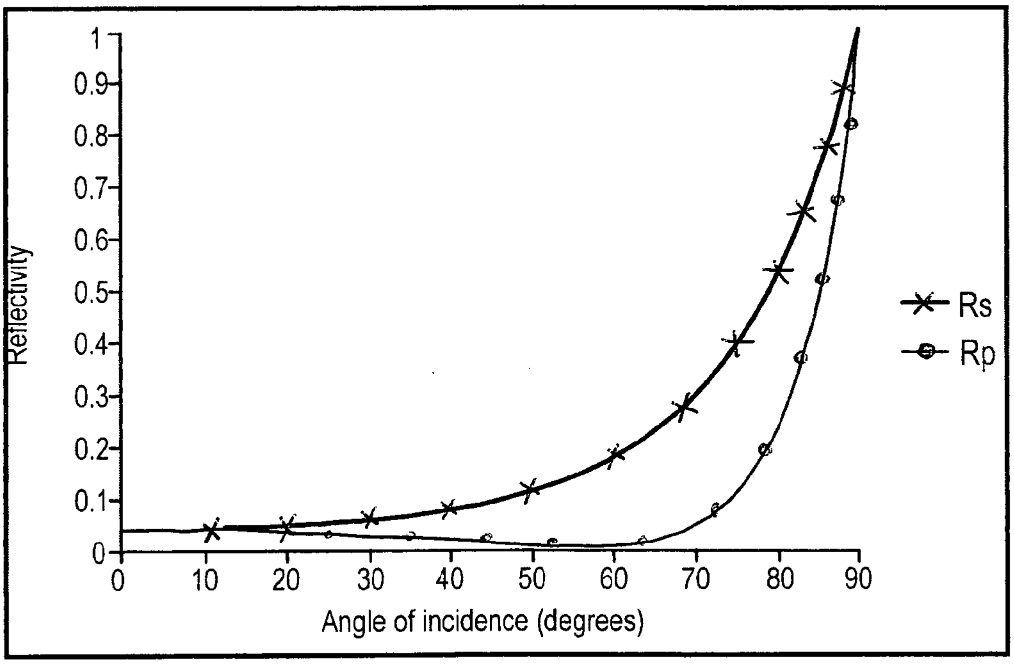

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Reflectivity
0
10
20
30
40
50
60
70
80
90
Angle of incidence (degrees)
Rs
Rp

FIG.12.

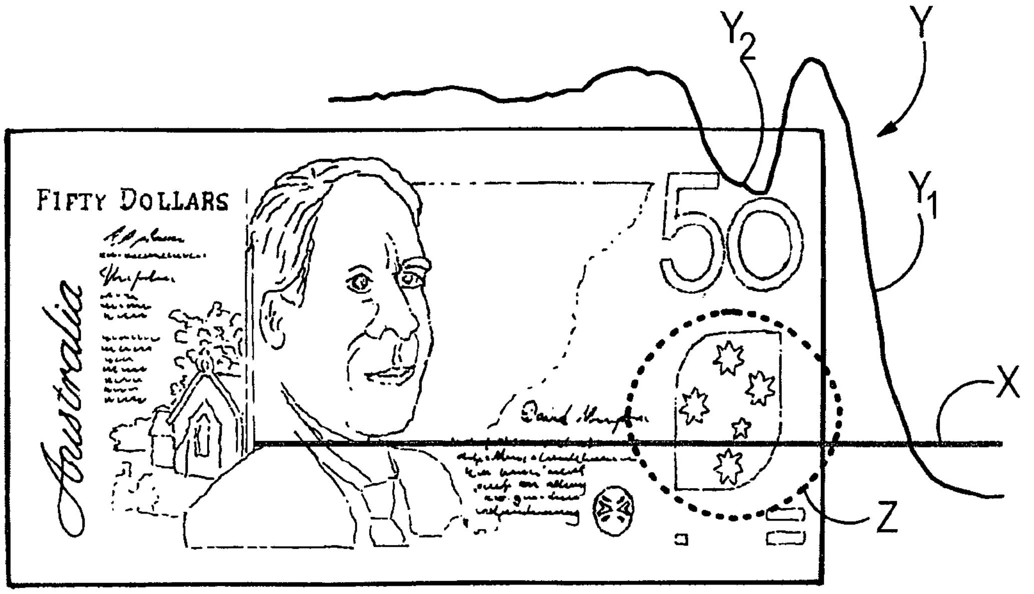

Y2
Y
Y1
X
Z
FIFTY DOLLARS
Australia
50

FIG.13.

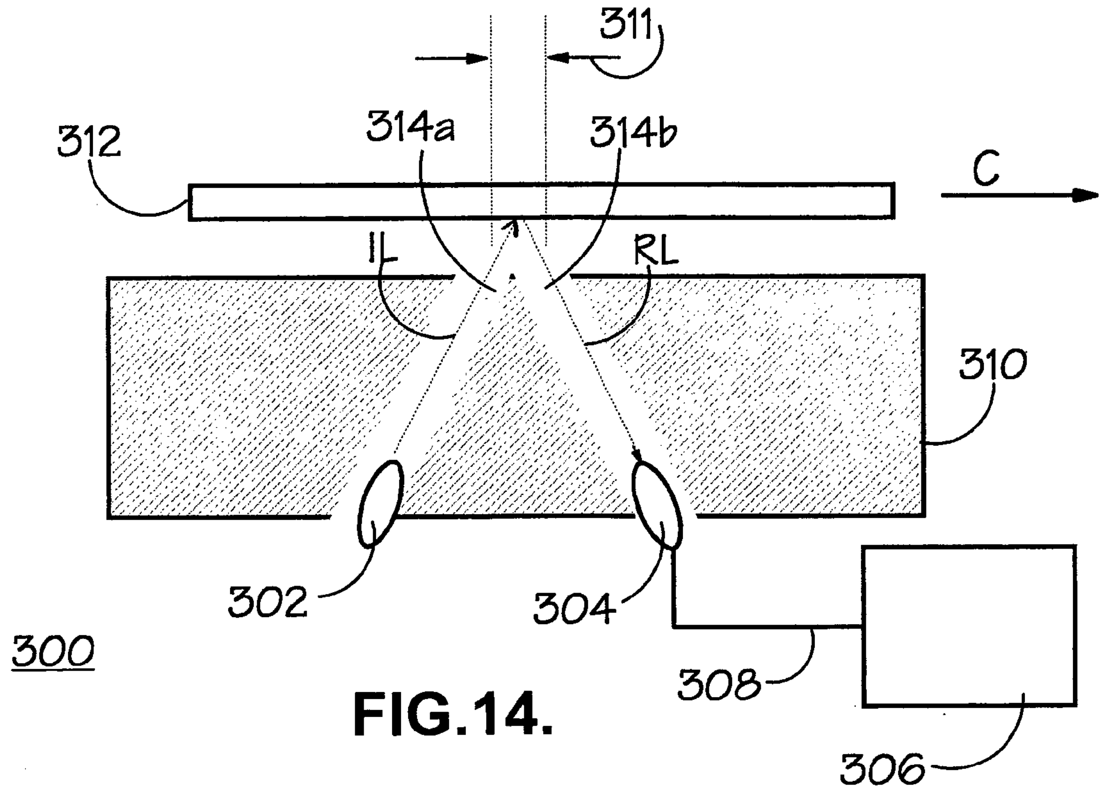

311
312
314a
314b
C
IL
RL
310
302
304
300
308
306

FIG.14.

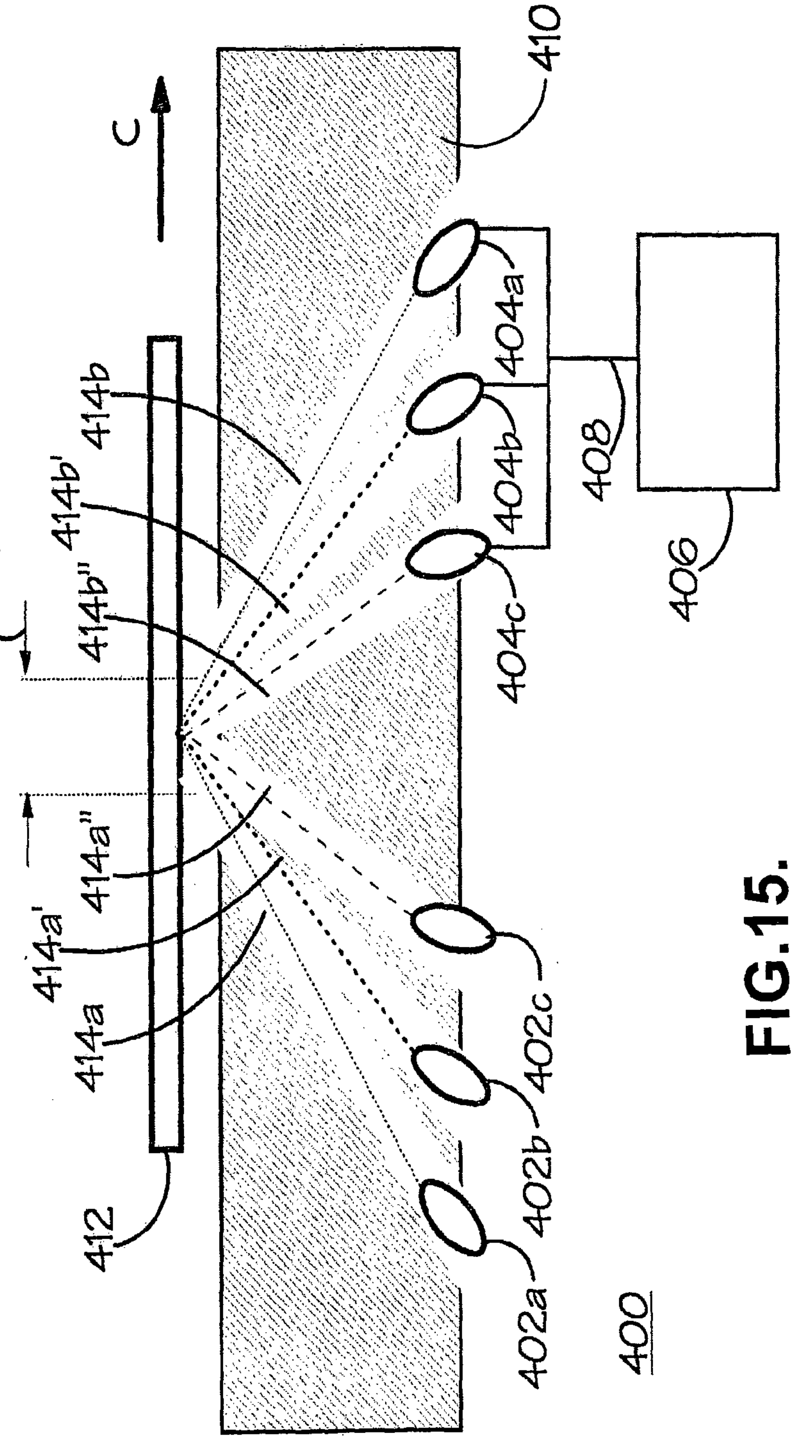

410
C
404a
404b
404c
408
406
414b
414b'
414b''
411
414a''
414a'
414a
412
402a
402b
402c
400

FIG.15.

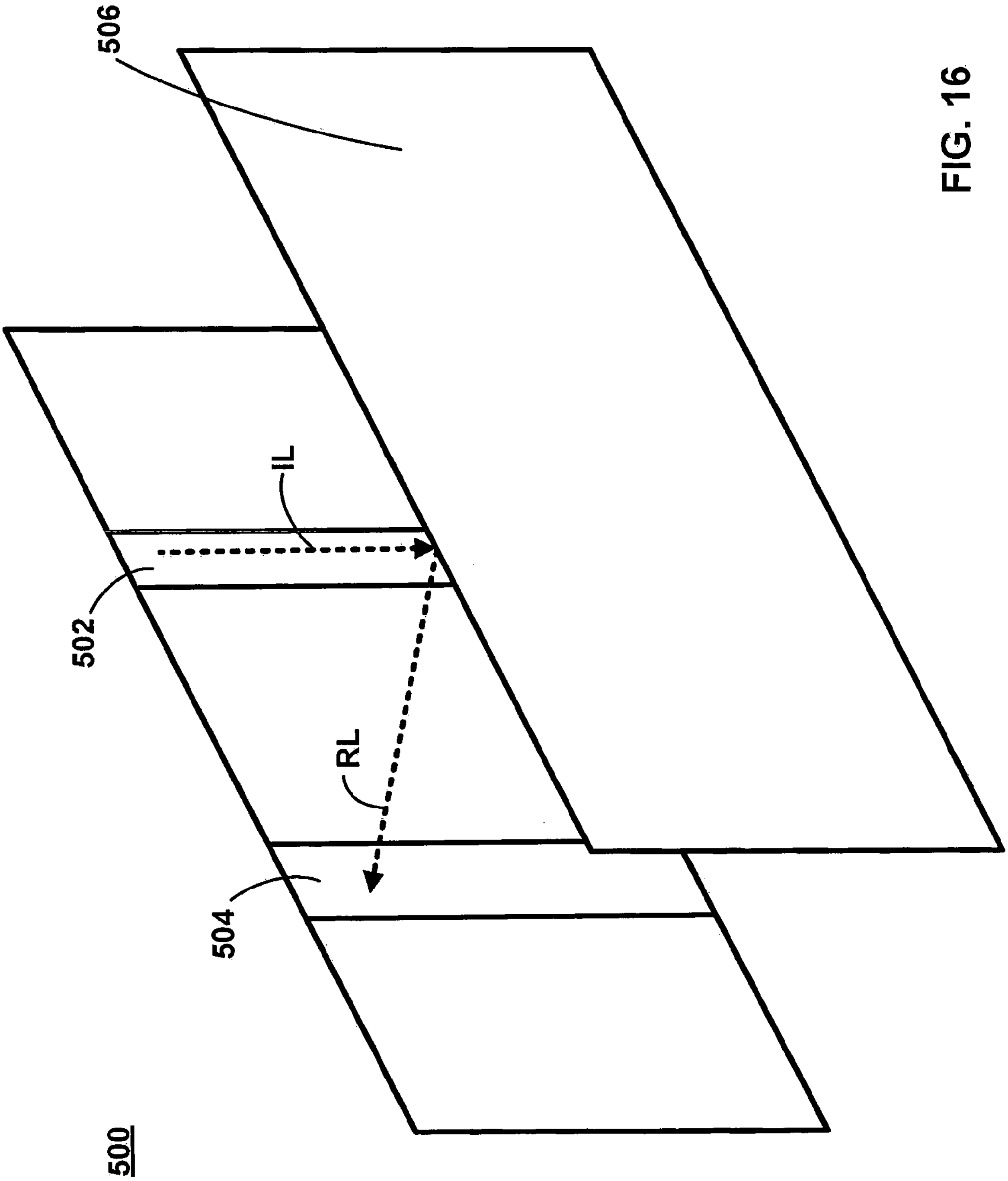


FIG. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/071435

A. CLASSIFICATION OF SUBJECT MATTER
INV. G07D7/12
ADD.

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where 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	WO 2010/001165 A1 (SCALAR TECHNOLOGIES LTD [GB]; BAIN IAN WILLIAM [GB]; FAICHNIE DAVID [G) 7 January 2010 (2010-01-07) page 4, line 15 - page 7, line 6 page 8, line 9 - page 9, line 9 page 10, line 4 - line 12 page 13, line 1 - page 15, line 20 page 17, line 5 - line 22 -----	1-65
X	WO 2009/133390 A1 (INNOVIA FILMS SARL [CH]; STEWART ROBERT LAIRD [GB]) 5 November 2009 (2009-11-05) cited in the application page 1, line 1 - page 3, line 10 page 4, line 14 - page 6, line 9 page 12, line 31 - page 18, line 22 ----- -/--	1-65

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"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
8 January 2014	21/01/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bohn, Patrice

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 155 605 A (BRATCHLEY ROBIN [GB] ET AL) 5 December 2000 (2000-12-05) column 1, line 1 - line 25 column 4, line 1 - line 7 -----	1,45, 47-50, 60,63-65
A	US 2010/306532 A1 (KOMATSU NOBUAKI [JP] ET AL) 2 December 2010 (2010-12-02) paragraph [0385] - paragraph [0389] -----	1,50

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/071435

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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(19)中华人民共和国国家知识产权局

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(30)优先权数据

1218463.6 2012.10.15 GB

(85)PCT国际申请进入国家阶段日

2015.04.14

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(87)PCT国际申请的公布数据

WO2014/060362 EN 2014.04.24

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代理人 王达佐 刘铮

(51)Int.Cl.

G07D 7/12(2006.01)

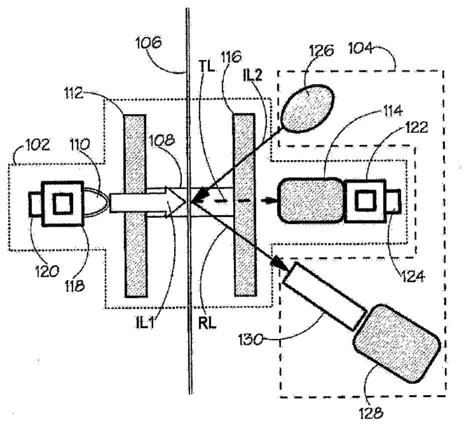
权利要求书7页 说明书27页 附图12页

(54)发明名称

验证装置和方法

(57)摘要

验证装置，其进行操作以响应于检测到物品的位于所述装置的测量区域中的部分具有预定双折射特性来判定包括膜基底的物品的真实性，所述验证装置包括：物品检测单元，其进行操作以判定物品的至少一部分是否位于所述验证装置的测量区域中；以及基于光学的双折射测量装置，其中所述验证装置进行操作以比较测量的双折射特性与预定双折射特性并且基于所述比较产生指示所述物品的真实性与否的真实性信号，所述验证装置还包括控制装置，所述控制装置进行操作以响应于所述物品检测单元判定出所述物品的所述至少一部分存在于所述测量区域中与否来控制真实性信号从所述验证装置的输出。



CN 104737211 A

1.一种验证装置，其进行操作以响应于检测到物品的位于所述验证装置的测量区域中的部分具有预定双折射特性来判定包括膜基底的所述物品的真实性，所述验证装置包括：

物品检测单元，所述物品检测单元进行操作以判定物品的至少一部分是否位于所述验证装置的测量区域中；以及

基于光学的双折射测量装置，

其中，所述验证装置进行操作以比较测量的双折射特性与预定双折射特性并基于所述比较产生指示所述物品的真实性与否的真实性信号，

所述验证装置还包括控制装置，所述控制装置进行操作以响应于由所述物品检测单元判定出所述物品的所述至少一部分是否存在于所述测量区域中来控制所述真实性信号从所述验证装置的输出。

2.根据权利要求1所述的验证装置，其中，所述物品检测单元包括：

物品检测发射器，所述物品检测发射器定位且进行操作以用电磁辐射来照射所述验证装置的物品检测区域；以及

物品检测检测器，所述物品检测检测器定位且进行操作以接收从所述物品检测区域反射的电磁辐射以及透射通过所述物品检测区域的电磁辐射中至少之一，

其中，所述物品检测检测器还进行操作以提供指示物品是否存在于所述物品检测区域中的信号，以及

所述物品检测单元进行操作以响应于所述物品检测检测器接收到指示物品存在于所述物品检测区域中的信号判定所述物品的所述至少一部分位于所述测量区域中。

3.根据权利要求2所述的验证装置，其中，所述物品检测发射器进行操作以发射白光和/或红外光。

4.根据权利要求2或3所述的验证装置，其中，所述物品检测检测器进行操作以检测白光和/或红外光。

5.根据上述权利要求中任一项所述的验证装置，其中，所述验证装置进行操作以区别由发泡过程制成的物品膜基底与由不同的过程制成的物品膜基底。

6.根据上述权利要求中任一项所述的验证装置，其中，所述基于光学的双折射测量装置包括：

双折射测量发射器，所述双折射测量发射器定位且进行操作以用电磁辐射照射所述验证装置的所述测量区域；

第一起偏器，所述第一起偏器位于所述双折射测量发射器与所述测量区域的第一侧之间，使得由所述双折射测量发射器发射的电磁辐射通过所述第一起偏器；

双折射测量检测器，所述双折射测量检测器位于所述测量区域的第二侧并且进行操作以从所述双折射测量发射器接收透射通过所述测量区域的电磁辐射；以及

第二起偏器，所述第二起偏器位于所述测量区域的所述第二侧与所述双折射测量检测器之间，使得透射通过所述测量区域的电磁辐射通过所述第二起偏器，并且所述第二起偏器定向成以在与所述第一起偏器的方向垂直的方向上实现偏振，

其中，所述双折射测量检测器进行操作以输出与测量的双折射特性相对应的信号。

7.根据权利要求6所述的验证装置，其中，由所述双折射测量检测器输出的与测量的双折射特性相对应的输出信号与接收的透射电磁辐射的强度成比例。

8.根据权利要求 7 所述的验证装置，其中，所述双折射测量检测器进行操作以将与测量的双折射特性相对应的所述输出信号通信至处理器，所述处理器进行操作以比较所述输出信号的值与所述预定双折射特性。

9.根据权利要求6至8中任一项所述的验证装置，其中，所述预定双折射特性包括以下之一：

与当所述物品的不透明的或半不透明的区域位于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第一值范围；

与当所述物品的透明的或者半透明的区域位于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第二值范围；以及

与当没有物品存在于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第三值范围。

10.根据权利要求 6 至 9 中任一项所述的验证装置，其中，所述双折射测量发射器包括光源。

11.根据权利要求 10 所述的验证装置，其中，所述光源包括发射白光的 LED。

12.根据权利要求6至10中任一项所述的验证装置，其中，所述双折射测量检测器包括光电检测器。

13.根据权利要求 12 所述的验证装置，其中，所述光电检测器包括光电二极管。

14.根据权利要求 13 所述的验证装置，其中，所述光电二极管适于检测白光。

15.根据权利要求6至14中任一项所述的验证装置，其中，所述双折射测量发射器可滑动地安装在轨道或者杆上。

16.根据权利要求 15 所述的验证装置，其中，所述双折射测量发射器通过附接件附接至所述轨道或者杆，所述附接件相对于所述轨道或者杆能够滑动并且包括固定元件，以允许相对于所述轨道或者杆固定所述双折射测量发射器的位置。

17.根据权利要求6至16中任一项所述的验证装置，其中，所述双折射测量检测器可滑动地安装在轨道或者杆上。

18.根据权利要求 17 所述的验证装置，其中，所述双折射测量检测器通过附接件附接至所述轨道或者杆，所述附接件相对于所述轨道或者杆能够滑动并且包括固定元件，以允许相对于所述轨道或者杆固定所述双折射测量检测器的位置。

19.根据上述权利要求中任一项所述的验证装置，其中，所述物品检测单元包括用于判定物品验证区域是否位于所述测量区域中的基于光学的反射率测量装置，其中所述反射率测量装置包括：

反射率测量发射器，所述反射率测量发射器进行操作以用电磁辐射照射所述验证装置的所述测量区域；以及

反射率测量检测器，所述反射率测量检测器定位且进行操作以接收从所述验证装置的所述测量区域反射的电磁辐射，以及进行操作以输出与从所述测量区域反射的所述电磁辐射的测量特性相对应并且指示物品验证区域是否存在于所述测量区域中的信号，

其中，所述反射率测量装置进行操作以比较测量的反射特性与一组预定反射特性，并基于所述比较判定所述物品验证区域是否存在于所述测量区域中，并且还进行操作以向所述控制装置提供指示所述判定的信号，从而控制所述真实性信号从所述控制装置的输出。

20. 根据权利要求 19 所述的验证装置，其中，由所述反射率测量检测器输出的与测量的反射特性相对应的所述输出信号与接收的反射电磁辐射的强度成比例。

21. 根据权利要求 19 或 20 所述的验证装置，其中，所述反射率测量检测器进行操作以将与测量的反射特性相对应的所述输出信号通信至处理器，所述处理器进行操作以比较与测量的反射特性相对应的所述输出信号的值与所述预定反射特性，所述预定反射特性包括指示所述物品的物品验证区域存在于所述测量区域中的预先限定值，并且所述处理器进行操作以基于所述比较实施所述物品真实区域存在或者不存在于所述测量区域中的所述判定，并进行操作以向所述控制装置提供指示所述判定的所述信号。

22. 根据权利要求 21 所述的验证装置，其中，如果所述预定反射特性与由所述反射率测量检测器输出的与测量的反射特性相对应的所述输出信号的所述比较指示所述物品验证区域位于所述测量区域中，所述处理器进行操作以向所述控制装置输出指示所述物品验证区域存在于所述测量区域中的判定信号，其中，响应于接收到所述判定信号，所述控制装置进行操作以基于所述预定双折射特性与由所述双折射测量检测器输出的与测量的双折射特性相对应的所述输出信号的所述比较输出指示所述物品的真实性与否的所述真实性信号。

23. 根据权利要求 19 至 22 中任一项所述的验证装置，其中，所述预定反射特性包括以下中的一个或多个：

与当所述物品的不透明的或者半不透明的区域位于所述测量区域中时期望的反射率测量检测器输出信号值相对应的第一值范围；

与当所述物品的透明的或者半透明的区域位于所述测量区域中时期望的反射率测量检测器输出信号值相对应的第二值范围；以及

与当没有物品存在于所述测量区域时期望的反射率测量检测器输出信号值相对应的第三值范围。

24. 根据权利要求 19 至 23 中任一项所述的验证装置，其中，所述反射率测量检测器具有与其关联的遮挡件，所述遮挡件包括至少一个孔，其中所述孔相对于所述反射率测量检测器定位，以准许由所述反射率测量检测器接收从所述物品的所述至少一部分反射的电磁辐射。

25. 根据权利要求 24 所述的验证装置，其中，所述遮挡件包括管，并且所述孔包括所述管的中空部分。

26. 根据权利要求 25 所述的验证装置，其中，所述反射率测量检测器定位在所述管的端部或者定位在所述管内。

27. 根据权利要求 24 所述的验证装置，其中，所述孔包括所述遮挡件中的管状区域。

28. 根据权利要求 27 所述的验证装置，其中，所述反射率测量检测器定位在所述遮挡件的所述管状区域的端部或定位在所述管状区域内。

29. 根据权利要求 19 至 28 中任一项所述的验证装置，其中，所述反射率测量发射器具有与其关联的遮挡件，所述遮挡件包括孔，其中所述孔相对于所述反射率测量发射器定位，以准许从所述反射率测量发射器发射的电磁辐射被导向至所述验证装置的所述测量区域。

30. 根据权利要求 29 所述的验证装置，其中，所述遮挡件包括管，并且所述孔包括所述管的中空部分。

31.根据权利要求 30 所述的验证装置，其中，所述反射率测量发射器定位在所述管的端部或者定位在所述管内。

32.根据权利要求 29 所述的验证装置，其中，所述孔包括所述遮挡件中的管状区域。

33.根据权利要求 32 所述的验证装置，其中，所述反射率测量发射器定位在所述遮挡件的所述管状区域的端部或定位在所述管状区域内。

34.根据权利要求 19 至 33 中任一项所述的验证装置，其中，所述反射率测量发射器进行操作以发射相干电磁辐射。

35.根据权利要求 19 至 34 中任一项所述的验证装置，其中，所述反射率测量发射器包括至少一个 LED。

36.根据权利要求 35 所述的验证装置，其中，所述至少一个 LED 进行操作以发射位于电磁谱的红外范围中的光和 / 或包括白光发射源。

37.根据权利要求 19 至 36 中任一项所述的验证装置，其中，所述反射率测量发射器包括至少一个条状电磁辐射源。

38.根据权利要求 19 至 37 中任一项所述的验证装置，其中，所述反射率测量检测器包括至少一个光电二极管。

39.根据权利要求 38 所述的验证装置，其中，所述至少一个光电二极管进行操作以检测位于电磁谱的红外范围中的光。

40.根据权利要求 19 至 39 中任一项所述的验证装置，其中，所述反射率测量检测器包括至少一个线扫描照相机和 / 或包括至少一个分光仪以及 CCD 或 CMOS 图像传感器。

41.根据权利要求 19 至 40 中任一项所述的验证装置，其中，

所述反射率测量发射器包括以下中的至少之一：

多个 LED；

多个白光发射源；以及

多个条状电磁辐射源，以及

所述反射率测量检测器包括以下中的至少之一：

多个光电二极管；

多个线扫描照相机；以及

多个分光仪以及 CCD 或 CMOS 图像传感器，

其中所述多个 LED 中的每个与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或 CMOS 图像传感器中对应的一个成对，其中所述多个白光发射源中的每个与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或 CMOS 图像传感器中对应的一个成对，以及其中所述多个条状电磁辐射源中的每个与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或 CMOS 图像传感器中对应的一个成对。

42.根据权利要求 41 所述的验证装置，其中，所述多个 LED 中的至少之一进行操作以发射位于电磁谱的红外范围中的光。

43.根据权利要求 41 或 42 所述的验证装置，其中，所述多个光电二极管中的至少之一进行操作以检测位于电磁谱的红外范围中的光。

44.根据上述权利要求中任一项所述的验证装置，其中，所述装置包括传输路径，所述

传输路径的一部分包括所述测量区域，所述物品能够沿着传输路径进行传运。

45. 根据上述权利要求中任一项所述的验证装置，其中，所述物品包括钞票。

46. 根据引用权利要求 9 的权利要求 45 或直接或间接引用权利要求 9 的权利要求 10 至 44 中任一项所述的验证装置，其中，

所述不透明的或者半不透明的区域包括钞票的印刷区域，和 / 或

所述物品的所述透明的或者半透明的区域包括所述钞票的未印刷区域或者窗区域。

47. 一种钞票计数装置，包括根据上述权利要求中任一项所述的验证装置，所述钞票计数装置还包括钞票计数设备，所述钞票计数设备进行操作以维持传运通过所述装置的钞票的计数，所述钞票计数设备还进行操作以从所述验证装置接收指示所述物品的真实性与否的所述真实性信号，其中所述钞票计数设备进行操作以仅当所述信号指示所述测量区域中的物品是真的时改变钞票计数。

48. 根据权利要求 47 所述的钞票计数装置，其中，一旦接收到指示所述测量区域中的所述物品是真的的所述信号，所述钞票计数设备进行操作以改变所述钞票计数。

49. 根据权利要求 48 所述的钞票计数装置，其中，所述钞票计数设备进行操作以通过增加计数来改变所述钞票计数。

50. 一种验证包括膜基底的物品的方法，所述方法包括检测物品的位于验证装置的测量区域中的部分是否具有预定双折射特性，并且所述方法还包括 ：

通过物品检测单元判定物品的至少一部分是否位于所述验证装置的测量区域中 ；

比较由基于光学的双折射测量装置获得的测量的双折射特性与预定双折射特性 ；

基于所述比较产生指示所述物品的真实性与否的真实性信号 ；以及

响应于通过所述物品检测单元判定出所述物品的所述至少一部分是否存在于所述测量区域中，通过控制装置控制所述真实性信号从所述验证装置的输出。

51. 根据权利要求 50 所述的方法，包括通过形成所述物品检测单元的一部分的物品检测发射器用电磁辐射照射所述装置的物品检测区域，以及通过形成所述物品检测单元的一部分的物品检测检测器接收从所述物品检测区域反射的电磁辐射和透射通过所述物品检测区域的电磁辐射中至少之一，并且还包括提供指示物品是否存在于所述物品检测区域中的信号，以及响应于接收到指示物品存在于所述物品检测区域中的物品检测检测器信号，通过所述物品检测器单元判定所述物品的所述至少一部分位于所述测量区域中。

52. 根据权利要求 50 或 51 所述的方法，其中，所述方法区别由发泡过程制成的物品膜基底以及由不同过程制成的物品膜基底。

53. 根据权利要求 50 至 52 中任一项所述的方法，包括 ：

利用双折射测量发射器用电磁辐射照射所述验证装置的所述测量区域 ；

将第一起偏器定位在所述双折射测量发射器与所述测量区域的第一侧之间，使得由所述双折射测量发射器发射的电磁辐射通过所述第一起偏器 ；

将双折射测量检测器定位在所述测量区域的第二侧 ；

在所述双折射测量检测器处从所述双折射测量发射器接收透射通过所述测量区域的电磁辐射 ；

将第二起偏器定位在所述测量区域的所述第二侧与所述双折射测量检测器之间，使得透射通过所述测量区域的电磁辐射通过所述第二起偏器 ；

定向所述第二起偏器，以在与所述第一起偏器的方向垂直的方向上实现偏振；

从所述双折射测量检测器输出与测量的双折射特性相对应的信号。

54. 根据权利要求 53 所述的方法，包括：

将与测量的双折射特性相对应的所述输出信号通信至处理器；以及

在所述处理器中比较所述输出信号的值与所述预定双折射特性。

55. 根据权利要求 53 或 54 所述的方法，其中，所述预定双折射特性包括以下之一：

与当所述物品的不透明的或者半不透明的区域位于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第一值范围；

与当所述物品的透明的或者半透明的区域位于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第二值范围；以及

与当没有物品存在于所述测量区域中时期望的双折射测量检测器输出信号值相对应的第三值范围。

56. 根据权利要求中 50 至中任一项所述的方法，所述方法包括：通过所述物品检测单元的基于光学的反射率测量装置判定物品的物品验证区域是否位于所述测量区域中，其中通过以下步骤来实施判定的步骤：

通过所述反射率测量装置的反射率测量发射器用电磁辐射照射所述验证装置的所述测量区域；

通过所述反射率测量装置的反射率测量检测器接收从所述验证装置的所述测量区域反射的电磁辐射；

从所述反射率测量检测器输出与从所述测量区域反射的所述电磁辐射的测量特性相对应并且指示物品验证区域是否存在于所述测量区域中的信号；

在所述反射率测量装置中比较测量的反射特性与一组预定反射特性；

基于所述比较判定所述物品验证区域是否存在于所述测量区域中；以及

向所述控制装置提供指示所述判定的信号，以控制所述真实性信号从所述控制装置的输出。

57. 根据权利要求 56 所述的方法，包括将与测量的反射特性相对应的所述输出信号通信至处理器，所述处理器进行操作以比较与测量的反射特性相对应的所述输出信号的值与所述预定反射特性，所述预定反射特性包括指示所述物品的物品验证区域存在于所述测量区域中的预定值，并且所述处理器进行操作以基于所述比较实施所述物品验证区域存在或者不存在于所述测量区域中的所述判定以及进行操作以向所述控制装置提供指示所述判定的所述信号。

58. 根据权利要求 57 所述的方法，其中，如果所述预定反射特性和由所述反射率测量检测器输出的与测量的反射特性相对应的所述输出信号的所述比较指示所述物品验证区域位于测量区域中，从所述处理器向所述控制装置输出指示所述物品验证区域存在于所述测量区域中的判定信号，其中，响应于接收到所述判定信号，基于所述预定双折射特性和由所述双折射测量检测器输出的与测量的双折射特性相对应的所述输出信号的所述比较，从所述控制装置输出指示所述物品的真实性与否的所述真实性信号。

59. 根据权利要求 56 至 58 中任一项所述的方法，其中，所述预定反射特性包括以下中的一个或多个：

与当所述物品的不透明的或者半不透明的区域位于所述测量区域中时期望的反射率测量检测器输出信号值相对应的第一值范围；

与当所述物品的透明的或者半透明的区域位于所述测量区域中时期望的反射率测量检测器输出信号值相对应的第二值范围；以及

与当没有物品存在于所述测量区域中时期望的反射率测量检测器输出信号值相对应的第三值范围。

60. 根据权利要求 50 至 59 中任一项所述的方法，其中，所述物品包括钞票。

61. 根据引用权利要求 55 的权利要求 60 或者直接或间接引用权利要求 55 的权利要求 56 至 59 中任一项所述的方法，其中，

所述不透明的或者半不透明的区域包括钞票的印刷区域，和 / 或

所述物品的所述透明的或者半透明的区域包括所述钞票的未印刷区域或窗区域。

62. 根据权利要求 50 至 61 中任一项所述的方法，包括在所述验证装置中提供传输路径，所述传输路径的一部分包括所述测量区域，以及沿着所述传输路径传运所述物品。

63. 一种钞票计数方法，包括根据权利要求 50 至 62 中任一项所述的方法，所述钞票计数方法还包括：

使用钞票计数设备维持传运通过所述装置的钞票的计数；

在所述钞票计数设备处从所述验证装置接收指示所述物品的真实性与否的所述真实性信号；以及

仅当所述真实性信号指示所述测量区域中的物品是真的时改变钞票计数。

64. 根据权利要求 63 所述的方法，还包括一旦接收到指示所述测量区域中的物品是真的的真实性信号，则改变所述钞票计数。

65. 根据权利要求 64 所述的方法，包括通过增加所述钞票计数来改变所述钞票计数。

验证装置和方法

[0001] 本发明涉及验证装置和方法，具体地但非排他性地涉及用于验证包括聚合物膜的物品的验证装置和方法。

[0002] 在安全、验证、识别以及防伪很重要的领域，聚合物膜越来越多地用作基底。这样的领域中基于聚合物的产品包括例如钞票、重要文件（例如，ID 材料如例如护照和地契，股份证书和教育证书）、用于包装高价物品的膜以用于防伪目的、以及安全卡。

[0003] 基于聚合物的安保材料在安全、功能性、耐久性、成本有效性、清洁性、处理能力和环境考虑方面具有优势。也许在这些之中最突出的是安全优势。例如，基于纸的钞票会相对易于复制，基于聚合物的钞票比起基于纸的钞票在各国家中伪造的发生率较低。基于聚合物的钞票还是持续性长的以及不容易撕裂的。

[0004] 基于聚合物膜的安全材料由此结合了各种可见及隐藏的安全特征。从约 25 年前引入首张聚合物钞票起，安全特征包括光学可变设备 (OVD)、不透明特征、印刷安全特征安全螺纹、凸起、透明窗和衍射光栅。除了复杂的安全特征，还存在更直接的优势：如果伪造者试图使用复制机器简单地复制安全材料（例如钞票）时，复制机器中使用的高温通常将引起基于聚合物的材料的熔化或者扭曲。

[0005] 但是，当前仅有限的使用适合于在销售点验证安全文件的独立装置。销售点可具有用于检测钞票上的荧光墨的 UV 光源，或者无法在真实的钞票上做标记的笔。这些设备无法对伪造者提供高技术障碍。销售点还可以具有电子装置，该电子装置使用嵌入在卡中的防篡改电子电路来验证信用卡或者借记卡。但是，该装置是复杂且昂贵，要求时间来处理，需要与远程服务器的通讯链路，并且不适合于在日常现金交易中用来验证钞票。

[0006] 用于核查钞票真实性的更复杂装置通常由信贷机构和专业现金处理者使用以核查将要返回流通的钞票，但这种装置是昂贵的，尤其是因为其通常需要核查多个安全特征的存在以验证钞票。现金接收机具有复杂度低的验证装置，因为它们需要保持相对低的成本。

[0007] 各种聚合物可用作安全基底。在这之中有聚丙烯膜。制造聚丙烯膜的三种主要方法是拉幅方法、浇铸方法和发泡方法。

[0008] 在浇铸及拉幅方法中，将聚合物芯片通常放置在挤出器中并且对其加热，使得挤出件从缝模挤出至冷辊上以形成膜（在浇铸方法的情形下）或者厚聚合物带（在拉伸方法的情形下）。在拉幅方法中，厚聚合物带然后被再加热，然后被沿长度方向（称为“机器方向”）和宽度方向（称为“横向方向”）拉伸以形成膜。

[0009] 在发泡方法中，聚合物不是通过缝模挤出而是通过环形模挤出，以形成相对厚的挤出件，挤出件呈中空柱或“排水管”形状，空气通过该挤出件吹送。环形模位于装置的顶部，其中该装置通常相当于若干楼层那么高（例如 40 至 50 米）。挤出件向下移动并且连续地加热，使得其膨胀以形成泡。泡然后分成两个半泡，每个半泡可以单独用作“单网(monoweb)”膜；或者可替代性地，两个半泡可以捏合以及层压在一起以形成双厚度的膜（或者泡可以坍塌以形成双厚度的膜）。通常，模具处具有三个同心环，使得中空柱是具有三个层的挤出件。例如，可以存在三元共聚物皮层位于一侧并且另一三元共聚物皮层位于

另一侧的聚丙烯芯层。在该情况下，单网包括聚丙烯在中间的三层，双网包括五层，因为中间的层为每个半泡的相同表层（三元共聚物）。例如，在环的数量、表层的类型、芯层的类型等方面，许多其他可能布置以及部件是可能的。

[0010] 因此，发泡方法是通过形成泡来产生薄膜（例如 10 微米至 100 微米厚），而拉伸方法是通过拉伸材料来产生薄膜。发泡方法产生均匀拉伸的膜，其不同于拉幅膜并且对于某些目的优于拉幅膜。双轴向定向聚丙烯 (BOPP) 膜是由英国威尔顿的 Innovia Films Ltd. 通过发泡过程制成的。除了聚丙烯，还可以使用发泡过程使其他聚合物（例如 LLDPE、聚丙烯 / 丁烯共聚物）形成为薄膜。

[0011] 先前的验证装置和方法使用了已知的安全文件基底片材，该片材能够允许电磁辐射，例如，对电磁谱的可见区域是透明的。已知的是通过将不透明墨印刷到透明塑料基底材料的片材上且留下透明的窗来形成安全文件（诸如钞票）。所得到的窗提供了人眼易见的明显安全特征。已知将额外光学安全特征（诸如由衍射光栅形成的光学可变设备）印刷、蚀刻、嵌到所得到的透明窗上或透明窗中，以提供额外的明显安全特征。已知提供自动验证装置，其能够根据存在或者不存在这些额外光学安全特征来判定真实性，但这种装置通常是复杂且昂贵的。

[0012] WO 2009/133390 公开了一种验证聚合物膜的方法，该方法包括测量其中芯层的双折射。

[0013] 双折射或者双折射是因材料对于两种不同偏振即 s- 偏振及 p- 偏振的以及在其表面位置的两个轴线之间的不同折射率导致的材料属性。

[0014] 双折射材料在偏振光照射时将光分为正常射线以及异常射线，它们都因透射通过双折射材料而被延迟不同程度。在透射通过与偏振光成 90° 的第二起偏器之后，两种射线再次结合并且彼此相消干涉或相长干涉。随着双折射材料从最小值（相对于起偏器是 0° ）旋转至最大值（相对于起偏器是 45° ），所产生的效应是呈正弦波形式的可变透射。

[0015] 以三种方式在透明聚合物膜中引起双折射：晶体定向、聚合物链定向以及晶格变形。

[0016] 折射率与材料的密度成比例；聚合材料以两种形式存在，即结晶以及无定形，这两种形式都以已知比例存在于具体聚合物类型中 - 聚丙烯根据其分子量范围以及其立体化学可具有 35％至 50％的结晶。在发泡过程中，随着使用冷水对熔化的浇铸管（1mm 厚）进行淬火，出现结晶；冷却是快速的并且在膜的整个厚度上出现温度梯度，从而给予了结晶一些方向性。结晶区域形成了整个浇铸管，然后在拉伸过程中浇铸管在最终的聚合物内被拉成最终的形状。双折射是由结晶区域的各尺寸的长度差以及其在聚合物内的定向所导致的；因为发泡聚合物沿机器方向以及横向方向相同地拉伸，期望的是平均地产生低双折射；然而结晶区域的不均匀分布在 1 - 3mm 的距离内会导致双折射的变化。

[0017] 折射率还受聚合物链在材料内的定向的影响；这对总双折射具有最大的影响，其中总折射率与拉伸期间机器方向与横向方向的应力之比成比例。

[0018] 最后，晶格变形在理论上是双折射的起因，但是在软的低熔点材料（诸如聚丙烯）中不会是显著的。

[0019] 材料的双折射产生的效应显示其本身为透射通过材料的光的偏振角度；该效应经由界面作用激发，并且通过双折射材料传播；观察到的双折射程度是初始界面相互作用

(即入射角)和通过材料的后继光程长度(subsequent path length)的产物。

[0020] 正如从以上注意到的,双折射效应是膜的厚度和两轴之间折射率的区别程度的产物。如果膜放置在两个相交的起偏器之间并且在最小值(相当于来自相交的起偏器的透射无变化)和45°处的最大值(在该处尽可能多的光将透射通过单个起偏器)之间旋转通过90°,则能够观察到该效应。

[0021] 膜中的双折射是由机器方向和横向方向产生的定向差异所引发的;所得到的膜具有彼此成90°的两个轴线,在这些点处双折射为其最小值,从任一轴起45°为最大值。由于以卷轴和片材加工的膜的性质,通过每个已知过程产生的每种材料将具有包括起偏器的相同属性。

[0022] 因为聚合物的定向的普遍性,在45°的单次测量双折射足以判定任何膜的最大值以及由该膜产生的任何印刷产品。起偏器本身也符合此规律;因此在制造这样的设备时,用于起偏器的规格应该是其应该从主起偏器片材以45°进行切割。

[0023] 在WO2009/133390中公开的方法和装置涉及使用相对于彼此定向成90°的一对转动式起偏器。起偏器进行操作以以相同速度旋转,该装置进行操作以测量通过放置于起偏器之间的样本的光的强度。

[0024] 图1至图3示出了如WO2009/133390所公开的用于观察双折射的不同方法的装置的部件。

[0025] 参照图1,观察双折射的第一方法是经由使用相交的起偏器。线性起偏器允许s-偏振光或p-偏振光中的一个类型通过它们,使得当第二线性起偏器存在且相对于第一线性起偏器扭转90°时,过滤掉由单个偏振类型产生的剩余的光;该技术称为使用相交的起偏器。双折射材料有效地旋转偏振轴线并因此当放置在两个相交的起偏器之间时,将影响允许多少光通过它们。旋转相交的起偏器之间的双折射材料导致光的强度随着双折射角度的改变而改变。薄聚合物膜双折射在第一级上操作并将趋于使光在0°至90°之间旋转;完全的双折射材料将在从不增强起偏器之间的透射至通过将光旋转通过第二起偏器来消除第一起偏器的效应之间改变。该行为形成了一种测量膜双折射方法的基础;通常样本放置在两个机动化的相交偏振滤光器之间,偏振滤光器然后旋转通过360度且同时彼此维持相同旋转配置,光从光源通过滤光器/样本/滤光器,并且使用光电二极管测量其强度。测量出的强度将遵循两个180°的周期,其最大值及最小值与膜的双折射相关。

[0026] 参照图2,用于测量双折射的第二方法是使用包括材料扇区的两个圆形线性偏振滤光器,每个圆形线性偏振滤光器具有其自身的偏振角度,该偏振角度与扇区在圆形镜片上的角度位置有关。如果通过其s-和p-定向来区分这些镜片中的两个,则二者的组合将用作用于每个扇区的相交起偏器。单个光源可用于照射放置在这两个起偏器之间的样本,来自每个扇区的透射光能够供给至光学纤维中,该光学纤维接着使用光电二极管测量透射光的强度。以该方式,在单次测量中无需旋转起偏器就可测量膜的双折射行为-这种测量的分辨率取决于每个扇区的角度尺寸,例如,20°的扇区将进行18次测量,将足以找到最大和最小透射率。

[0027] 参照图3,用于测量双折射的第三方法是使用石英楔。在这种情况下,双折射材料放置在偏振滤光器与校准石英楔之间,同时将光照射向检查系统,该检测系统测量该楔上条纹的位置。

[0028] 为了区别指定的真膜和其他的膜，可以采用上述的双折射测量方法以允许用户排除其他类型的膜，即指定的伪造膜：通过拉伸方法制造的 BOPP 膜更多地定向在横向方向而不是机器方向，因而比通过双发泡过程制造的 BOPP 膜具有更有双折射性。使用双发泡处理能够精确控制双折射并因此能够提供可排除膜的独特标志。

[0029] WO2009/133390 的方法允许照原样保护膜。使用所公开的方法观察膜的具体固有特性，不需要添加任何其他的安全或者识别特征。该识别允许安全目的的验证并且还允许确定膜的原料。

[0030] 本文中涉及的膜通常是片材形式的材料，并且可作为独立的片材，或作为网的材料，网的材料可以随后进行加工（例如通过模切割）以提供片材或者物件形式的材料。当在本说明书中提到“膜”时，除非另有明确说明，其旨在包括呈片材、物件或者网的形式的膜。

[0031] WO2009/133390 的方法适合于验证包括通过发泡过程制成的膜的物品。发泡过程产生的膜具有平衡定向、良好限定且均匀的厚度以及其他属性（高拉伸强度、低延伸率、高光泽度以及清澈，良好的耐刺穿性及耐挠裂性、耐油和油脂、良好的不透水性），其限定了膜的指示膜是通过发泡过程制造的“标志”。

[0032] 为了区别膜（例如 BOPP 膜以及其他膜），可测量膜的总厚度以及诸如层压层的各层的厚度。这允许判定取决于具体处理（例如具体发泡过程）的具体特性。另外或可替代地，可评估膜的独特双折射标志并且用其判定膜是否通过具体方法制成，以及相应地判定例如其是否是真的钞票或者是伪造的。双折射取决于材料的各向异性，并且通过发泡过程制成的膜具有不同的各向异性，因而具有与由其他过程制成的膜不同的双折射属性。此外，发泡过程中使用的精确条件将影响双折射标志。

[0033] 因而 WO2009/133390 认识到，无需添加安全或者识别特征，通过具体过程（诸如发泡过程）制造的膜的固有属性是独特的并且可充当标志。

[0034] 实际上伪造的膜更可能被买到而不是被伪造者制成。存在可分为三种主要类型的多个源：

[0035] 1、浇铸或吹膜 - 浇铸膜是通过将聚合物从模具挤出至冷辊上而制造的。吹塑膜是通过将聚合物挤出圆形模具以及在半熔化状态下使泡膨胀而制成的。浇铸膜和吹膜通常是无定向或略微定向的，因而具有较差的尺寸稳定性（即它们能够容易地拉伸）、较弱的光学性及厚度控制。

[0036] 2、单定向膜 – 单定向膜是通过从模具挤出并沿机器方向拉伸而制造的。单定向膜是高度定向的，它们具有较弱的光学性以及差的横向方向尺寸稳定性。

[0037] 3、双轴向定向膜 - 双轴向定向膜能够从 Innovia Films Limited 和多个其他供应商处商业上获得。来自许多供应商的商用级 BOPP 通常是通过拉伸过程制造的，其中 PP 从缝模挤出至冷辊上，在加热辊上沿机器方向拉伸，并且在张布框架中沿横向方向拉伸。这些膜不同于通过双发泡过程制造的 BOPP 本质上是各向异性的，BOPP 在所有方向上是均匀地拉伸定向的。

[0038] 存在这样的可能性：伪造者会意识到上述双折射效应。为了欺骗采用上述方法的系统，伪造者可以通过在膜上以 45° 印刷至膜的片材边缘或者卷轴边缘来生产伪造物品。同时这么做的难度可能有效排除任何工业过程，对于精明的确定的伪造者来说仍然存在危险。

[0039] 上述的双折射测量方法可能需要相对长时间来进行适当的测量。实践中,这可以大于1秒,从而有效排除高速测量。此外,存在物品放置和测量区域的问题。物品的透明区域或者“窗”区域可能是小的,并且用印痕部分地覆盖。因而,在钞票验证的具体领域,可能可以进行具体面额的自动对准,但在人工使用时会变得尴尬。测量区域的尺寸使该情况更复杂:大区域会是更精确的,但将更可能意外地包括窗的一些印刷区域。

[0040] 上述的双折射测量方法可用于验证形成安全文件的一部分的膜。但是,在一些情况下,这些安全文件可以包括膜基底,至少一部分膜基底被印刷在其上。为了确保对膜基底本身进行正确的双折射测量,测量应该针对膜的未印刷或者“窗”区域进行,即针对物品的物品验证区域进行。对膜基底的印刷区域执行的双折射测量会导致“误报(false positive)”,因为对于印刷区域的双折射测量读数可能与真膜具有相似的读数水平。因此,重要的是,双折射测量是对物品的未印刷或者“窗”区域(即直接位于膜基底上)执行,而不是对印刷区域执行,以避免这种“误报”以及获得膜基底的精确双折射测量。当放置在两个起偏器之间时,非窗区域会被误认为是低双折射区域或者空气,因为在这两种情形下相交的起偏器之间的透射较低。

[0041] 如可理解的那样,确保在物品的窗区域(或者物品验证区域)而非对印刷区域上执行双折射测量的需要可能要求用户对物品进行一些操纵。用户可能需要在测量装置内移动物品,直到物品的窗区域位于测量区域中,其中在该区域中可执行双折射测量方法。这证明是耗时的并且用户操纵物品以将窗适当地定位在测量区域中。

[0042] 期望的是,使用机器供给装置实施双折射测量方法以用于验证物品。这可以潜在地增大能够验证物品的速度。

[0043] 基于上述考虑提出了本发明。

[0044] 根据本发明的一方面,提供了一种验证装置,其进行操作以响应于检测到物品的位于所述装置的测量区域中的部分具有预定双折射特性来判定包括膜基底的物品的真实性,所述装置包括:物品检测单元,其进行操作以判定物品的至少一部分是否位于所述验证装置的测量区域中;以及基于光学的双折射测量装置,其中,所述验证装置进行操作以比较测量出的双折射特性与预定双折射特性并且基于所述比较来产生指示所述物品的真实性与否的真实性信号,所述装置还包括控制装置,所述控制装置进行操作以响应于所述物品检测单元判定出所述物品的所述至少一部分存在于所述测量区域中与否来控制真实性信号从所述装置的输出。

[0045] 这可以允许装置仅当真实或者真物品的一部分位于测量区域中时输出真实性信号。物品检测器单元的操作可以用于降低所述装置的功率消耗:可以仅当物品存在时由所述装置输出真实性信号。否则不输出任何信号。

[0046] 可选地,所述物品检测单元可以包括:物品检测发射器,其定位且进行操作以用电磁辐射来照射所述装置的物品检测区域;以及物品检测检测器,其定位且进行操作以接收从所述物品检测区域反射的电磁辐射以及透射通过所述物品检测区域的电磁辐射中至少之一,其中,所述物品检测检测器进一步进行操作以提供指示物品存在于所述物品检测区域中与否的信号,以及所述物品检测单元进行操作以响应于所述物品检测检测器接收到指示物品存在于所述物品检测区域中的信号来判定出所述物品的所述至少一部分位于所述测量区域中。

[0047] 所述物品检测发射器可以进行操作以发射白光和/或红外光，以及所述物品检测检测器可以进行操作以检测白光和/或红外光。

[0048] 进一步可选地，所述装置可以进行操作以区别由发泡过程制成的物品膜基底以及由不同的过程制成的物品膜基底。

[0049] 所述基于光学的双折射测量装置可以包括：双折射测量发射器，其定位且进行操作以用电磁辐射照射所述装置的所述测量区域；第一起偏器，其位于所述双折射测量发射器和所述测量区域的第一侧之间，使得由所述双折射测量发射器发射的电磁辐射通过其中；双折射测量检测器，其位于所述测量区域的第二侧，以及进行操作以从所述双折射测量发射器接收透射通过所述测量区域的电磁辐射；以及第二起偏器，其位于所述测量区域的所述第二侧和所述双折射测量检测器之间，使得透射通过所述测量区域的电磁辐射通过其中，所述第二起偏器定向成以在与所述第一起偏器的方向垂直的方向上实现偏振，其中，所述双折射测量检测器进行操作以输出对应于测量出的双折射特性的信号。

[0050] 由所述双折射测量检测器输出的对应于测量出的双折射特性的所述输出信号可以与接收到的透射电磁辐射的强度成比例。

[0051] 可选地，所述双折射测量检测器可以进行操作以将对应于测量出的双折射特性的所述输出信号输送至处理器，所述处理器进行操作以比较所述输出信号的值与所述预定双折射特性。

[0052] 进一步可选地，所述预定双折射特性可以包括以下之一：如果所述物品的不透明的或者半不透明的区域位于所述测量区域中，对应于期望双折射测量检测器输出信号值的第一值范围；如果所述物品的透明的或者半透明的区域位于所述测量区域中，对应于期望双折射测量检测器输出信号值的第二值范围；以及如果没有物品存在于所述测量区域中，对应于期望双折射测量检测器输出信号值的第三值范围。

[0053] 所述双折射测量发射器可以包括光源。可选地，所述光源可以包括发射白光的LED。

[0054] 所述双折射测量检测器可以包括光电检测器。可选地，所述光电检测器可以包括光电二极管。进一步可选地，所述光电二极管可以适于检测白光。

[0055] 所述双折射测量检测器可以可滑动地安装在轨道或者杆上。可选地，所述双折射测量检测器可以通过能够相对于所述轨道或者杆滑动的附接件附接至所述轨道或者杆，并且所述附接件可以包括固定元件（例如锁定螺钉）以允许相对于所述轨道或者杆固定所述双折射测量检测器的位置。

[0056] 所述双折射测量检测器可以可滑动地安装在轨道或者杆上。可选地，所述双折射测量检测器可以通过能够相对于所述轨道或者杆滑动的附接件附接至所述轨道或者杆，并且所述附接件可以包括固定元件（例如锁定螺钉）以允许相对于所述轨道或者杆固定所述双折射测量检测器的位置。

[0057] 可选地，所述物品检测单元可以包括用于判定物品验证区域是否位于所述测量区域中的基于光学的反射率测量装置，其中，所述反射率测量装置可以包括：反射率测量发射器，其进行操作以用电磁辐射照射所述装置的所述测量区域；以及反射率测量检测器，其定位且进行操作以接收从所述装置的所述测量区域反射的电磁辐射，以及进行操作以输出对应于从所述测量区域反射的所述电磁辐射的测量特性并且指示物品验证区域存在于测量

区域中与否的信号，其中，所述反射率测量装置进行操作以比较测量出的反射特性与一组预定反射特性，并且基于所述比较来判定所述物品验证区域存在于所述测量区域中与否，并且进一步进行操作以向所述控制装置提供指示所述判定的信号以用于控制从所述控制装置输出真实性信号。

[0058] 这可以允许装置仅当物品的物品验证区域位于测量区域中时输出真实性信号。在所有其他时间，装置可以输出另一信号类型。例如，信号可以包括指示没有样本存在的信号，或者例如指示物品位于测量区域中的区域不是验证区域（例如物品的非窗区域或者印刷区域）的信号。

[0059] 可选地，由所述反射率测量检测器输出的对应于测量出的反射特性的所述输出信号可以与接收到的反射电磁辐射的强度成比例。

[0060] 可选地，所述反射率测量检测器可以进行操作以将对应于测量出的反射特性的所述输出信号输送至处理器，所述处理器进行操作以比较对应于所述测量出的反射特性的所述输出信号的值与所述预定反射特性，所述预定反射特性可以包括指示所述物品的物品验证区域存在于所述测量区域中的预先限定值，并且所述处理器进行操作以基于所述比较来实施所述物品真实区域存在或者不存在于所述测量区域中的所述判定，以及进行操作以向所述控制装置提供指示所述判定的所述信号。

[0061] 可选地，如果所述预定反射特性与由所述反射率测量检测器输出的对应于测量出的反射特性的所述输出信号的所述比较指示所述物品验证区域位于测量区域中，所述处理器进行操作以输出指示所述物品验证区域存在于所述测量区域中的判定信号至所述控制装置，其中，响应于接收，所述控制装置进行操作以基于所述预定双折射特性与由所述双折射测量检测器输出的对应于测量出的双折射特性的所述输出信号的所述比较来输出指示所述物品的真实性与否的真实性信号。

[0062] 可选地，所述预定反射特性可以包括以下中的一个或多个：如果所述物品的不透明的或者半不透明的区域位于所述测量区域中，对应于期望反射率测量检测器输出信号值的第一值范围；如果所述物品的透明的或者半透明的区域位于所述测量区域中，对应于期望反射率测量检测器输出信号值的第二值范围；以及如果没有物品存在于所述测量区域中，对应于期望反射率测量检测器输出信号值的第三值范围。

[0063] 可选地，所述反射率测量检测器可以具有与其关联的遮挡件，所述遮挡件包括至少一个孔，其中，所述孔可以相对于所述反射率测量检测器定位以允许从所述物品的所述至少一部分反射的电磁辐射由所述反射率测量检测器接收。

[0064] 可选地，所述遮挡件可以包括管，并且所述孔可以包括所述管的中空部分。进一步可选地，所述孔可以包括所述遮挡件中的管状区域。所述反射率测量检测器可以定位在所述管的端部或者所述管内，或者定位在所述遮挡件的所述管状区域的端部或所述管状区域内。

[0065] 可选地，所述反射率测量发射器具有与其关联的遮挡件，所述遮挡件包括孔，其中，所述孔相对于所述反射率测量发射器定位以允许从所述反射率测量发射器发射的电磁辐射被导向所述装置的所述测量区域。

[0066] 可选地，所述遮挡件可以包括管，并且所述孔可以包括所述管的中空部分。进一步可选地，所述孔可以包括所述遮挡件中的管状区域。所述反射率测量发射器可以定位在所

述管的端部或者所述管内，或者定位在所述遮挡件的所述管状区域的端部或所述管状区域内。

[0067] 可选地，所述反射率测量发射器进行操作以发射相干电磁辐射。进一步可选地，所述反射率测量发射器可以包括至少一个 LED。所述至少一个 LED 可以进行操作以发射位于电磁谱的红外范围中的光和 / 或可以包括白光发射源。还进一步可选地，所述反射率测量发射器可以包括至少一个条状电磁辐射源。

[0068] 可选地，所述反射率测量检测器可以包括至少一个光电二极管。进一步可选地，所述至少一个光电二极管可以进行操作以检测位于电磁谱的红外范围中的光。还进一步可选地，所述反射率测量检测器可以包括至少一个线扫描照相机和 / 或可以包括至少一个分光仪以及 CCD 或 CMOS 图像传感器。

[0069] 可选地，所述反射率测量发射器可以包括以下中至少之一 ：多个 LED ；多个白光发射源 ；以及多个条状电磁辐射源，并且所述反射率测量检测器可以包括以下中至少之一 ：多个光电二极管 ；多个线扫描照相机 ；以及多个分光仪以及 CCD 或 CMOS 图像传感器，其中，所述多个 LED 中的每一个与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或者 CMOS 图像传感器中对应的一个成对，其中所述多个白光发射源中的每一个可以与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或者 CMOS 图像传感器中的对应一个成对，并且其中所述多个条状电磁辐射源中的每一个可以与所述多个光电二极管和 / 或所述多个线扫描照相机和 / 或所述多个分光仪以及 CCD 或者 CMOS 图像传感器中对应的一个成对。

[0070] 可选地，所述多个 LED 中的所述至少一个可以进行操作以发射位于电磁谱的红外范围中的光。进一步可选地，所述多个光电二极管中的至少一个可以进行操作以检测位于电磁谱的红外范围中的光。

[0071] 所述装置可选地可以包括传输路径，传输路径的一部分可以包括所述测量区域，所述物品能够沿着物品传输路径传运。

[0072] 所述物品可以包括钞票。

[0073] 所述不透明的或者半不透明的区域可以包括所述钞票的印刷区域，和 / 或，所述物品的所述透明的或者半透明的区域可以包括所述钞票的未印刷或者窗区域（物品验证区域）。

[0074] 根据本发明的另一方面，提供了一种钞票计数装置，其包括具有上述任一个或多个特征的所述验证装置，所述钞票计数装置还包括钞票计数设备，所述钞票计数设备进行操作以维持传运通过所述装置的钞票的计数，并且所述钞票计数设备还进行操作以从所述验证装置接收指示所述物品的真实性与否的真实性信号，其中所述钞票计数设备进行操作以仅当所述信号指示测量区域中的物品是真实的时改变钞票计数。

[0075] 可选地，一旦接收到指示测量区域中的物品是真实的所述信号，所述钞票计数设备可以进行操作以改变所述钞票计数。进一步可选地，所述钞票计数设备可以进行操作以通过增加计数来改变所述钞票计数。

[0076] 根据本发明的另一方面，提供了验证包括膜基底的物品的方法，所述方法包括检测物品的位于验证装置的测量区域中的部分是否具有预定双折射特性，并且还包括 ：通过物品检测单元判定物品的至少一部分是否位于所述验证装置的测量区域中 ；比较由基于光

学的双折射测量装置获得的测量出的双折射特性与预定双折射特性；基于所述比较来产生指示所述物品的真实性与否的真实性信号；通过控制装置响应于所述物品检测单元判定出所述物品的所述至少一部分存在于所述测量区域中与否来控制从所述装置输出真实性信号。

[0077] 可选地，所述方法可以包括：通过形成所述物品检测单元的一部分的物品检测发射器用电磁辐射来照射所述装置的物品检测区域，以及通过形成所述物品检测单元的一部分的物品检测检测器接收从所述物品检测区域反射的电磁辐射以及透射通过所述物品检测区域的电磁辐射中至少之一，并且还包括提供指示物品存在于所述物品检测区域中与否的信号，以及响应于接收到指示物品存在于所述物品检测区域中的物品检测检测器信号，通过所述物品检测器单元判定出所述物品的所述至少一部分位于测量区域中。

[0078] 可选地，所述方法可以区别由发泡过程制成的物品膜基底以及由不同过程制成的物品膜基底。

[0079] 可选地，所述方法可以包括利用双折射测量发射器用电磁辐射照射所述装置的所述测量区域；将第一起偏器定位于所述双折射测量发射器和所述测量区域的第一侧之间，使得由所述双折射测量发射器发射的电磁辐射通过其中；将双折射测量检测器定位于所述测量区域的第二侧；在所述双折射测量检测器处从所述双折射测量发射器接收透射通过所述测量区域的电磁辐射；将第二起偏器定位于所述测量区域的所述第二侧和所述双折射测量检测器之间，使得透射通过所述测量区域的电磁辐射通过其中；定向所述第二起偏器以在与所述第一起偏器的方向垂直的方向上实现偏振；从所述双折射测量检测器输出对应于测量出的双折射特性的信号。

[0080] 可选地，所述方法可以包括将对应于测量出的双折射特性的所述输出信号输送至处理器；以及在所述处理器中比较所述输出信号的值与所述预定双折射特性。

[0081] 可选地，所述预定双折射特性可以包括以下之一：如果所述物品的不透明的或者半不透明的区域位于所述测量区域中，对应于期望双折射测量检测器输出信号值的第一值范围；如果所述物品的透明的或者半透明的区域位于所述测量区域中，对应于期望双折射测量检测器输出信号值的第二值范围；以及如果没有物品存在于所述测量区域中，对应于期望双折射测量检测器输出信号值的第三值范围。

[0082] 可选地，所述方法可以包括：通过所述物品检测单元的基于光学的反射率测量装置判定物品的物品验证区域是否位于测量区域中，所述判定步骤通过这样实施：通过所述反射率测量装置的反射率测量发射器用电磁辐射照射所述装置的所述测量区域；通过所述反射率测量装置的反射率测量检测器接收从所述装置的所述测量区域反射的电磁辐射；从所述反射率测量检测器输出对应于从所述测量区域反射的所述电磁辐射的测量特性且指示物品验证区域存在于测量区域中与否的信号；在反射率测量装置中比较测量出的反射特性与一组预定反射特性；并且基于所述比较来判定所述物品验证区域存在于所述测量区域中与否；以及向所述控制装置提供指示所述判定的信号以用于控制从所述控制装置输出真实性信号。

[0083] 可选地，所述方法可以包括将对应于测量出的反射特性的所述输出信号输送至处理器，所述处理器进行操作以比较对应于所述测量出的反射特性的所述输出信号的值与所述预定反射特性，所述预定反射特性可以包括指示所述物品的物品验证区域存在于所述测

量区域中的预先限定值，并且所述处理器进行操作以基于所述比较来实施所述物品验证区域存在或者不存在于测量区域中的所述判定，以及进行操作以向所述控制装置提供指示所述判定的所述信号。

[0084] 可选地，如果所述预定反射特性与由所述反射率测量检测器输出的对应于测量出的反射特性的所述输出信号的所述比较指示出所述物品验证区域位于测量区域中，从所述处理器向所述控制装置输出指示所述物品验证区域存在于测量区域中的判定信号，其中响应于接收，基于所述预定双折射特性与由所述双折射测量检测器输出的对应于测量出的双折射特性的所述输出信号的比较来从所述控制装置输出指示所述物品的真实性与否的真实性信号。

[0085] 所述预定反射特性可以包括以下中的一个或多个：如果所述物品的不透明的或者半不透明的区域位于所述测量区域中，对应于期望反射率测量检测器输出信号值的第一值范围；如果所述物品的透明的或者半透明的区域位于所述测量区域中，对应于期望反射率测量检测器输出信号值的第二值范围；以及如果没有物品存在于所述测量区域中，对应于期望反射率测量检测器输出信号值的第三值范围。

[0086] 所述不透明的或者半不透明的区域可以包括钞票的印刷区域，和 / 或，所述物品的所述透明的或者半透明的区域可以包括所述钞票的未印刷或者窗区域（物品验证区域）。

[0087] 可选地，所述方法可以包括在验证装置中提供传输路径，传输路径的一部分可以包括所述测量区域；以及沿着所述传输路径传运所述物品。

[0088] 根据本发明的另一方面，提供了钞票计数方法，包括上述的任何一个或多个方法步骤，所述钞票计数方法还包括使用钞票计数设备维持传运通过所述装置的钞票的计数；在所述钞票计数设备处从所述验证装置接收指示所述物品的真实性与否的真实性信号；以及仅当真实性信号指示测量区域中的物品是真实的时改变钞票计数。

[0089] 可选地，所述方法还可以包括一旦接收到指示测量区域中的物品是真实的真实性信号，则改变所述钞票计数。进一步可选地，所述方法可以包括通过增加计数来改变所述钞票计数。

[0090] 将参考以下附图仅通过示例的方式来描述根据本发明的诸方面的一个或多个具体实施方式。

[0091] 图 1 至图 3 示意性地示出了用于实施观察双折射的不同方法的已知装置的部件；

[0092] 图 4 示意性地示出了根据本发明的一个或多个实施方式的验证装置的俯视图；

[0093] 图 5 示意性地示出了根据本发明的一个或多个实施方式的验证装置的侧视图；

[0094] 图 6 示意性地示出了用于例示性实施方式中的验证装置的电路图；

[0095] 图 7 示意性地示出了可选布置中的验证装置；

[0096] 图 8a 和图 8b 示意性地示出了另一可选布置中的验证装置；

[0097] 图 9a 示意性地示出了再一可选布置中的验证装置的俯视图；

[0098] 图 9b 示意性地示出了再一可选布置中的验证装置的侧视图；

[0099] 图 9c 示出了图 9a 的验证装置的双折射测量装置的输出信号响应的图；

[0100] 图 10a、10b 和 10c 示意性地示出了形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置的检测器单元；

[0101] 图 11 示出了绘出根据入射辐射的角度和检测器的区域的在检测器处接收的辐射强度的图；

[0102] 图 12 示出了绘出照射辐射的入射角度相对于来自物品表面的照射辐射的反射率的图；

[0103] 图 13 示出了当钞票通过根据本发明一个或多个实施方式的验证装置时由反射率测量装置的检测器接收的反射辐射的强度的轮廓；

[0104] 图 14 示意性地示出了在本发明一个或多个实施方式的验证装置的可选布置中所使用的反射率测量装置的发射器 - 检测器 - 物品布置的俯视图；

[0105] 图 15 示意性地示出了在本发明一个或多个实施方式的验证装置的可选布置中所使用的反射率测量装置的发射器 - 检测器 - 物品布置的俯视图；以及

[0106] 图 16 示意性地示出了在本发明一个或多个实施方式的验证装置的可选布置中所使用的反射率测量装置的发射器 - 检测器 - 物品布置的立体图。

[0107] 图 4 和图 5 示出了验证装置 100，其包括双折射测量装置 102 和反射率测量装置 104。

[0108] 验证装置 100 进行操作以测量物品 106（例如钞票）的双折射以及反射率特性。具体地，验证装置 100 进行操作以测量物品 106 位于验证装置 100 的测量区域 108 中的部分的双折射特性以及反射率特性。

[0109] 双折射测量装置 102 包括第一发射器 110 或双折射测量发射器（可选地，进行操作以发射白光的 LED）、第一起偏器 112、第一检测器 114 或双折射测量检测器（可选地，进行操作以检测白光的光电二极管）和第二起偏器 116。

[0110] 双折射测量装置 102 的元件布置成使得第一发射器 110 和第一起偏器 112 位于测量区域 108 的第一侧，第一检测器 114 和第二起偏器 116 位于测量区域 110 的第二侧（即与第一发射器 110 和第一起偏器 112 相对）。

[0111] 第一发射器 110 进行操作以用电磁辐射（图中由虚线箭头 IL 表示）照射测量区域 108，第一检测器 114 定向成并进行操作以接收透射通过物品 106 位于测量区域 108 中的部分的电磁辐射（图中由虚线箭头 TL 表示）。照射电磁辐射 IL1 在照射物品 106 位于测量区域 108 中的部分之前通过第一起偏器 112。在通过物品 106 位于测量区域 108 中的部分之后，透射电磁辐射 TL 在由第一检测器 114 接收之前通过第二起偏器 116。

[0112] 在图示的布置中，测量区域 108 位于第一平面中。第一起偏器 112 与第一平面相间隔并位于测量区域 108 的第一侧的第二平面中。第二平面基本平行于第一平面。类似地，第二起偏器 116 与第一平面相间隔并位于测量区域 108 的第二侧的第三平面中。第二起偏器 116 定位成与第一起偏器 112 相对，并且第三平面基本平行于第一平面和第二平面。第一和第二起偏器 112、116 的透射定向的布置使得它们包括相交的起偏器。也就是说，第一起偏器 112 布置成使得其透射定向与物品 106 位于测量区域 108 中的部分的透射定向约成 +45°。第二起偏器 116 布置成使得其透射定向与物品 106 位于测量区域 108 中的部分的透射定向约成 -45°。可替代地，第一起偏器 112 的透射定向可以使得其与物品 106 位于测量区域 108 中的部分的透射定向约成 -45°，第二起偏器 116 的透射定向可以使得其与物品 106 位于测量区域 108 中的部分的透射定向约成 +45°。

[0113] 因而，在图示的布置中，由第一起偏器 112 使由第一发射器 110 发射的照射电磁辐

射 IL1 偏振，照射物品 106 位于测量区域 108 中的部分，通过物品 106，继续作为透射电磁辐射 TL 到达第二起偏器 116（即相交的起偏器）并且通过第二起偏器 116，以及继续由第一检测器 114 接收。第一检测器 114 响应于检测到入射在其上的透射电磁辐射 TL，输出信号至处理装置（未示出），其中该信号与接收的透射电磁辐射 TL 成比例。

[0114] 处理装置一旦从第一检测器 114 接收到输出信号，进行操作以比较接收的信号的值与存储在数据库（未示出）中的一组预定值。这些预定值可对应于在以下一种或多种情况中期望的透射电磁辐射值：物品的印刷区域位于测量区域 108 中；物品的未印刷区域（例如窗区域或者物品验证区域）位于测量区域 108 中（物品的膜基底是真的）；物品的未印刷区域（例如窗区域）位于测量区域 108 中（物品的膜基底不是真的）；以及无钞票位于测量区域 108 中。

[0115] 第一发射器 110 可滑动地安装在轨道或者杆 118 上。第一发射器 110 可通过固定螺钉 120 沿着轨道或者杆 118 的长度固定在具体位置处。该布置允许改变第一发射器 110 相对于测量区域 108 的位置。类似地，第一检测器 114 可滑动地安装在轨道或者杆上 122。第一检测器 114 可通过固定螺钉 124 沿着轨道或者杆 122 的长度固定在具体位置处。并且，该布置允许改变第一检测器 114 相对于测量区域 108 的位置。

[0116] 包括高度定向的膜的物品 106 将导致第一检测器 114 的高读数（因为将透射大量电磁辐射，即透射电磁辐射 TL 的强度将相对高）。然而，平衡膜将导致第一检测器 114 的零值或者低读数，因为通过第一和第二相交的起偏器的电磁辐射的行为将在很大程度上未被改变。

[0117] 具有平衡定向的膜（例如 BOPP 膜）将在第一检测器 114 处产生低双折射信号。这种信号可基本和与膜的印刷区域位于测量区域 108 中或者测量区域 108 中没有任何膜对应的信号相同。另一方面，当拉伸器或者其他定向的膜位于测量区域 108 中时，第一检测器 114 将产生将不同于所有上述情形的高双折射信号。

[0118] 双折射测量装置 102 因此能够一直基于“物品是真实的”的结果来操作，直到碰到包括假膜的物品，在该时间点可以激活警报和 / 或视觉警告：换句话说其将找出否定性的而不是识别肯定性的。

[0119] 为了应对此问题，验证装置 100 包括反射率测量装置 104。

[0120] 反射率测量装置 104 包括第二发射器 126 或者反射率测量发射器（可选地，进行操作以发射在电磁谱的红外区域中的电磁辐射的 LED）、第二检测器 128 或者反射率测量检测器（可选地，进行操作以检测在电磁谱的红外区域中的电磁辐射的光电二极管）以及与第二检测器 128 关联的遮挡件 130。遮挡件 130 用于保护第二检测器 128 不受杂散光影响，以防止由杂散光从除了第二发射器 126 之外的源入射在第二检测器 128 上的所引起的错误读数。

[0121] 反射率测量装置 104 配置成使得第二发射器 126 和第二检测器 128 定向成朝向测量区域 108。第二发射器 126 进行操作以用电磁辐射照射测量区域 108（图中由箭头 IL2 表示），并且第二检测器 128 定向成并进行操作以接收从物品 106 位于测量区域 108 中的部分反射的电磁辐射（图中由箭头 RL 表示）。

[0122] 在可选布置中，验证装置 100 可包括这样的路径：物品可沿着该路径传运。测量区域 108 形成该路径的一部分。因此，在该具体布置中，物品可沿着路径从验证装置 100 的一

侧传运至另一侧，并在传送过程中通过测量区域108。也就是说，在该可选布置中，待验证的物品可以相对于验证装置100移动，或者反之亦然。这种可选布置将参考图7更详细地描述。在另一可选布置中，可以在物品静止时进行验证测量。也就是说，可以将物品引入验证装置100的物品定位区域（测量区域108形成该区域的一部分），物品保持于此处，直到进行了验证测量。将参考图8a和图8b更详细地描述这种可选布置。

[0123] 在操作中，物品106可引入至验证装置100中，使得物品106的一部分将位于测量区域108中。此时，来自第二发射器126的照射电磁辐射IL2入射在物品106位于测量区域108中的部分上。入射在测量区域108中的物品106上的照射电磁辐射IL2的至少一部分将由物品106位于测量区域108中的部分反射。该反射电磁辐射RL朝向第二检测器128反射。随着其靠近第二检测器128，其将通过遮挡件130的孔，然后由第二检测器128检测到。第二检测器128响应于检测到入射在其上的反射电磁辐射RL，输出信号至处理装置（未示出），其中该信号与接收到的反射电磁辐射RL的强度成比例。

[0124] 处理装置一旦从第二检测器128接收到输出信号，进行操作以比较接收的信号的值与存储在数据库（未示出）中的一组预定值。这些预定值可以对应于在以下一种或多种情况中期望的反射电磁辐射值：物品的印刷区域位于测量区域108中；物品的未印刷区域（例如窗区域）位于测量区域108中（物品的膜基底是真的）；物品的未印刷区域（例如窗区域）位于测量区域108中（物品的膜基底不是真的）；以及无钞票位于测量区域108中。

[0125] 处理装置可以布置成基于从第一检测器114和第二检测器128接收的输出信号来发送输出信号至一个或多个视觉或者音频警告系统。

[0126] 因此，在可选布置中，如果没有物品存在于测量区域108中，处理装置可以发出输出信号以控制视觉警告系统显示第一视觉警告（例如红光）以及控制音频警告系统输出第一音频警告（例如蜂鸣器）。如果物品的印刷区域存在于测量区域108中，处理装置可以发出输出信号以控制视觉警告系统显示第一视觉警告（例如红光）以及控制音频警告系统输出第一音频警告（例如蜂鸣器）。如果物品的窗区域存在于测量区域108中并且形成物品的膜基底是真的（如由双折射测量装置判定的），处理装置可以发出输出信号以控制视觉警告系统显示第二视觉警告（例如绿光）以及控制音频警告系统静音。如果物品的窗区域存在于测量区域108中并且形成物品的膜基底不是真的（如由双折射测量装置判定的），处理装置可以发出输出信号以控制视觉警告系统显示第一视觉警告（例如红光）以及控制音频警告系统输出第一音频警告（例如蜂鸣器）。

[0127] 该装置100可以实施在例如钞票计数系统。处理装置可进行操作以仅当从双折射测量装置102和反射率测量装置104接收的信号指示出物品106的窗区域位于测量区域108中并且形成窗区域的膜基底是真的时，输出信号至计数设备。但是，当从双折射测量装置102和反射率测量装置104接收的信号指示出物品106的窗区域位于测量区域108中但形成窗区域的膜基底是不真的时，可以不输出信号。也就是说，由计数设备进行的计数可以仅当真的窗区域对准在测量区域108中时改变。

[0128] 在图4和图5图示的布置中，第一发射器110包括进行操作以发射白光的光发射二极管(LED)，第一检测器114包括进行操作以检测白光的光电二极管。

[0129] 此外，第二发射器126包括LED，LED进行操作以发射波长对应于电磁谱的红外(IR)区域的电磁辐射。可选地，LED进行操作以发射波长约为890nm的电磁辐射。

[0130] 图示的布置中的第二检测器 128 包括光电二极管，其进行操作以检测波长对应于电磁谱的 IR 区域的电磁辐射，可选地，检测波长在约 880nm 和 1140nm 之间的电磁辐射。

[0131] 当然，在其他可选布置中，第二发射器 126 和第二检测器 128 可以进行操作以发射和检测电磁谱中其他波长的电磁辐射。

[0132] 在第二发射器 126 的 LED 进行操作以发射波长约为 890nm 的电磁辐射的布置中，第二检测器 128 的光电二极管进行操作以当检测到 880nm 至 1140nm 之间的光时生成最大约 350mV 的电压。

[0133] 反射率测量装置 104 的敏感度取决于第二发射器 126 和第二检测器 128 相对于彼此的角度、测量区域 108 相对于第二发射器 126 和第二检测器 128 的距离以及角度、环境光的水平和遮挡件 130 的尺寸。

[0134] 图示的布置中的遮挡件 130 包括管状元件（可选地是黑管）。第二检测器 128 可以位于遮挡件 130 的第一侧上的管状元件的一个端部处或靠近该端部（或者靠近遮挡件 130 的第一侧位于管状元件内）。管状元件相对于第二发射器 126 和测量区域 108 定位并且定向，使得从测量区域 108 反射的反射电磁辐射 RL 进入管状元件的开口部。在经由开口部进入管状元件之后，反射电磁辐射 RL 沿着管状元件行进至第二检测器 128。管的长度以及直径确定进入第二检测器 128 的入射电磁辐射的角度范围（即，管越长且越窄，进入的入射电磁辐射的角度范围越窄）。诸如这样的布置能够由于这些材料中每个的光泽度的差别来区别聚合物窗、印刷表面以及空气。

[0135] 利用适当位置处的光泽度测量（即由反射率测量装置 104 执行的测量），验证装置 100 现在具有如下信息：双折射低或者高；以及存在或者不存在窗。可选地，反射光泽度系统定位在偏振系统中与第一发射器 110 相反的一侧，以降低或者抑制从第一发射器 110 泄露至红外检测器中的光的影响（仅在当膜之间存在高度双折射膜时允许光通过膜，此时泄露至红外检测器中的光是不重要的，因为实际上存在窗）。

[0136] 反射率测量装置 104 与待验证的物品之间的间隔宽度将影响窗存在检测系统（即反射率测量装置 104）的准确度。在物品缝的最小实际宽度与第二检测器可接受的角度范围之间可以存在折衷，以确保尽可能平的读数（可接受的范围越宽，错误信号的危险越大）。

[0137] 部件放置的重要性问题是第一发射器 110、第一检测器 114、第二发射器 126 和第二检测器 128 的竖直位置和尺寸。物品窗（例如钞票窗）在竖直方向上并不始终在同一地方，而刷动系统（例如图 7 图示的）将考虑窗的水平放置，还需要考虑窗在物品中的竖直放置。为了应对此问题，在可选布置中，能够测量物品表面的两个或更多位置，和 / 或发射器和检测器是可移动的。如图示于图 4 和图 5 的，发射器以及检测器安装在轨道 118、122 上。为了允许用于验证诸如钞票（钞票中的窗区域位置对于不同面额可以不同，或者钞票中的窗区域位置对于不同国家可以不同）的物品的验证装置 100 的灵活性，轨道系统可以允许初始调节至规定高度，然后发射器以及检测器可固定在该高度。

[0138] 可选地，多个发射器以及检测器可以安装在同一轨道上，和 / 或可采用更长的检测器阵列以及发射源。

[0139] 图 6 是用于验证装置 100 的示意性电路图。为清楚起见，省略了一些特征，诸如例如电容器、电阻器等。

[0140] 电路包括电源 131，电源 131 进行操作以对第一发射器 110、第二发射器 126 和处理器 132 供电。

[0141] 第一检测器 114 和第二检测器 128 联接至处理器 132（可选地为微控制器），使得通过这些设备输出的输出信号由处理器 132 接收。来自第一检测器 114 的输出信号反馈至处理器 132 的门 2，来自第二检测器 128 的输出信号反馈至处理器 132 的门 1。

[0142] 检测器 114、118 中的任一个或者两者全部可选地可以在其输出与处理器 132 之间联接有可变电阻器。这可以提供控制来自光学系统的信号水平的装置，因而允许校准验证装置。

[0143] 警告系统 134 联接至处理器 132。警告系统包括视觉警告元件（即图示的布置中的绿色 LED136 和红 LED138）以及音频警告元件（即图示的布置中的蜂鸣器 140）。这些元件联接至处理器 132 的门 3、4 和 5。当然，在其他可选布置中，除了警告系统中示出的这些元件之外还可以使用其他元件，或使用其他元件来代替警告系统中示出的这些元件。

[0144] 以下表 1 总结了描述了当装置与钞票结合使用时所示电路中的元件的行为的输入以及输出。

[0145] 表 1. 电路元件行为总结

[0146]

条件	检测器		门					结果
	第一检测器 144（双折射）	第二检测器 128（反射率，即窗检测）	1	2	3	4	5	
无钞票	低	低	0	0	1	1	0	红光以及蜂鸣器
非窗口（例如印刷区域）	低	高	0	0	1	1	0	红光以及蜂鸣器
真的窗口	低	中等	1	0	0	0	1	绿光
非真的窗口（即伪造的膜）	高	中等	1	1	1	1	0	红光以及蜂鸣器

[0147] 窗的存在导致强度在无窗和存在钞票时之间的反射信号。因而，反射率测量装置必须能够区别三种状态（即无钞票、钞票的窗区域或者钞票的印刷区域存在于测量区域中）以使验证装置能够起作用为仅当钞票的窗区域存在于测量区域中时输出信号。这可以有用地用作机构来控制装置的功率使用，即钞票的窗区域的存在充当开关以启动装置来执行双折射测量。否则，装置可以保持（或者恢复）待机模式。

[0148] 验证装置的操作可以总结如下。自验证装置启动时起，测量电磁辐射信号（例如光信号）。当物品（例如钞票）边缘进入测量区域时，由反射测量装置获取的测量读数可能存在波动或者改变。当物品的窗区域通过测量区域时可能存在进一步的波动或者改变。当出现该情况时，记录在此时执行的双折射测量。如果双折射测量较低，则验证装置指示该物品是真的。然而，如果双折射测量较高，则验证装置指示该物品是伪造的。因而，一旦在测

量区域中已检测到窗，并且执行双折射测量且双折射测量值指示钞票是真的，物品将被认为是真的。未检测到任何窗可导致验证装置不生成任何输出。

[0149] 图 7 示出了可适于验证钞票的设备 142。设备 142 包括成上述任何一个或多个布置的验证装置 100。设备 142 可以适合作为便携式手持设备。

[0150] 设备 142 包括基本 U 形单元，U 形单元具有槽 144，钞票可传运通过槽 144（例如“刷动”）。可选地，槽深度是 40mm（约是一个或多个国家流通的较大面额聚合物膜基底钞票的尺寸的一半）。当钞票的窗区域通过位于设备 142 内部的验证装置的双折射测量装置时，由验证装置输出的信号传运至照明设备，其中该照明设备根据窗的双折射读数进行操作以向设备照射绿光或者红光。例如，如果钞票由真的聚合物膜形成，设备 142 可利用绿光进行照射。然而，如果钞票不是由真的聚合物膜形成，设备 142 可利用红光进行照射。

[0151] 设备 142 的尺寸可以取决于允许设备起作用所需的电子元件以及电源的尺寸。但是，所需的尺寸是槽高度的尺寸。槽 144 必须有足够深度，使得随着钞票传运通过槽，钞票的窗在设备 142 的位于槽 144 任一侧的直立部分之间（因而在反射率测量装置和双折射测量装置的元件之间）通过。另一所需尺寸将是槽宽度的尺寸，该尺寸应该在足够窄以维持钞票在通过槽 144 期间的平面度以获得准确结果的槽以及足够宽以允许钞票易于通过槽 144 的槽之间实现折衷。可选地，可以采用约 0.5 - 1mm 的槽宽度。进一步可选地，槽 144 可以包括弯曲的入口和 / 或出口点以辅助将钞票端部插入槽 144 和 / 或辅助从槽 144 移除钞票。

[0152] 图 8a 和图 8b 示出了另一可选验证装置布置。在该布置中，验证装置可以适于当钞票静止时进行钞票验证。

[0153] 在该布置中，提供了定位突起 146，定位突起 146 包括用于将钞票接纳在其上的表面。定位突起 146 包括设置在其上的钞票模板 148。例如，钞票模板 148 可以刻在定位突起 146 的表面中，使得凹陷区域形成在中定位突起 146 的表面中。该凹陷区域可具有与钞票类似的尺寸以及形状确定为将钞票接纳在其中。

[0154] 因此，在使用中，包括一个或多个印刷表面特征 152 和窗区域 154 的钞票 150 放置在定位突起 146 的钞票模板 148 上，并且使用形成在凹陷区域的边缘处的隆起边缘将钞票引导至适当位置（见箭头 A）。验证装置的元件位于定位突起上方以及下方，以测量钞票 150 位于定位突起 146 的测量区域 108 中的部分。测量区域 108 相对于定位突起 146 定位，以当这种钞票位于定位突起 146 上时与钞票的窗区域重合。验证装置的反射率测量装置检测钞票的窗区域何时处于测量区域 108 中适当位置，验证装置然后进行操作以对窗区域 154 执行双折射测量。

[0155] 为了使图示的布置适合于不同面额和 / 或不同货币（可能具有不同的尺寸），可在定位突起上设置（例如刻在定位突起上的）一系列钞票轮廓模板。用户可将钞票保持在适当的钞票轮廓上。例如，这可通过如下方式实现 ：使用位于定位突起 146 的顶部和左侧或右侧处的隆起边缘将钞票引导至适当位置（取决于在何处窗更一致地定位）。

[0156] 在可选布置中，通过提供多个双折射测量位置，能够适应窗的不同尺寸以及位置。

[0157] 图 9a 和图 9b 示出了根据另一可选布置的验证装置的俯视图以及侧视图。该布置可以适合于移动系统，即物品（例如钞票）相对于验证装置移动（或者反之亦然）的系统。

[0158] 在图示的布置中，示出了钞票 150 在箭头 B 指示的方向相对于双折射测量装置 102

传运通过测量区域 108。在图示的布置中，双折射测量装置 102 在测量区域宽度上包括双折射测量元件的阵列。这些传感器双折射测量元件进行操作以指示钞票 150 在测量区域 108 中的部分的双折射是否高。图示的布置还包括钞票检测器单元 156，其定位成与双折射测量装置 102 邻近。该钞票检测器单元 156 进行操作以从发射器 158 或者发射器阵列（物品检测发射器）朝向钞票传输路径发射电磁辐射射束。检测器 160 或者检测器阵列（物品检测检测器）定位且进行操作以从透射通过钞票传输路径的和 / 或从该传输路径反射的电磁辐射射束接收电磁辐射。因此，当钞票进入钞票传输路径的由钞票检测器单元 156 的发射器 158 发射的电磁辐射射束所照射的区域时，通过钞票检测器单元 156 来检测钞票的存在。也就是说，当钞票存在于传输路径中时，由发射器 158 发射的电磁辐射射束可以由钞票反射以及由定位成接收反射电磁辐射的检测器接收，或者射束随着其通过钞票会衰弱，定位成接收透射电磁检测的检测器可检测到所接收的透射电磁辐射的减少（由于的钞票存在于射束中）。因而，钞票检测器单元 156 可以进行操作以通过当钞票 150 存在时照射电磁辐射射束的反射和 / 或通过透射的照射电磁辐射光束的强度的减小（由于钞票存在于射束中）来检测钞票 150 的存在与否。因此，当钞票 150 切断照射电磁辐射射束时，钞票检测器单元 156 检测钞票 150 的存在。钞票检测器单元 156 进行操作以控制双折射测量装置 102 的操作，使得双折射测量装置 102 仅当钞票存在时执行测量。

[0159] 反射率测量装置可选地可以存在或者不存在。在不具有反射率测量装置的可选布置中，双折射测量装置一直进行操作以检测低 / 高双折射读数，但仅当钞票检测器单元存在传感器检测到钞票时进行判定。

[0160] 在这种“仅透射”布置中，即进行双折射测量但不进行反射率测量，该装置进行操作以通过观察双折射测量装置的一个或多个检测器的信号来判定窗是否存在于测量区域中。背景信号将导致来自一个或多个检测器的相对中等水平的输出信号。当钞票的印刷部分存在于测量区域中（即印刷区域阻挡一个或多个检测器），这将导致来自一个或多个检测器的相对低水平的输出信号。当钞票的窗区域存在于测量区域中时（背景信号加上双折射），这在存在伪造钞票的情况下将导致来自一个或多个检测器的相对高水平的输出信号，以及在存在真的窗的情况下将导致相对低水平的输出信号。图 9c 示出了当使用装置测量伪造钞票的各部分时的一个或多个检测器的响应。如图 9c 所示，当钞票的印刷部分存在于测量区域中时，由一个或多个发射器发射的照射辐射由钞票的印刷部分阻挡，非常少的照射辐射透射通过钞票到达一个或多个检测器。当伪造钞票的窗区域存在于测量区域中，来自一个或多个检测器的输出信号是相对高的，并且装置进行操作以输出信号：钞票是伪造的。

[0161] 在可选布置中，可以存在一个或者两个或者甚至一整排的钞票检测器。它们可以是透射型的（如图 9b 图示的）或反射型的。由钞票检测器单元的发射器发射的电磁辐射可以是白光或者甚至是窄带红外光。

[0162] 以下表 2 示出了用于图 9a 和图 9b 中示出的可选布置的验证装置的元件的决策表。

[0163] 表 2

[0164]

双折射测量装置输出	钞票检测器单元输出	验证装置输出
高	无钞票存在	无输出
低	无钞票存在	无输出
高	钞票存在	失败（钞票是伪造的）
低	钞票存在	钞票是真的

[0165] 图 9a 至图 9c 的布置可以与图 7 或图 8a 和图 8b 所示的上述布置的特征组合使用。

[0166] 现在将讨论与形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置相关的参数。因为反射率测量装置进行操作以测量聚合物表面的反射信号，期望的是，反射是镜面反射，并且来自尽可能窄的角度范围以确保仅来自测量区域中的膜的反射被接收。

[0167] 在以下描述中，所提到的“光”旨在包括处于电磁谱的“可见”部分的电磁辐射和处于电磁谱的“不可见”部分的电磁辐射。

[0168] 遮挡件孔

[0169] 在反射率测量装置的检测器由遮挡件保护的这些布置中，应该考虑遮挡件孔的尺寸。在一些可选布置中，遮挡件孔可简单包括位于遮挡件中的孔或缝。在其他可选布置中，遮挡件孔可以包括管，该管可选地由非反射材料组成或衬有非反射材料。

[0170] 孔宽度确定了以任何角度收集的电磁辐射射线的量，但不区分这些射线的源，因此并不有助于消除来自环境电磁辐射源的噪声或者散射。

[0171] “后退距离”（即第二检测器与遮挡件孔的物品侧即“孔开口”之间的距离）与装置的准确度相关。孔入口部与第二检测器之间的大距离将意味着仅非常精确角度的光将沿孔管的长度行进至第二检测器。

[0172] 后退距离可由内部装有诸如该检测器的检测器的设备的物理约束的限制。

[0173] 装置的准确度还可以取决于孔宽度。也就是受，装置的准确度可取决于孔宽度与后退距离之比。因此，在能够采用较大后退距离的较大设备中，可以使用较大的孔宽度。但是，对于后退距离可能较小的更多约束的较小设备，应使用较窄的孔。因此，这将意味着收集的射线减少，因此设备的敏感度降低。

[0174] 遮挡件的孔设计成排除大角度光。这可通过使用窄开口且第二检测器从开口偏置或“后退”来实现。存在两个合适的可选布置：黑管，其将吸收其壁中的杂散辐射（即上述诸如图 4 所示的布置）；以及孔后面的开放空间，在该开放空间中大角度光将在第二检测器的范围之外进行传播。

[0175] 在图 10a 和图 10b 示意性示出了这些可选布置。可选布置可简化（为了执行计算的过程）成图 10c 所示的布置。

[0176] 参照图 10c，w 是孔或管宽度，l 是第二检测器距离孔的偏置或者“后退”距离。当第二检测器宽于孔 / 管直径时，基于管的设计可以是更有效的一个设计。对于孔设计，如果第二检测器宽于孔，那么第二检测器能够接受的光角度范围将较大，对于以下计算，w 将变为第二检测器宽度。

[0177] 对此的例外是设备的准确度，其与光学系统的入口宽度成比例。

[0178] 以其最大强度进入系统的光的角度 θ_{max}是：

[0179] $$\theta_{max} = \tan^{-1}\left(\frac{w}{l}\right) \quad (1)$$

[0180] 在比这更高的角度，进入光学系统的光射线仅可达到第二检测器的区域的一部分，因此可看作损失与光射线所入射在第二检测器的角度区域成比例的光射线的强度。

[0181] 可通过首先在孔的横截面区域的中心处设定排除直径 z 来计算该区域 A_z。通过 z，可计算中央区中更大角度光不能访问的区域，然后随后从总缝角度减去该区域以产生结果（其实际上是内径为 z 以及外径为 w 的环）。

[0182] 以下方程示出了：

[0183] $$\theta_z = \tan^{-1}\left(\frac{w+z}{l}\right) \quad (2)$$

[0184] $$A_z = \frac{\pi}{4}\left[w^2 - z^2\right] \quad (3)$$

[0185] 其中，θ_z是讨论的角度。如果对于直径＝ 2mm 以及长度为 10mm 的孔绘制 θ_z和 A_z并且将其结果标准化，可获得图 11 图示的图。

[0186] 如图所示，对于诸如这样的系统，小于约 11.5° 的入射光以其全强度进行接收，在更高角度强度降低，下降至在大 22° 时为 0。

[0187] 由此能够判定出系统可接收的光的最大角度以及系统效率何时开始减小。

[0188] <u>入射角度</u>

[0189] 通常，入射射线的反射随着入射角度的增加略微减小，直到达到布鲁斯特角度(44-54°)，在该角度之后反射急剧增加。然而，对于半透明材料（诸如 BOPP 膜或者膜涂层中使用的填充颜料的墨水）来说，这是粗略的简化。事实上，这样的材料在上物理表面之下具有多个光学表面。

[0190] 嵌入材料（诸如通常具有实质上不同的吸收及反射属性的颜料）的存在将导致材料在一系列角度上具有实质上不同的反射属性。

[0191] 用于光泽度测量的入射角度可通过考虑 s 及 p 偏振状态下的表面的理论反射率来确定：

[0192] $$R_s = \left[\frac{\sin(\theta_t-\theta_i)}{\sin(\theta_t+\theta_i)}\right]^2 = \left[\frac{n_1\cos(\theta_i)-n_2\cos(\theta_t)}{n_1\cos(\theta_i)+n_2\cos(\theta_t)}\right]^2 \quad (4)$$

[0193] $$R_p = \left[\frac{\tan(\theta_t-\theta_i)}{\tan(\theta_t+\theta_i)}\right]^2 = \left[\frac{n_1\cos(\theta_t)-n_2\cos(\theta_i)}{n_1\cos(\theta_t)+n_2\cos(\theta_i)}\right]^2 \quad (5)$$

[0194] 其中，θ_i＝入射角度，θ_t＝透射角度，n_1和 n_2分别为介质 1 和介质 2 的折射率。

[0195] 对于随机偏振的材料，s 反射及 p 反射被一起平均，以获得典型光源的理论反射率。图 12 所示的图示出了折射率为 1.49 的假设的聚丙烯表面的理论反射率。

[0196] 如图 12 所示，s 偏振状态在低角度处占主导地位，而 p 状态反射非常差，直到超过布鲁斯特角度 ($\tan^{-1}(n_1/n_2)$ ＝ 56.3°)。使用非偏振光源避免了过程在布鲁斯特角度处可能的失败，其中在该角度处信号将是零。

[0197] 在判定验证装置的反射率测量装置的可行性的实验中，使用的角度为约 45° 至约

60° 。使用这种角度，反射率为约 5％至约 9％。

[0198] 如上所述，由于表面下存在加颜料材料，所以印刷区域的反射率将更复杂。首先，如果印刷区域的表面像非印刷区域一样平，那么可使用方程 (4) 和 (5) 计算总反射率，但具有将墨的表面下的颜料的反射率考虑在内的额外值。因为颜料通常较小以及很好地分布，这被视为合理的假设。

[0199] 颜料设计成吸收一部分电磁谱并且反射其他电磁谱。理想颜料将反射尽可能多的光，同时仍维持其目标颜色 - 否则其将是非常无光的。方便地，对于由本发明的一个或多个实施方式的装置执行的方法，通常的颜料以及具体的钞票颜料都是无光的。与此结合，颜料在所有方向上反射光（否则无法看到颜料，除非以与环境中的环境光的入射角相等的角度观察颜料）。这意味着，在任一角度，仅看见反射光的一部分。将这两个因素综合起来并且这意味着，不期望印刷区域和未印刷区域的反射率之间存在很大的区别，除了当期望的是上表面（以及在未印刷膜的情形中的下表面）反射相对于颜料反射占主导地位从而使得未印刷区域反射更多时在颜料反射将使印刷区域反射更多的小角度 (<30°) 处以及大于布鲁斯特角的角度处。

[0200] 在使用形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置测量光泽度的实验中，澳大利亚 $50 钞票通过反射率测量装置的测量区域以模拟钞票分类系统。

[0201] 图 13 示出了当澳大利亚 $50 钞票通过形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置时，检测到的强度轮廓。

[0202] 在图中，直线 X 示出了装置扫描钞票的位置，另一个线 Y 示出了由反射率测量装置的第二检测器输出的电压信号。

[0203] 钞票的加颜料区域比窗区域 Z 反射更多（虽然不是特别多），并且不会受钞票的颜色的太多影响（虽然该具体钞票上的颜色是相对素的）。该实验在 60° 角度处进行，在这种情况下期望 9％的膜的反射率。如果角度降低，那么颜料在反射中的重要性将增加，反之亦然。

[0204] 从图可以清楚地观察到，能够检测到钞票的边缘（即图右侧中曲线（用 Y_1表示）的陡峭增加）。而且，可检测到钞票的窗区域 Z，注意电压轮廓（用 Y_2表示）的减小与窗区域 Z 的位置重合。

[0205] <u>第二检测器“相隔”距离 / 发散性 / 第二检测器信号</u>

[0206] 来自大多数源的光是高度发散的（除非是激光以及星光），因此随着第二检测器距反射点的距离增加，任何理想入射射线 / 反射射线模型很快失效。任何发散光源的中心仍将包含理想射线，但第二检测器距反射点的距离越大，接收的反射射线的强度将越低。

[0207] 因此，应理解，照射射线的发散性增加和 / 或第二检测器距反射点的距离增加将降低来自第二检测器的读数的信号强度，因为接收的反射射线的强度将较小。

[0208] 然而，如果第二检测器靠近表面（因而靠近反射点），那么其将从更宽角度范围收集光。这可能导致第二检测器接收到不希望的射线，因而影响由第二检测器输出的信号的值。

[0209] 形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置可以要求第二检测器从精确的角度收集反射射线。

[0210] 因此通过以上描述应理解，增大第二检测器与物品表面之间的距离将增加其准确度（因为降低了第二检测器从更宽角度范围收集光的可能性）。然而，增大第二检测器与物品表面之间的距离还将降低由第二检测器接收的反射射线的强度。

[0211] 此外，降低照射源（即第二发射器）的发散性还将增加反射率测量装置的准确度，因为降低的发散性可导致更少的杂散反射。因此，在可选布置中，第二发射器包括激光光源。

[0212] 光电二极管生成与落到其上的光的强度成比例的电压。可从光源的辐照度计算出光的强度（其不能与辐射强度混淆）：

[0213] $$I_o=\frac{P\pi d^2}{4} \qquad (6)$$

[0214] 其中，I_o是光源的辐照度（W/mm2），P 是光源的功率（W），d 是光源的直径（mm）。

[0215] 然而，关注是第二检测器的辐照度，而不是源（即第二发射器）的辐照度。为了建立该等式，必须计算光源与第二检测器（共同称为“探针”）之间的路径长度。路径长度即 l_{path}与相隔距离即 Z_{probe}之间的关系如下：

[0216] $$l_{path}=\frac{2z_{probe}}{\cos\theta_{probe}} \qquad (7)$$

[0217] 其中，θ_{probe}是光源和第二检测器相对于表面被设定的角度（光源与第二检测器之间的角度将是该角度的两倍）。该距离是光源与第二检测器之间的距离。

[0218] 第二检测器（例如光电二极管）处的射束的直径即 d_{photo}可通过下式计算：

[0219] $d_{photo}=d+2l_{path}\tan\theta_{div}$ (8)

[0220] 其中 d 为光源的直径，θ_{div}为光源的发散性（其将被引用为光源的技术规格的一部分）。

[0221] 然后第二检测器处的强度可计算为：

[0222] $$I_{div}=\frac{P\pi d_{photo}^2}{4}=\frac{P\pi(d+2l_{path}\tan\theta_{div})}{4} \qquad (9)$$

[0223] 源与第二检测器之间的强度降因此能够通过如下计算：

[0224]

$$强度降=\frac{I_{div}}{I_o}=\frac{d_{photo}^2}{d^2} \qquad (10)$$

[0225] 相隔距离的任何计算因此必须考虑从光源至第二检测器的强度降，其中该强度降是所涉及的角度与光的路径长度的结果。这样所造成的限制将由光源强度、第二检测器敏感度和环境光噪声水平确定。

[0226] 由光源发射的光相对于第二检测器具有三个独立情况：

[0227] 如果 $d_{photo}>w$，那么第二检测器离测量区域过远，有用的小角度光被丢失。

[0228] 如果 $d_{photo}=w$，那么第二检测器处于距测量区域正确的距离处。

[0229] 如果 $d_{photo}<w$，那么第二检测器太靠近测量区域，比第二检测器所设计的可接受的角度更大角度的光可进入第二检测器。

[0230] 等式（7）和（8）可重布置以给出等式（11）和（12），等式（11）示出了对于发散角

度以及设备角度如何计算最佳的相隔距离即 z_{phobe}；等式 (12) 示出了对于相隔距离和发散角度如何计算最佳的设备角度：

[0231] $$z_{probe}=\frac{(w-d)\cos\theta_{probe}}{4\tan\theta_{div}} \quad (11)$$

[0232] $$\theta_{probe}=\cos^{-1}\left(\frac{4z_{probe}\tan\theta_{div}}{(w-d)}\right) \quad (12)$$

[0233] 从等式 (11)，可理解，光源发散性越低，可能相隔距离越远。

[0234] <u>边缘检测的分辨率</u>

[0235] 形成根据本发明一个或多个实施方式的验证装置的一部分的反射率测量装置的另一考虑可以是边缘检测的准确度，其是尺寸 w（即入口孔 / 管直径的尺寸）的函数。实践中，检测的分辨率将略微小于孔尺寸，因为反射光随着其从膜行进至孔将会发散。

[0236] 首先，必须计算路径长度。这使用与等式 (7) 所示类似的等式。但是，该路径长度是仅从膜的表面和从孔至膜的路径长度，而不是从膜至检测器的路径长度：

[0237] $$l_{reflected}=\frac{z_{aperture}}{\cos\theta_{probe}} \quad (13)$$

[0238] 其中，$l_{reflected}$是反射路径长度，$z_{aperture}$是膜表面与孔之间的距离。

[0239] 由此可计算出在长度为 l_{ref}的路径上的并可由宽度为 $d_{aperture}$的孔接受的射线的宽度 d_{res}。该方法是等式 (8) 的反转，代入描述反射光的新宽度以及路径长度：

[0240] $d_{res}=d_{aperture}-2l_{ref}\tan\theta_{div}$ (14)

[0241] 因此分辨率将大于孔，其可看作系统的最小分辨率。

[0242] <u>波长</u>

[0243] 照射射线的波长可以根据表面粗化改变反射的行为（即改变的干涉）。

[0244] 在可选布置中，使用 IR 发射器。这可以改善装置的准确度，因为在这种布置中第二检测器是 IR 射线敏感的，因此可不受环境光源的干涉的影响。然而，在其他可选布置中，进行操作以发射其他部分电磁谱的电磁辐射的第二发射器可以是合适的。在这种情况下，可以通过例如遮挡件来保护第二检测器不受杂散射线影响。

[0245] <u>物品或者钞票角度</u>

[0246] 虽然在理想情形中，物品或者钞票相对第二检测器的角度将始终相同，但是实际上并不总是这样。例如，钞票可包含皱褶，或者气流可导致钞票在测量区域中的“振动”。钞票相对于第二检测器角度的变化将改变期望反射的角度。为了应对此问题，可增加第二检测器可接受的角度范围（通过缩短后退距离）。但是，这会降低设备的准确度，因此需要在这些冲突参数之间实现合适的平衡。

[0247] 由上述示例现象导致的反射率角度的变化可加上或减去一些角度。在可选布置中可通过在装置中采用解释模块以有效消除由于反射率角度的变化导致的第二检测器读数来补偿这种变化。

[0248] 图 14 示意性地示出了在本发明一个或多个实施方式的验证装置的可选布置中使用的反射率测量装置的发射器 - 检测器 - 物品布置的俯视图。为清楚起见，未示出验证装置的双折射测量装置。

[0249] 反射率测量装置 300 包括第二发射器 302、第二检测器 304、通过信号线 308 电子

地联接至第二检测器 304 的处理装置 306 以及与第二发射器 302 和第二检测器 304 相关联的遮挡件 310。下面将更详细地描述遮挡件 310。

[0250]　反射率测量装置 300 配置为使得第二发射器 302 和第二检测器 304 定向成朝向测量区域 311。第二发射器 302 进行操作以用电磁辐射照射测量区域 311（图中由虚线箭头 IL 表示），并且第二检测器 304 定向成并且进行操作以接收从物品位于测量区域 311 中的部分反射的电磁辐射（图中由虚线箭头 RL 表示）。

[0251]　可选地，验证装置可包括这样的路径：物品可沿着该路径进行传运。测量区域 311 形成该路径的一部分。因而，在该具体布置中，物品可沿着路径从验证装置的一侧传运至另一侧，在其传送过程中通过测量区域 311。

[0252]　在图示的布置中，物品包括钞票 312。

[0253]　遮挡件 310 在图示的布置中包括主体元件，在主体元件中设置了第二发射器管 314a 和第二检测器管 314b。第二发射器 302 定位在遮挡件 310 的第一侧的第二发射器管 314a 的一个端部处或者靠近该端部。第二检测器 30 定位在遮挡件 310 的第一侧的第二检测器管 314b 的一个端部处或者靠近该端部。由第二发射器 302 发射的照射电磁辐射 IL 行进通过第二发射器管 314a 并且从第二发射器管 314a 的开口部射出。该开口部定位在遮挡件 310 的第二侧。第二检测器管 314b 相对于第二发射器管 314a 和测量区域 311 定位并且定向在遮挡件 310 内，使得从测量区域 311 反射的反射电磁辐射 RL 进入第二检测器管 314b 的开口部。第二检测器管 314b 的开口部定位在遮挡件 310 的第二侧。在经由开口部进入第二检测器管 314b 之后，反射电磁辐射 RL 沿着第二检测器管 314b 行进至第二检测器 304。

[0254]　在操作中，钞票 312 将沿着路径在从图的左侧至右侧（即箭头 C 指示的）的方向上传运。图 14 中示出的示例示出了一部分位于测量区域 311 中的钞票 312。来自第二发射器 302 的照射电磁辐射 IL 通过第二发射器管 314a 并且从其上的开口部离开第二发射器管 314a。在离开第二发射器管 314a 之后，照射电磁辐射 IL 入射在钞票 312 位于测量区域 311 中的部分上。入射照射电磁辐射 IL 的至少一部分将由钞票 312 反射。该反射电磁辐射 RL 朝向第二检测器管 314b 的开口部反射，从开口部处进入第二检测器管 314b 以及此后继续到第二检测器 304。第二检测器 304 响应于检测到入射至其上的反射电磁辐射 RL，经由信号线 308 输出信号至处理装置 306，该信号与接收的反射电磁辐射 RL 的强度成比例。

[0255]　处理装置 306 一旦从第二检测器 304 接收到输出信号，进行操作以比较接收的信号的值与存储在数据库（未示出）中的一组预定值。这些预定值可对应于在以下一种或多种情况中的期望的反射电磁辐射值：钞票的印刷区域位于测量区域 311 中；钞票的未印刷区域（例如窗区域）位于测量区域 311 中；无钞票位于测量区域 311 中。处理装置可以使用该信号并且结合从双折射测量装置（未示出）接收的信号来输出这样的信号，该信号指示钞票是否真的。

[0256]　随着钞票 312 继续通过反射率测量装置 300，处理装置 306 从第二检测器 304 接收数个读数。可选地，双折射测量装置仅当窗区域位于测量区域 311 中时执行其测量（即双折射测量的操作可基于由反射率测量装置输出的信号）。

[0257]　该装置 300 可形成例如实施在钞票计数系统中的验证装置的一部分。处理装置 306 可以进行操作以仅当真钞票通过验证装置时输出信号至计数设备。

[0258]　在可选布置中，遮挡件 310 可以包括注射模制部（可选地是单个注射模制部），该

注射模制部进一步可选地包括吸收性黑色加颜料聚合物，诸如聚乙烯、尼龙或者聚丙烯。

[0259] 第二发射器 302 可选地可包括具有多个不同波长的激光器和 / 或 LED。可选地，照射电磁辐射 IL 的波长可以在电磁谱的 IR 区域中，例如约 890nm。

[0260] 第二检测器 304 可选地可包括构造为提供宽谱第二检测器（例如进行操作以检测波长在约 400nm 至约 1140nm 范围内的反射射线）的光电二极管。在具体可选布置中，第二检测器可进行操作以检测波长在约 880nm 至约 1140nm 范围内的反射射线。

[0261] 图 15 示意性地示出了在本发明一个或多个实施方式的验证装置的可选布置中使用的反射率测量装置的发射器 - 检测器 - 物品布置的俯视图。再次，为清楚起见，未示出验证装置的双折射测量装置。

[0262] 图 15 中示出了类似于图 14 图示的特征。在图 15 中，与图 8 共同具有的特征现在所标的附图标记的类型是 4XX 而不是 3XX。因而，在图 15 中，附图标记 400(而不是 300) 表示反射率测量装置，附图标记 402(而不是 402) 表示第二发射器等。

[0263] 图 15 所示的布置类似于图 14，除了单个第二发射器以及单个第二检测器替换为多个第二发射器以及多个第二检测器。因而，在图 15 中，三个第二发射器 402a、402b、402c 替换图 14 所示的布置中的单个第二发射器 302，三个第二检测器 404a、404b、404c 替换图 14 所示的布置中的单个第二检测器 304。

[0264] 第一个第二发射器 402a 与第一个第二检测器 404a 成对，第二个第二发射器 402b 与第二个第二检测器 404b 成对，以及第三个第二发射器 402c 与第三个第二检测器 404c 成对。

[0265] 鉴于相比于图 14 所示的布置增加了第二发射器和第二检测器的数量，遮挡件也需要进行相应调整。因而三个第二发射器管 414a、414a’ 和 414a” 连同三个第二检测器管 414b、414b’、414b” 设置在遮挡件 410 中。

[0266] 由第一个第二发射器 402a 发射的照射电磁辐射 IL 将沿着第一个第二发射器管 414a 行进并且入射到钞票 412 位于测量区域 411 中的部分上。从测量区域 411 中的钞票 412 反射的反射电磁辐射 RL 将朝向第一个第二检测器管 414b 的开口行进，并且一旦通过其开口进入第一个第二检测器管 414b 将沿着第一个第二检测器管 414b 行进以由第一个第二检测器 404a 接收。

[0267] 类似地，由第二个第二发射器 402b 发射的照射电磁辐射 IL 将沿着第二个第二发射器管 414a’ 行进并且入射到钞票 412 位于测量区域 411 中的部分上。从测量区域 411 中的钞票 412 反射的反射电磁辐射 RL 将朝向第二个第二检测器管 414b’ 的开口行进，并且一旦通过其开口进入第二个第二检测器管 414b’ 将沿着第二个第二检测器管 414b’ 行进以由第二个第二检测器 404b 接收。

[0268] 此外，第三个第二发射器 402c 进行操作以将光发射至第三个第二发射器管 414a” 中。由于来自第三个第二发射器管 414a” 的照射电磁辐射 IL 的入射而导致的从钞票 412 位于测量区域 411 中的部分反射的射线将朝向第三个第二检测器管 414b” 的开口行进，并且一旦通过其开口进入第三个第二检测器管 414b”将沿着第三个第二检测器管 414b”行进以由第三个第二检测器 404c 接收。

[0269] 因此，在所示的可选布置中，反射率测量装置 400 包括多角度点分析装置。

[0270] 如上所述，第二发射器在其孔路径中与第二检测器相配。虽然在该示例中示出了

用于第二发射器和第二检测器的三个角度，但是在其他可选布置中如果需要可使用更多的角度。

[0271] 第二发射器 402a、402b、402c 定向成使得从其发射的电磁辐射的照射入射在正在进行检测的物品的表面的相同部分上，即测量区域中的同一点。接着，第二检测器 404a、404b、404c 应该类似地定向以接收从该表面的相同部分反射的电磁辐射。

[0272] 处理器 406 可进行操作以对从第二检测器 404a、404b、404c 接收的多个输出信号执行分析。

[0273] 在另一可选布置中，使用多个波长的反射测量可应用至单个或者多个角度测量（即图 14 或者图 15 所示的装置可构造为对多个不同的波长进行反射测量）。

[0274] 可基于与单波长测量设备的几何形状相同的几何形状的可能配置可包括：

[0275] a) 彩色第二发射器和第二检测器：单个彩色第二发射器替换图 14 的布置中的第二发射器。但是，如果在具体角度处采用多于一种颜色，这会是有问题的。可以存在两个方案，即：

[0276] i. 绕一个圈进行旋转测量：这样维持了角度并且同时测量了钞票的相同点，但风险是由于偏振通过反射而导致的变化。差别不会很大，并且如果每次使用相同的测量定向，结果将是一致的；以及

[0277] ii. 延迟信号：可以级联序列通过多排平行检测系统测量位于线上的点（在时间 1 通过站 1 测量点 1，在时间 2 通过站 2 测量点 1，同时通过站 1 测量点 2 等）

[0278] b) 白光发射源可以结合以下一个或多个使用：

[0279] i. 分光仪，代替光电二极管第二检测器；

[0280] Ii. 位于孔管中的分光仪的功能部件，（即衍射光栅以及 CCD 第二检测器 /CMOS）；以及

[0281] iii. 数字照相机。

[0282] 本发明的一个或多个实施方式的另一可选布置包括反射率测量装置，其进行操作以执行全区域扫描。图 15 中示出了这种布置。在该布置中，设置有反射率测量装置 500，其包括条状电磁辐射源 502，条状电磁辐射源 502 进行操作以朝向位于验证装置中的钞票 506 发射照射电磁辐射 IL。入射的电磁辐射 IL 可以由钞票反射作为朝向线扫描照相机 504 的反射电磁辐射 RL。

[0283] 在该布置中，操作模式与在以上其他布置中描述的操作模式相同，除了先前描述的第二发射器 / 第二检测器组合替换成条状电磁辐射源 502 和线扫描照相机 504。钞票 506 可以相对于条状电磁辐射源 502 和线扫描照相机 504 移动，或者反之亦然。这种布置可以用以通过使用线扫描照相机 504 测量所反射的电磁辐射 RL 的值来获得具体照明角度的表面反射率的完整分布图。

[0284] 该分布图可选地可以是单色或者彩色的（即通过彩色照相机或者经由联接至 2D CMOS 阵列的衍射光栅收集反射电磁辐射 RL）。此外，可根据通过以一系列角度照射钞票获得的一系列测量值建立分布图（例如类似于图 15 所示的布置，但利用有效延伸至纸的平面中 / 延伸出纸的平面的条状电磁辐射源以及线扫描照相机）。

[0285] 在可选布置中，可以使用刚好在可见谱之外的 IR 光。在另一可选布置中，一种潜在地降低噪声的方式是采用过滤器以过滤出白光。

[0286] 在所有以上描述的“非静态”布置中，钞票可以相对于验证装置移动（即沿着传输路径移动通过装置）。然而，在其他可选“非静态”布置中，钞票可以是静止的，而装置相对于钞票移动。

[0287] 在另一可选布置，双折射测量装置的一个或多个发射器和一个或多个检测器可以倾斜或者偏置，使得通过钞票的光学路径的长度增加。

[0288] 在上述布置中，双折射测量装置的起偏器是“相交的”。也就是说，第一起偏器 112 布置成使得其透射定向与物品 106 位于测量区域 108 中的部分的透射定向约成 ±45°。第二起偏器 116 布置成使得其透射定向与物品 106 位于测量区域 108 中的部分的透射定向约成 ±45°。也就是说，第一起偏器 112 的透射定向与第二起偏器 116 的透射定向的约成 90°。在可选布置中，第一起偏器 112 的透射定向与第二起偏器 116 的透射定向可成 90°。然而，在其他可选布置，第一起偏器 112 的透射定向与第二起偏器 116 的透射定向可以不是垂直的。例如，第一起偏器 112 的透射定向与第二起偏器 116 的透射定向可约成 89°。在这种“非垂直”布置中，相比于“垂直”布置，允许通过起偏器的照射辐射量增加。这将影响一个或多个检测器的背景水平并且可提高装置检测边缘的能力。

[0289] 在能够使用软件控制的可编程处理设备（诸如通用处理器或专用处理器、数字信号处理器、微处理器、或者其他处理设备、数据处理装置或计算机系统）至少部分地实施本发明的上述实施方式的范围内，将理解的是，用于配置可编程设备、装置或系统以实施上述方法和装置的计算机程序被设想作为本发明的一个方面。计算机程序可以实施为任何合适的类型的代码、诸如源代码、目标代码、编译代码、解释代码、可执行代码、静态代码、动态代码等等。指令可使用任何合适的高级的、低级的、面向对象的、可视的、编译的和 / 或解释的编程语言来执行，例如，Liberate、OCAP、MHP、Flash、HTML 和相关语言、JavaScript、PHP、C、C++、Java、BASIC、Perl、Matlab、Pascal、Visual Basic、JAVA 和 ActiveX、汇编语言、机器代码等等。本领域技术人员将容易理解的是，术语“计算机”在其最广泛的意义上包括诸如上面提到的可编程设备以及数据处理装置和计算机系统。

[0290] 适当地，计算机程序存储在机器可读形式的载体媒介上，例如载体介质可以包括存储器、可移动或者不可移动的媒介、可擦除或者非可擦除的媒介、可写或者可重写媒介、数字或者模拟媒介、硬盘、软盘、光盘只读存储器 (CD-ROM)、可刻录光盘 (CD-R)、可重写光盘 (CD-RW)、光盘、磁性媒介、磁光媒介、可移动的存储卡或者盘、各种类型数字通用盘 (DVD) 用户身份模块、带、盒式固态存储器。

[0291] 如本文中所使用的那样，当提到“一个实施方式”或者“实施方式”意味着，结合该实施方式描述的具体元件、特征、结构或者特性包括在至少一个实施方式中。说明书中不同地方出现的短语“在一个实施方式中”并不必须均指代相同实施方式。

[0292] 如本文中所使用的那样，术语“包括 (comprises)”、“包括 (comprising)”、“包括 (includes)”、“包括 (including)”、“具有 (has)”、“具有 (having)”或者任何其他变型旨在覆盖非排他性的包括。例如，包括一系列元件的过程、方法、物件或者装置并不必须限于仅这些元件，而是可以包括过程、方法、物件或者装置中未明确列出的或内在的其他元件。此外，除非明确相反的指出，“或者”指的是包括性的或者，而不是排他性的或者。例如，在以下任一中情况下满足条件 A 或者 B ：A 是真的（或者存在）和 B 是假的（或者不存在）；A 是假的（或者不存在）和 B 是真的（或者存在）；以及 A 和 B 都是真的（或者存在）。

[0293] 此外，使用“一个(a)”或者“一个(an)”用来描述本发明的元件以及部件。这仅是为了方便以及给出本发明的一般性意义。该描述应该理解为包括一个或者至少一个，单数形式还包括复数形式，除非其明显表示相反的含义。

[0294] 综上所述，对于本领域的技术人员来说清楚的是，可以在本发明的范围内进行各种修改。

[0295] 本公开的范围包括本文中明确公开或隐含公开的任何新颖的特征或者特征的组合或其概括，而无论其是否涉及所要求保护的发明或解决了本发明要解决的部分或所有问题。申请人特此声明，在本申请或者从本申请衍生的任何其他申请的审查过程中，可根据这样的特征形成新的权利要求。具体地，参考后附的权利要求书，从属权利要求的特征可以与独立权利要求的特征组合，各独立权利要求的特征可以以任何适当的方式组合，而不仅是以权利要求中所列出的具体组合方式进行组合。

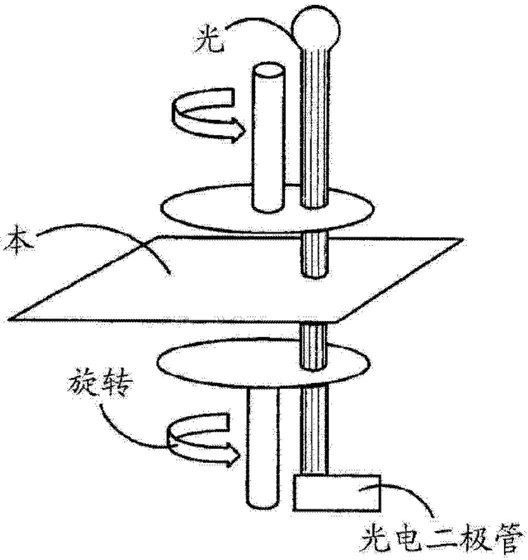


图 1（现有技术）
双折射检测器

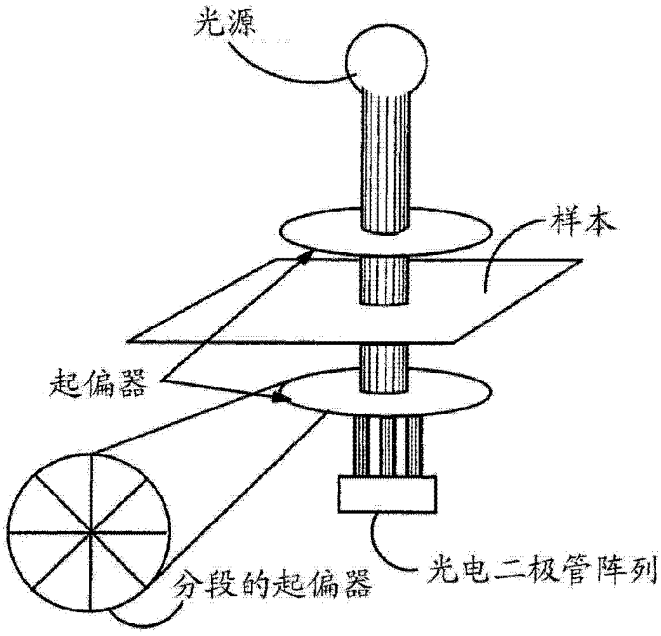


图 2（现有技术）
双折射检测器2

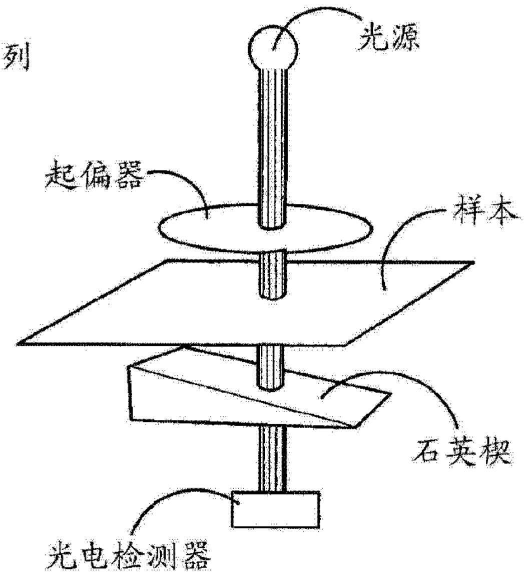


图 3（现有技术）
双折射检测器3

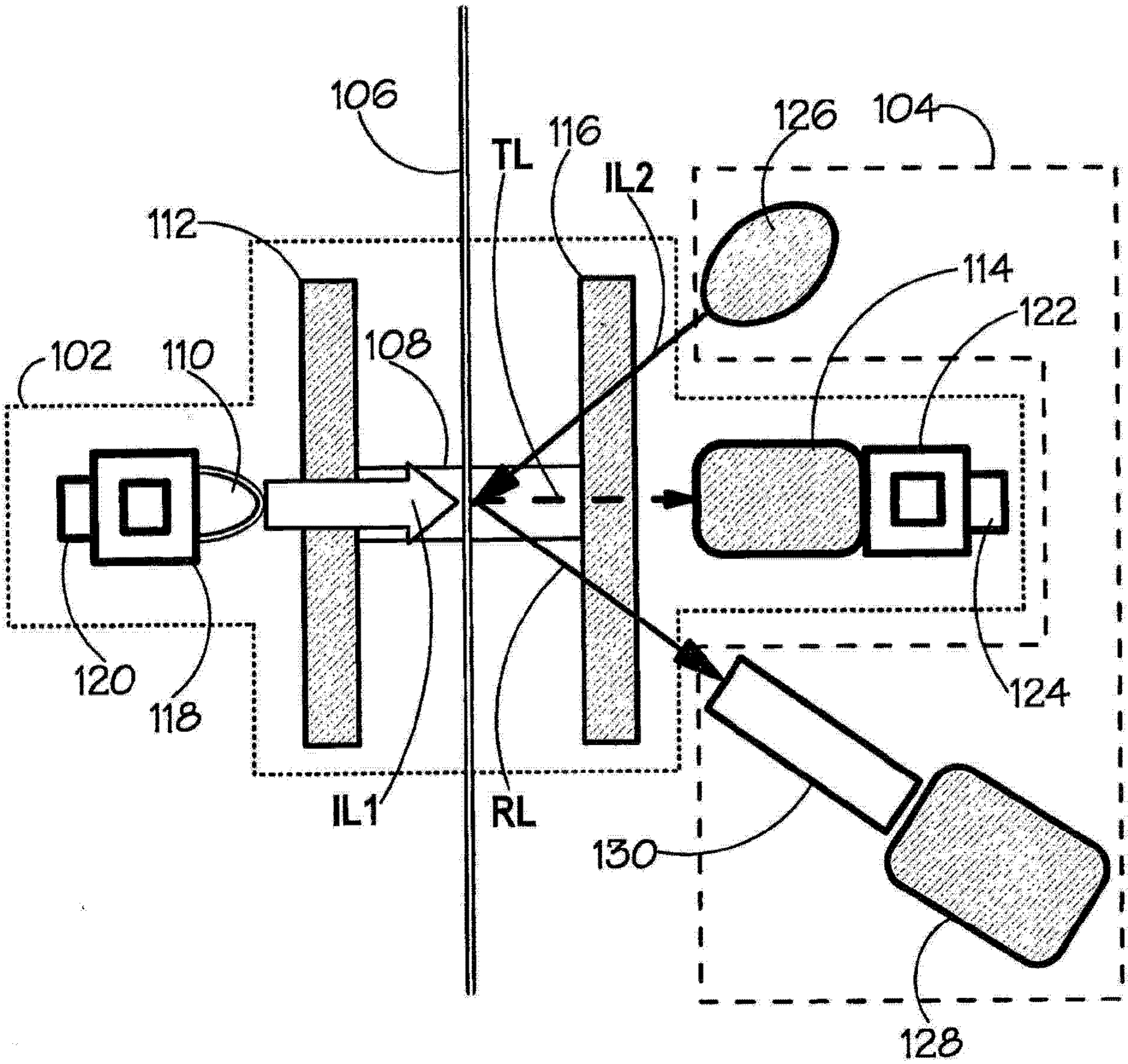

106
TL
116
IL2
126
104
112
114
122
102
110
108
120
118
124
IL1
RL
130
128

图 4

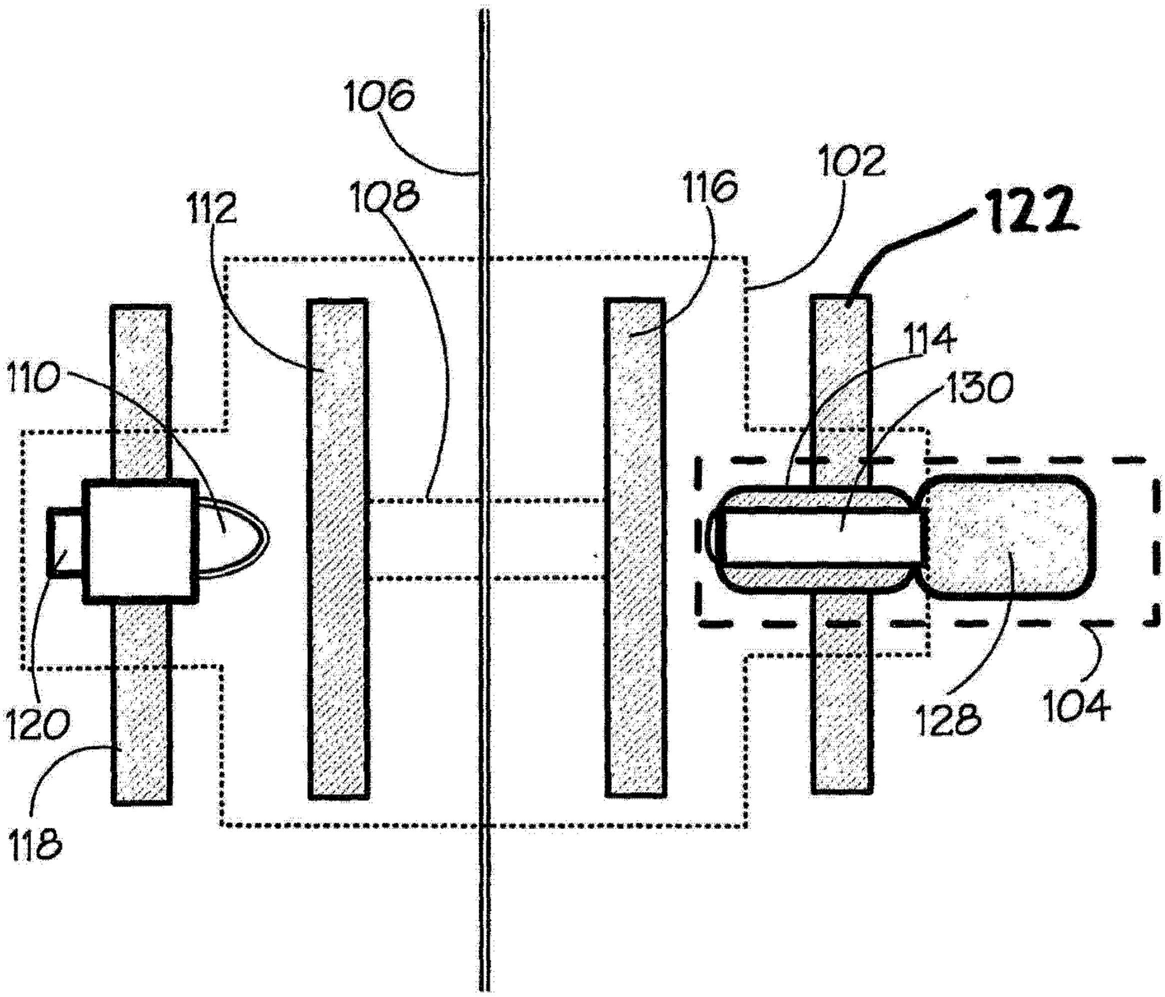


图 5

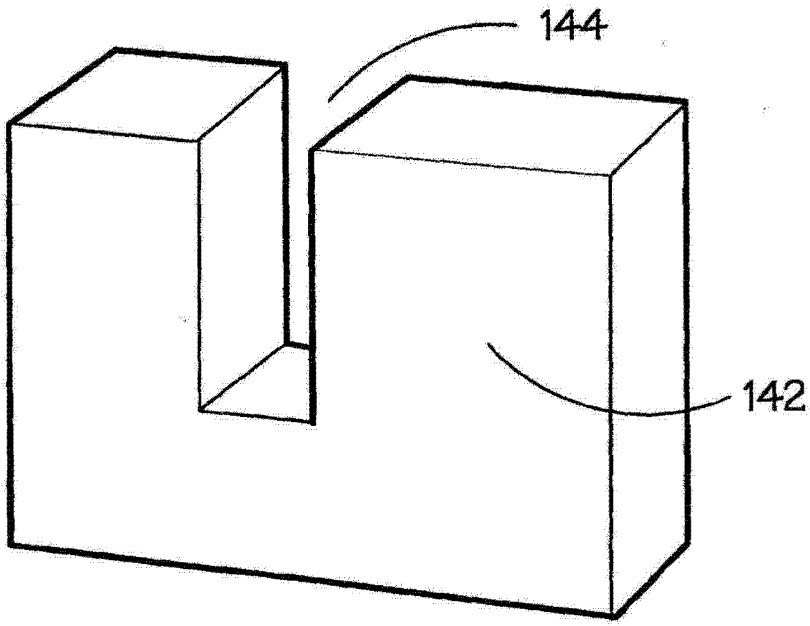


图 7

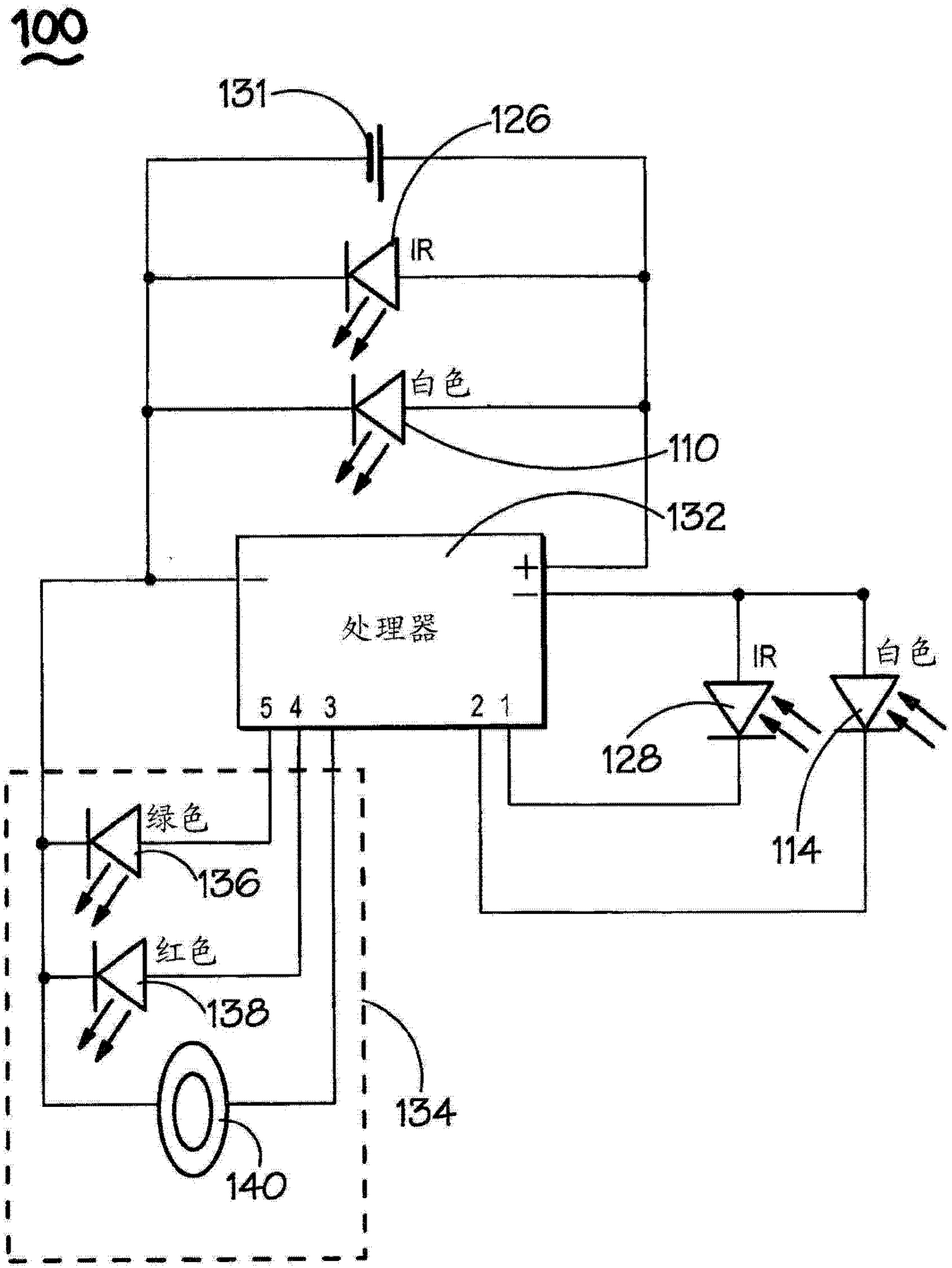

100
131
126
IR
白色
110
132
处理器
+
−
5 4 3
2 1
IR
白色
128
114
绿色
136
红色
138
134
140

图 6

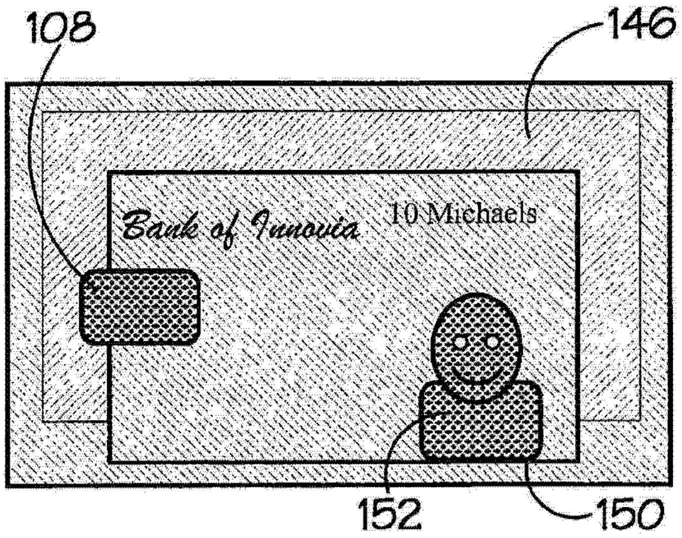

108
146
Bank of Innovia
10 Michaels
152
150

图 8a

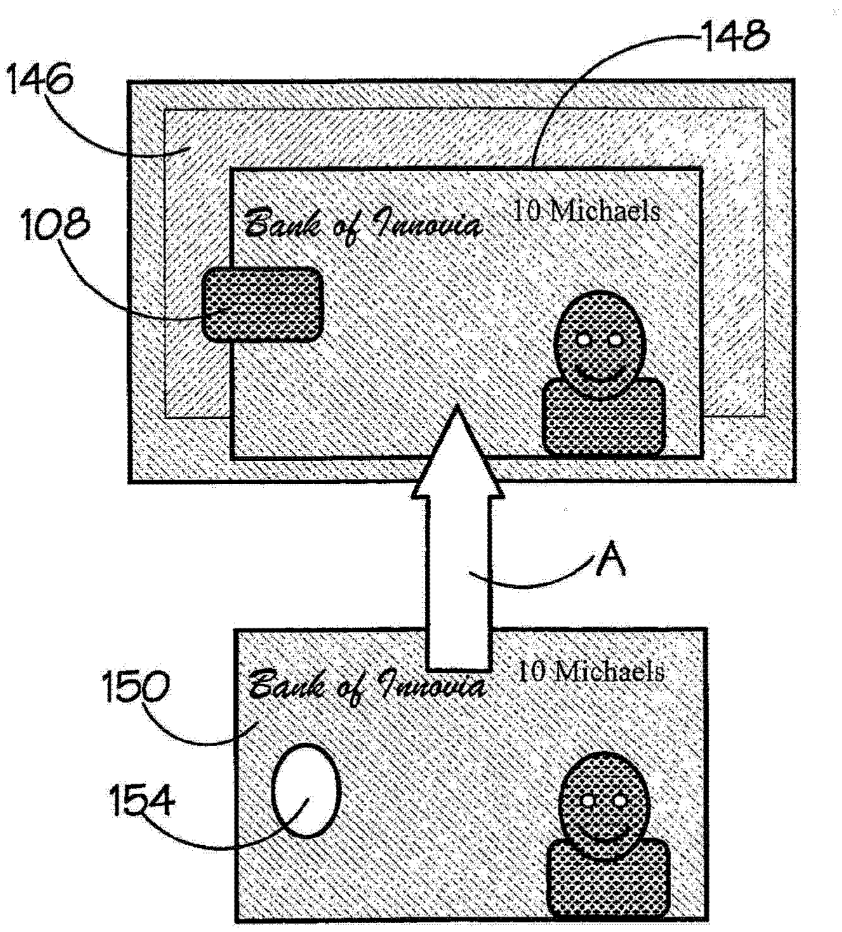

148
146
Bank of Innovia
10 Michaels
108
A
150
Bank of Innovia
10 Michaels
154

图 8b

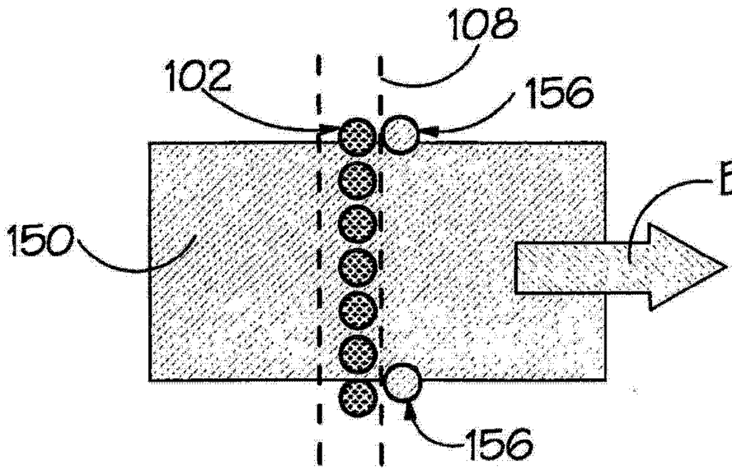


图 9a

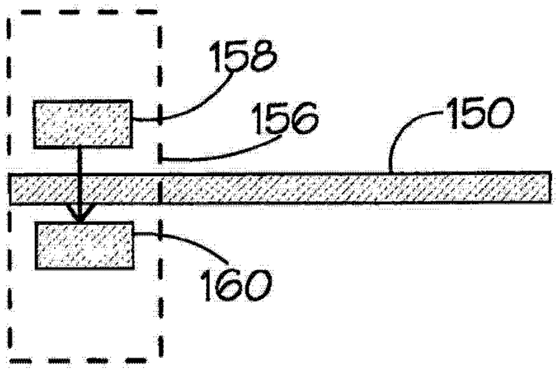


图 9b

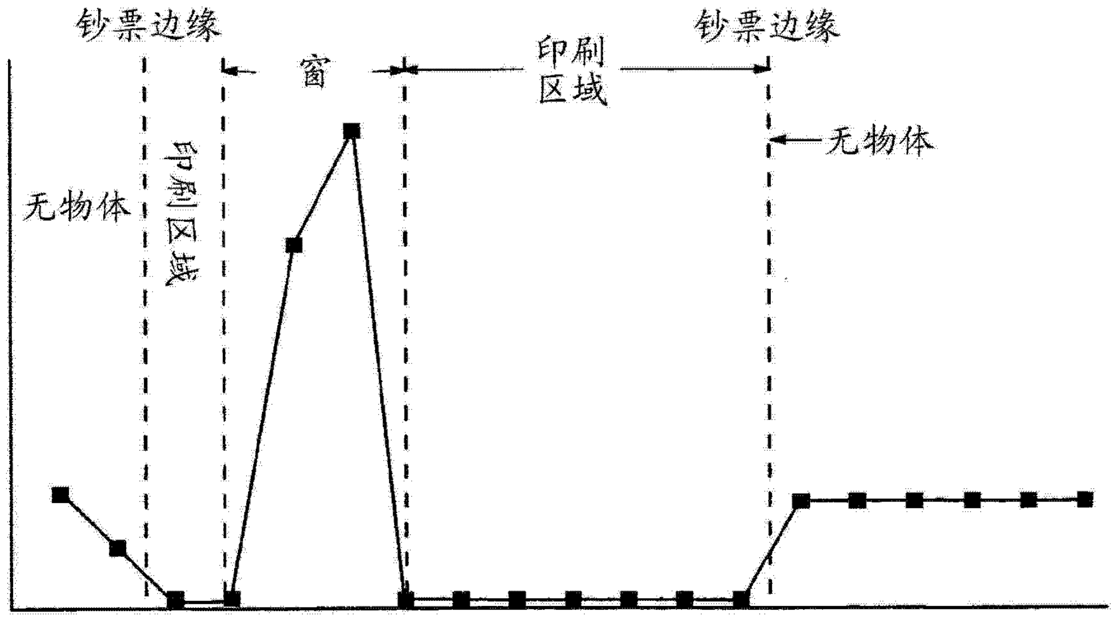


图 9c

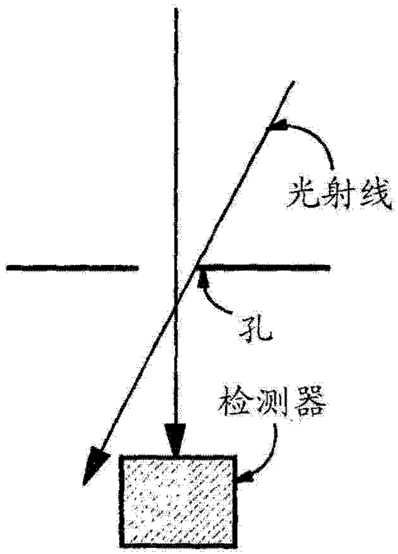


图 10a

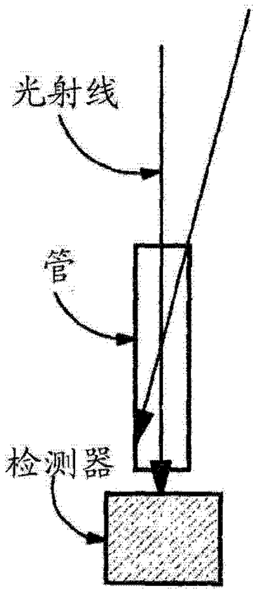


图 10b

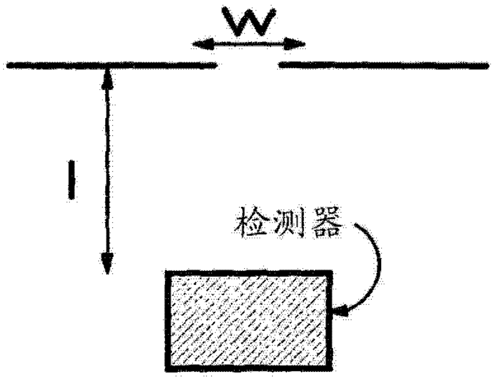


图 10c

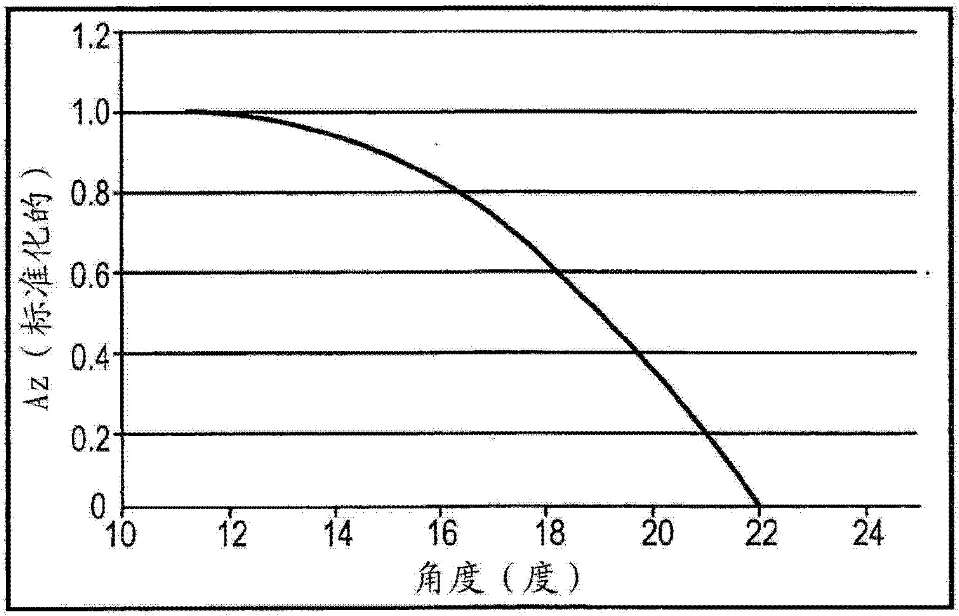

1.2
1.0
0.8
0.6
0.4
0.2
0
10
12
14
16
18
20
22
24
Az（标准化的）
角度（度）

图 11

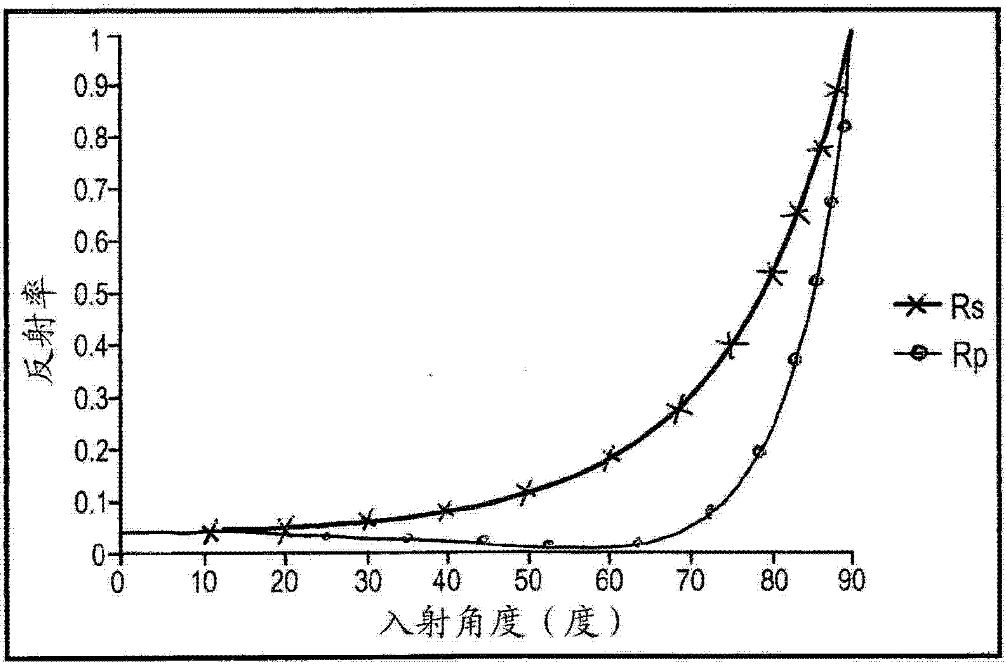

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
反射率
入射角度（度）
Rs
Rp

图 12

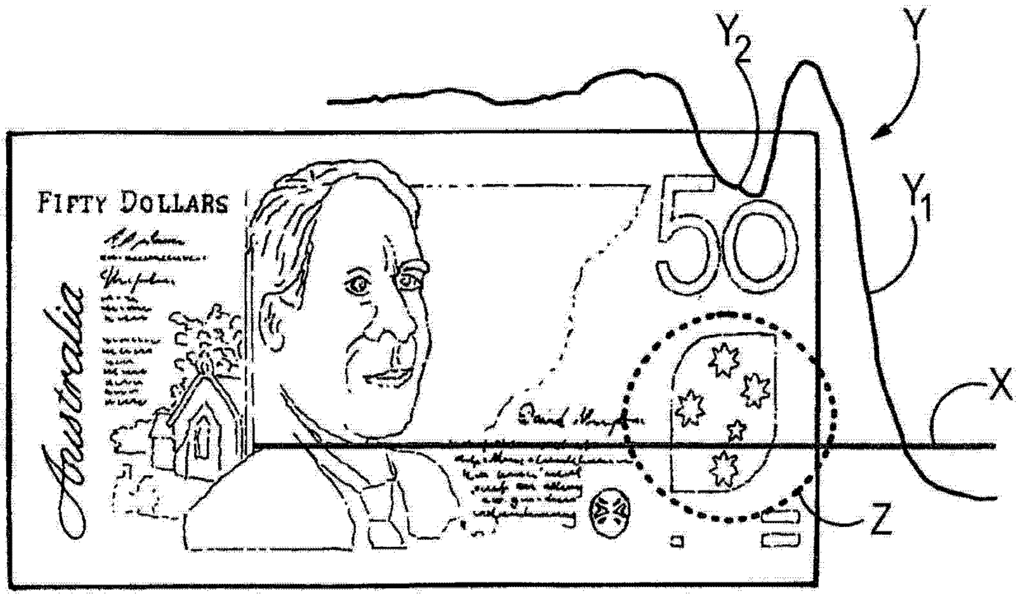

Y2
Y
Y1
FIFTY DOLLARS
Australia
50
X
Z

图 13

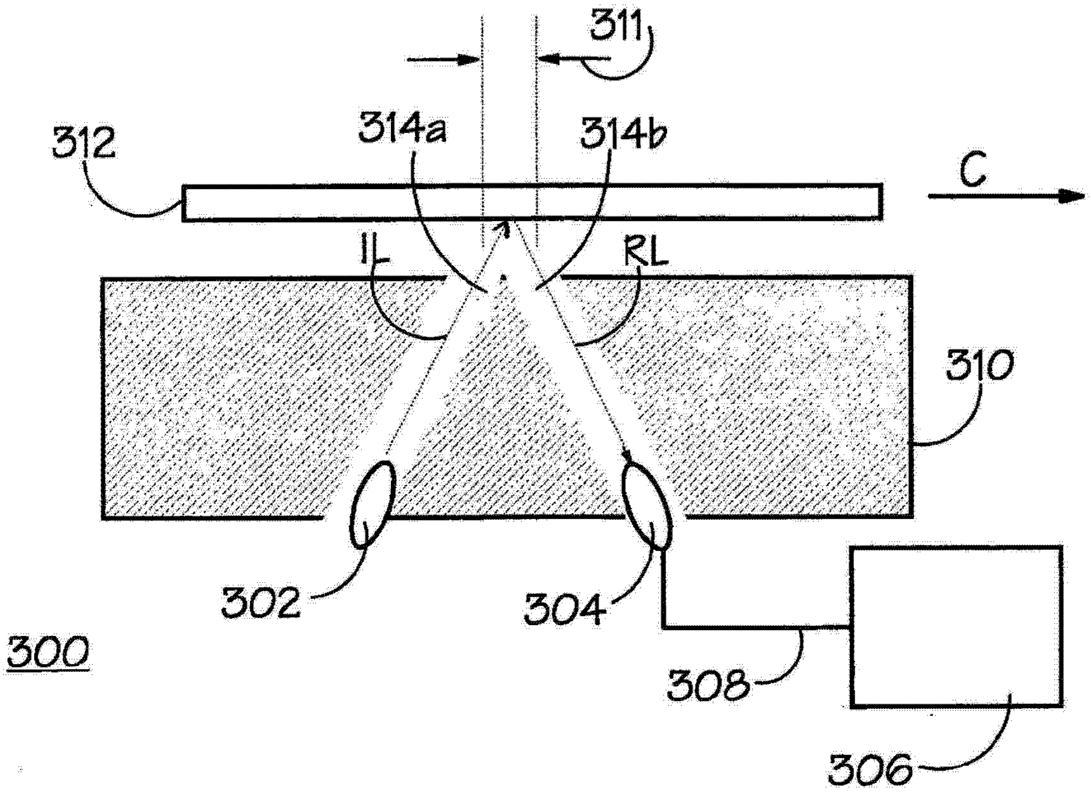

311
312
314a
314b
C
IL
RL
310
302
304
300
308
306

图 14

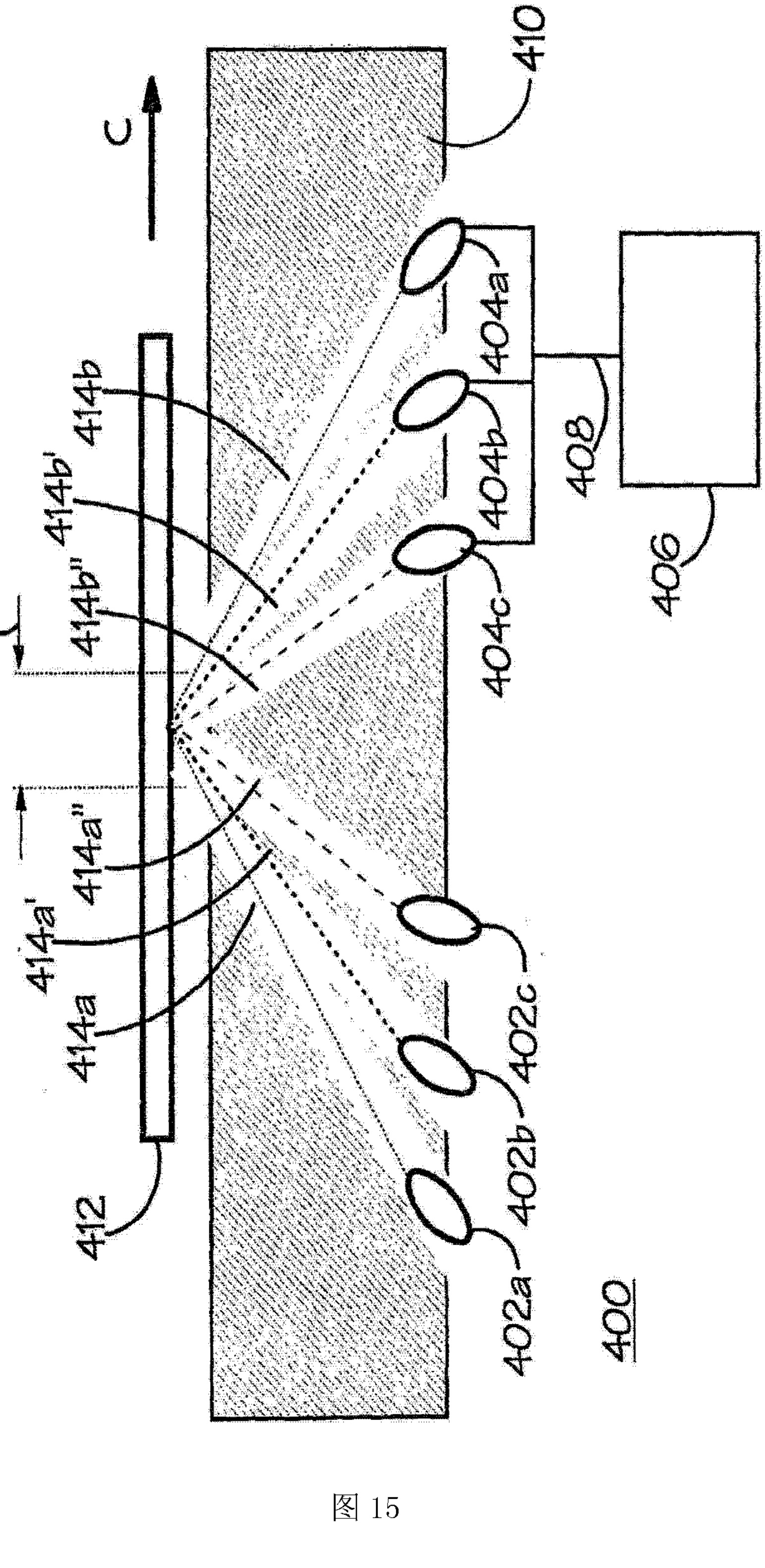

410
C
404a
404b
404c
408
406
411
414b
414b'
414b"
414a"
414a'
414a
412
402c
402b
402a
400

图 15

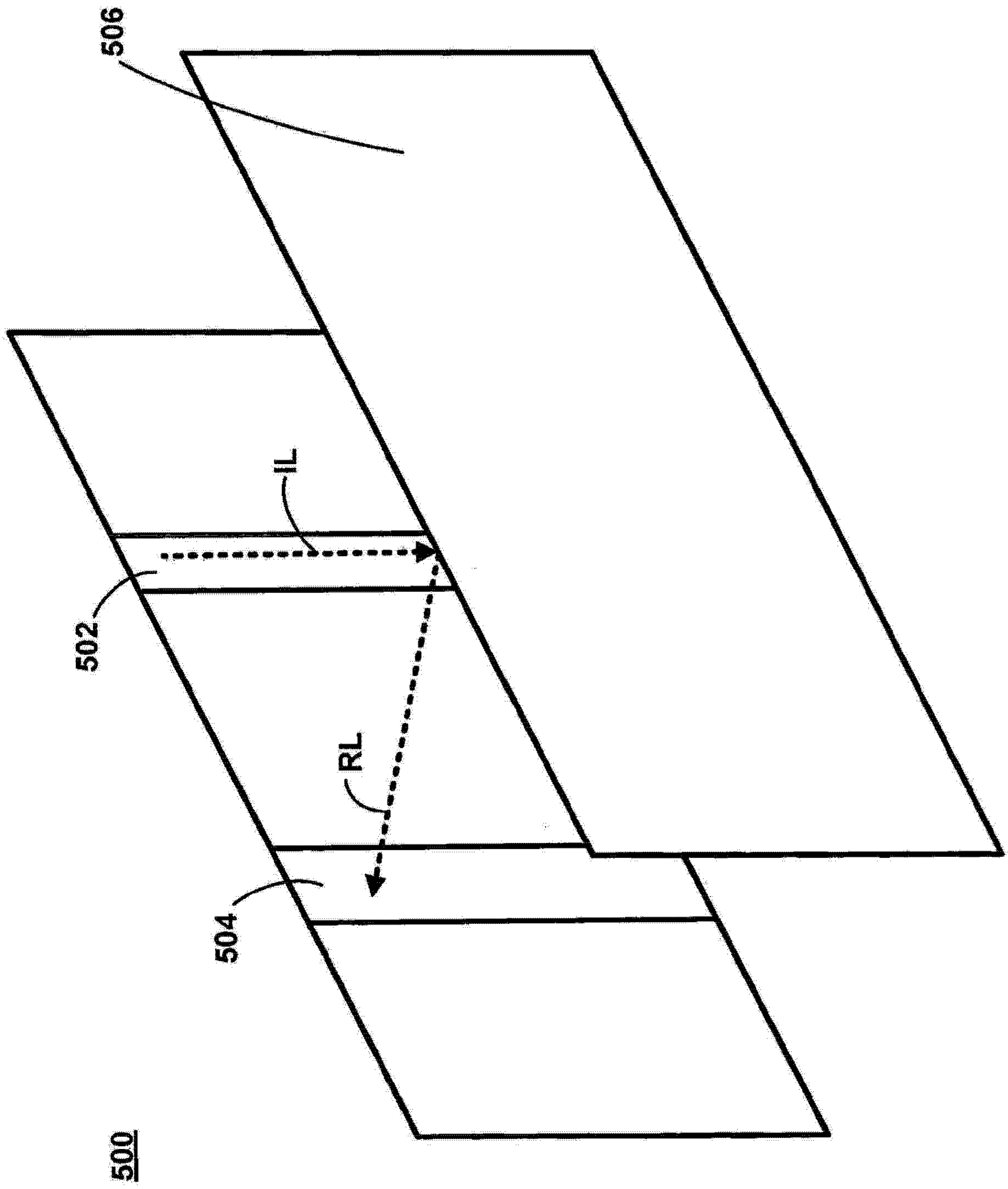


图 16

Abstract

An authentication apparatus operative to determine the authenticity of an item comprising a film substrate responsive to detection that a portion of said item located in a measuring region of said apparatus has a predetermined birefringence characteristic, said apparatus comprising: an item detection arrangement operative to determine if at least a portion of an item is located in a measuring region of said authentication apparatus; and an optically-based birefringence measuring apparatus, wherein said authentication apparatus is operative to compare a measured birefringence characteristic with a predetermined birefringence characteristic and to produce an authenticity signal indicative of authenticity or otherwise of said item based upon said comparison.