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(54) Title: PLANCHETTES CONTAINING INCONSTANT PIGMENT OR DYE FOR SECURE ARTICLE

(57) Abstract: The present invention describes planchettes incorporated into the substrate of secure articles, such as bank notes, passports and tax stamps. These planchettes may take various forms (such as fibers), regular shapes (such as circles), irregular shapes (such as polygons) or as threads or stripes running throughout the length of the document and are colored with an ultra color or inconstant pigment or dye, or a non-color inconstant pigment or dye, or combination thereof. Ultra color inconstant pigments and dyes appear as markedly different colors under light sources with differing spectral distributions. The planchettes are coated with an ink containing a color inconstant pigment and function as a method of authenticating the document. When the light source that the article is viewed under is changed, the planchettes change color at the same time. The effect is striking and proves the document to be genuine. This allows for facile authentication without the need of complex or costly equipment. The bulk of the substrate may also be colored to match the appearance of the planchettes under one illuminant, so that they only become visible when the spectral characteristics of the light source are changed.

**TITLE****Planchettes Containing Inconstant Pigment or Dye for Secure Article****BACKGROUND**

List of Prior Art Documents Found During Novelty Search:

- JP 2001 159094A
- WO 2007 144657
- US 4183989
- WO 2004 040062
- CA 570965

In recent times, counterfeiting has become a major issue affecting companies, individuals and governments. Counterfeiters are becoming ever more technically sophisticated and as a result many traditional security features are being compromised. As such, there is an urgent need for the development of new security features to stay ahead of the counterfeiters and to maintain the integrity of secure documents and therefore protect revenue, brand value, national security and tax revenue.

There are three classes of security features: covert; semi-overt; and overt. Covert applications require expensive and complex analytical equipment for authentication; semi-overt applications require simple and readily available equipment for verification; whereas overt features do not require the use of a device. Many covert features have been introduced in the past few years and there is a particular need for the development of overt and semi-overt security features to increase confidence in the legitimacy of secure documents as traditional overt features, such as holograms, are now commonly replicated.

The use of planchettes, fibers and threads in secure articles, such as banknotes, is widely known and is described in Optical Document Security, 3rd Ed., R. van Renesse, Artech House Publishers.

In the present invention a planchette is defined as a small colored form, such as a fiber, a regular shape such as a circle, an irregular shape, or a thread or stripe running throughout the length of the document. These planchettes may then be added to the pulped substrate prior to being formed, so that they form an integral part of the finished substrate. See diagrams 1, 2, 3 and 4 respectively for examples of planchette forms. Preferably, the planchettes range in dimension from about 5 mm to about 0.5 mm in the case of fibers. However other maxima and minima are possible.

Planchettes are frequently colored as overt features or coated with a fluorescent material as semi-overt features or coated with a machine readable feature as a covert feature or a combination of these. As overt features, they suffer from problems such as the ease with which they may be copied by photocopying or scanning and inkjet printing. Covert elements normally require complex and expensive authentication devices. Fluorescent pigments are semi-overt, however these are readily available to counterfeiters. WO2007144657 describes planchettes coated with UV fluorescent pigments.

The present invention discloses the use of planchettes colored with an ultra color inconstant pigment embedded in a substrate. The document containing the planchettes is simply authenticated by the use of two readily available light sources of different energy distributions. This method of counterfeit protection addresses some of the aforementioned problems.

Color inconstancy refers to the apparent change in color of a single sample under different illuminants. It is distinct from metamerism, which is the change in color difference between a pair of samples under different light sources. In Metamerism, the color difference or distance between the colors of the two samples in color space ( $\Delta E$ ) is

small under one light source and then large under a different light source, but two separate samples are required to observe this change. The Printing Ink Manual, 5<sup>th</sup> Ed, R. H Leach and R. J. Pierce, Blueprint, states that articles that do not possess color constancy will require a change in color description, e.g. yellow to red, as the color change is so marked when viewed under different illuminants. It defines metamerism as the color match of two samples under some light sources but not others due to differences in the absorption curves of the two samples in the visible region.

Color inconstant pigments exhibit a dramatic color change ( $\Delta E$ ) due to a change in their own color coordinates and do not need a second ink to demonstrate this. This color change occurs due to the absorption bands of these pigments which are distinct in the visible spectrum. Under a broad band spectral light source, the pigment appears one color, but when viewed under light of a discrete spectral distribution, the wavelengths available for absorption/reflection are decreased and the pigment appears as a different color. WO2007041579 and PCT/US2007/021021 give further definitions of color inconstancy and examples of appropriate compounds. These compounds exhibit many benefits over traditional pigments and some used in secure documents as security features, such as fluorescent pigments, in that they exhibit excellent lightfastness and resistance to degradation by chemicals. These properties are essential for use in secure articles as their use times tend to be long and it is a requisite of security features that they do not fail during the lifetime of the document.

JP2001159094A refers to planchettes or fibers coated with metameric inks and describes planchettes coated with two different inks which are needed to authenticate the document.

Color inconstant pigments have not previously been used for this application. Metameric pairs are described in the art, but these do not show such dramatic color changes and require a set of two inks to be used together. The dramatic effect obtained when using extreme color inconstant pigments makes verification and production of the secure article

much simpler; only one ink is needed. These pigments are also suited to this application due to their durability.

Semi-overt security features are in demand and there have been few recent innovations. The present invention is a simple, easily communicated concept that does not require a complex or costly authentication device. Both of these factors should make it attractive to potential clients.

Extreme color inconstant pigments have not previously been used to coat planchettes for use in secure documents. Metameric pairs have been used, but these require the use of two different inks. There is no prior teaching of matching the color of the planchettes and substrate under a single light source.

### **DETAILED DESCRIPTION OF THE INVENTION**

The present invention describes planchettes incorporated into the substrate of secure articles, such as bank notes, passports and tax stamps. These planchettes may take various forms, such as fibers; regular shapes (such as circles or stars); irregular shapes (such as polygons); or as threads or stripes running throughout the length of the document and are colored with an ultra color inconstant pigment or dye. Ultra color inconstant pigments and dyes appear as markedly different colors under light sources with differing spectral distributions. A partial list of examples of color inconstant pigments and dyes includes, but is not limited to: Pigments CR, P8 and CB7 from Stardust Materials LLC; Pigment violet 55; Quantum dot nanocrystals, which are crystals composed of transition elements, lanthanides and actinides and which range from about 2 to about 10 nanometers (10-50 atoms) in diameter, such as neodymium phosphate holmium-yttrium sulfide fused quantum dot, holmium-yttrium hydroxycarbonate fused quantum dot, and likewise for other rare earth elements; pigments comprising a lanthanide-based material with the appropriate counterion/ligand for the oxidation state of the given lanthanide – the

lanthanides include La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Yb; and the counterions/ligands include, but are not limited to phosphate, oxide, sulfide, oxysulfide, halides (fluoride, chloride, bromide), oxyhalide, carbonate, oxalate, and hydroxycarbonate. A more comprehensive list can be found in WO2007041579.

The planchettes are coated with an ink containing a color inconstant pigment or dye and function as a method of authenticating the document. When the light source that the article is viewed under is changed, the planchettes change color at the same time. The effect is striking and proves the document to be genuine. This allows for facile authentication without the need of complex or costly equipment. The bulk of the substrate may also be colored to match the appearance of the planchettes under one illuminant, so that the planchettes only become visible when the spectral characteristics of the light source are changed. Conversely, the planchettes may be colored to match the appearance of the substrate so that the planchettes only become visible when the spectral characteristics of the light source are changed

Secure documents incorporating this feature cannot be simply reproduced by color photocopying or scanning. As a special pigment is required, reproduction using standard inks will not demonstrate the effect. Depending on the light source in the photocopier or scanner, the planchettes will be copied as they appear under that light source and their appearance will not change when viewed under a different light source and the document will be shown to be counterfeit.

Unlike many security features which require complex and expensive devices for authentication, the present invention needs only two differing light sources, one that is of a broad spectral distribution and another that is discrete. Commercially available light boxes generally contain two such light sources.

Many overt and semi-overt features are underutilized by members of the general public or retail staff. Some are too difficult to see, such as traditional print security features of

micro text, and some many people are not aware of, such as see-through registered print. A dramatic color change in planchettes incorporated throughout the substrate is easily observed and is a straightforward concept to remember and utilize.

In one embodiment of the current invention, the color inconstant pigment containing ink can be printed directly onto the substrate. However, the preferred embodiment of the current invention is incorporation of color inconstant planchettes into the substrate by the means described in this application as this provides many benefits. The shape recognition coupled with control of the coating/printing density makes for a more recognizable feature and one which may be more readily color matched to an ink or colored paper substrate.

The present invention discloses the use of planchettes coated with an ultra color inconstant pigment or dye embedded in a substrate. Color inconstant pigments exhibit a dramatic color change and do not need a second ink to demonstrate this effect. The color change occurs due to the absorption bands of these pigments which are distinct in the visible spectrum. Under a broad band spectral light source, such as daylight, the pigment appears one color, but under illumination by a discrete spectral distribution, such as TL84, the wavelengths available for absorption/reflection are decreased and so the pigment appears as a different color. The degree of color inconstancy for a sample can be represented by the  $\Delta E$  CMC of the sample under different light sources. The larger the  $\Delta E$  CMC, the greater the color inconstancy and vice versa. The ISO standard for quantifying color inconstancy is CMCCON97. Examples of color inconstant pigments and dyes are included in this application. These pigments are preferably lightfast and exhibit high chemical resistance which are necessary to meet the durability requirements of security features used on secure documents.

It is also possible to incorporate non-color inconstant pigments or dyes into the planchettes to augment the color inconstant effect or to add other security effects, such as near infra red absorbency. Note that some color inconstant pigments exhibit properties

which may be exploited as a covert security feature, such as near infra red absorbency, up conversion and down conversion. A partial list of examples of non-color inconstant pigments and dyes includes, but is not limited to: Pigment Yellow 12, 13, 14, 83, 150, 128; Pigment Blue 15.3, 15:4, 61; Pigment Red 22, 48, 52, 57.1, 57.2, 122, 252; Pigment green 7, 36; Pigment black 7; Pigment Orange 13, 16, 34, 73; Pigment violet 3, 23, 19; Aluminum phthalocyanine chloride dye; special effect pigments such as mica based pearlescent and iridescent pigments. Non-color inconstant pigments or dyes can be used alone or in blends, or in combination with color inconstant pigments or dyes.

The planchettes are produced by coating or printing an ink containing a color inconstant pigment or dye (or combination thereof) onto a suitable substrate which is preferably cellulose; cotton; linen or other textile fiber; or polymeric. Other possible substrates include any typically used in the production of a wide variety of security documents (e.g. bank notes; stock certificates; bonds; currency; credit cards; key cards; passports; tax stamps; etc.) or any other substrate that would benefit from having a security feature disposed thereon. A color inconstant compound may also be used to mass tone the material used to form the planchette. The ink may be printed or coated on to the substrate by means such as screen, roller coat or curtain coat or other traditional printing and coating processes. Preferably, both sides of the substrate are coated as the orientation of the planchette within the finished substrate cannot be predetermined. A plurality of color inconstant pigments/dyes and non-color inconstant pigments/dyes may be used to enhance the color inconstant effect and or to create a pleasing visual effect. The color inconstant pigment containing layer may be overprinted with other layers, usually clear layers, to provide chemical and physical resistance and/or to ensure a good affinity to the substrate pulp to make sure that the planchette becomes an integral part of the end document.

The planchettes may be formed by various techniques such as punching or stamping or cutting the substrate. They may be added to the pulp of the substrate before the forming stage. A plurality of planchette shapes may be incorporated into a single document.



Finished secure articles incorporating the planchettes may be authenticated by examination under two light sources, preferably one of a discrete spectral distribution and another that is broad e.g. shop lighting (TL84) and daylight (D65). These are commonly obtainable in commercially available light boxes. Switching between the illuminants will result in a striking change in color of the planchettes, quickly and simply demonstrating that the article is genuine.

In one embodiment of the invention, the pulp of the substrate is colored so that it matches the appearance of the color inconstant pigment under one light source. As such the planchettes are indistinguishable from the bulk of the substrate and suddenly “appear” when the spectral distribution of the light source is changed. In another embodiment of the invention, ink printed onto the surface of the document is matched to one color of the planchettes to further enhance the effect.

In a further embodiment of the present invention, the planchettes contain at least one further security feature for example, up-converters; down-converters; infra red absorbers; infra red transparent compounds; piezochromics; and thermochromics. Up-converters are materials which absorb lower energy radiation and then re-emit this as higher energy radiation, for example, absorption of infra red and emission of visible light. This is achieved by emission of one photon of high energy for two or more photons of lower energy absorbed. Down-converters have the reverse properties in that they absorb radiation of higher energy than they emit. For example, UV fluorescent materials absorb UV radiation and emit visible light.

The up-converters, down-converters or other security features could be incorporated in the following ways; added to the ink used to coat the planchettes, added to the material used to form the planchette or incorporated into an overprint varnish applied over the color inconstant coated stock before the individual planchettes are formed.

Secure documents including this feature cannot be simply reproduced by color photocopying or scanning. As a special pigment/dye is used, reproduction using standard inks will not demonstrate the effect. The color reproduced will depend on the light source used by the scanner or photocopier.

### EXAMPLES

These examples should not be construed as limiting.

#### Example 1

**Broad:** A color inconstant pigment was dispersed into a suitable varnish in a 50:50 ratio by stirring and was then passed over a triple roll mill. The resulting ink was coated onto both sides of a carrier substrate which was then processed to form planchettes. These planchettes were then incorporated into a textile fiber pulp which was then used to form paper.

**Specific:** 50g color inconstant pigment (CR8, Stardust Materials LLC) was stirred into 50g solvent based vinyl varnish (Vynaglaze 4795, Sun Chemical) using a Dispermat. The resulting mixture was passed over a triple roll mill to achieve a fine dispersion. This ink was then screen printed using a 43 mesh screen onto both sides of heat stabilized polyester (Autostat CT3, MacDermid Autotype Ltd.). Circular planchettes of diameter 5 mm were then punched out of the coated polyester and added to a cotton and linen fiber pulp. The pulp was distributed over a 12-300 mesh screen and allowed to drain. After most of the moisture had been removed, the screen was laid over an absorbent substrate and pressure applied until completely dry. The formed paper was lifted off the screen and had planchettes distributed throughout.

### **Example 2**

The planchettes of example 1 were incorporated into pulp which was colored to match the appearance of the pigment under a broad band illuminant, in this example a creamy yellow color. The pulp was further processed to form paper in which the planchettes are not discernable under a broad band illuminant such as daylight, but then “appear” when observed under a discrete band light source such as point of sale lighting.

Coated polyester film, as prepared in example 1, was cut into thin fibers and was incorporated into paper as described in both examples 1 and 2.

Though other methods are possible, a typical example of how the planchettes would be fabricated and incorporated into a substrate in a commercial manufacturing setting is as follows:

- Color inconstant ink/coating is deposited onto a moving filmic substrate via gravure, flexographic, screen, Mayer bar or other means.
- The ink/coating is dried or cured, usually in-line using hot air or UV radiation.
- Off-line, the coated substrate is cut into planchettes to a pre-described shape and size.
- The planchettes are added and mixed with the pre-dyed paper pulp before the formation of the finished paper web.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 shows a sample of paper produced with circular color inconstant planchettes.

Figure 2 shows a sample of paper produced with star shaped color inconstant planchettes.

Figure 3 shows a sample of paper produced with color inconstant fibers.

Figure 4 shows a sample of paper produced with a continuous color inconstant thread running throughout the substrate.

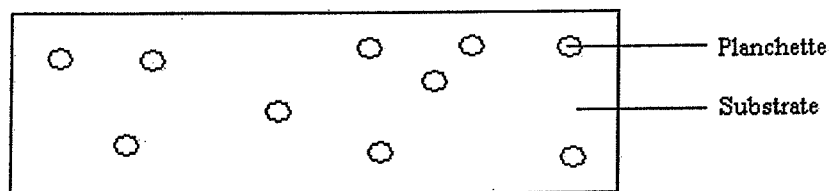
## WHAT IS CLAIMED IS:

1. A planchette comprising a combination of a substrate and a composition containing at least one inconstant pigment or dye, wherein the composition is deposited on at least one surface of the substrate.
2. The planchette of claim 1 in which the inconstant pigment or dye is a member of the group consisting of color inconstant; and non-color inconstant; or a combination thereof.
3. The planchette of claim 2 wherein the color inconstant pigment or dye is a member of the group consisting of Pigment violet 55; lanthanide-based pigments; Quantum dot nanocrystals; holmium-yttrium hydroxycarbonate fused quantum dot; or a combination thereof.
4. The planchette of claim 3 in which the Quantum dot nanocrystal is a member of the group consisting of neodymium phosphate holmium-yttrium sulfide fused quantum dot; holmium-yttrium hydroxycarbonate fused quantum dot neodymium phosphate; and holmium-yttrium sulfide fused quantum dot, and which range from about 2 to about 10 nanometers in diameter.
5. The planchette of claim 3 in which the lanthanide-based pigment comprises a lanthanide-based material with a counterion/ligand for the oxidation state of the given lanthanide pigment.
6. The planchette of claim 5 wherein the lanthanide-based material is a member of the group consisting of La; Ce; Pr; Nd; Pm; Sm; Eu; Gd; Tb; Dy; Ho; Er; Tm; and Yb; and the counterion/ligand is a member of the group consisting of phosphate; oxide; sulfide; oxysulfide; halides; oxyhalide; carbonate; oxalate; and hydroxycarbonate.
7. The planchette of claim 2 wherein the non-color inconstant pigment or dye is a member of the group consisting of Pigment Yellow 12, 13, 14, 83, 150, 128; Pigment Blue 15.3, 15:4, 61; Pigment Red 22, 48, 52, 57.1, 57.2, 122, 252; Pigment green 7, 36; Pigment black 7; Pigment Orange 13, 16, 34, 73; Pigment

- violet 3, 23, 19; Aluminum phthalocyanine chloride dye; Mica based pearlescent pigments; and iridescent pigments.
8. The planchette as in any of the preceding claims in which at least one further security feature is incorporated into the planchette.
  9. The planchette of claim 8 in which the further security feature is a member of the group consisting of up-converters; down-converters; infra red absorbers; infra red transparent compounds; piezochromics; and thermochromics.
  10. The planchette of claim 1 in which the substrate is a member of the group consisting of cellulose; textile; and polymer.
  11. The planchette as in any of the preceding claims in which the planchettes are in the form of a member of the group consisting of regular shapes; irregular shapes; and a combination thereof.
  12. The planchette as in any of the preceding claims in which the longest dimension is about 0.5 to about 5.0 mm.
  13. A security document comprising a plurality of planchettes as in any of the preceding claims.
  14. The security document of claim 13 in which the security document is a member of the group consisting of currency; bank notes; passports; tax stamps; stock certificates; bonds; treasury notes; credit cards; and key cards.
  15. The security document of claim 13 or claim 14 in which at least a portion of the planchettes match a color of the security document under one light source.
  16. A method of manufacturing planchettes comprising the steps of applying to a substrate, a composition containing at least one inconstant pigment or dye, and then forming the substrate into a plurality of planchettes.
  17. A method of manufacturing a security document, comprising incorporating the planchettes as in any of claim 1 to claim 12 into a security document.
  18. The method of claim 17 in which the security document is a member of the group consisting of currency; bank notes; passports; tax stamps; stock certificates; bonds; treasury notes; credit cards; and key cards

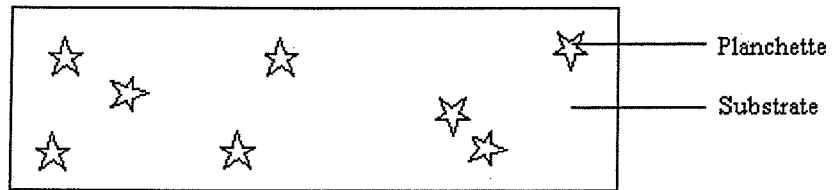
19. The method of claim 17 or claim 18 in which the planchettes are incorporated into a raw material used to form the security document.
20. The method of claim 19 in which the raw material used to form the security document is selected from the group consisting of cellulose; textile; or polymer.
21. A method of investigating a security document comprising interrogating the security document with a source of radiation and determining whether there is a response indicative of the presence of at least one planchette as in any of claim 1 to claim 12.
22. The method of claim 21 in which the at least one planchette comprises a plurality of planchettes and at least 2 planchettes respond differently from each other to a single light source.

**Figure 1**





**Figure 2**



**Figure 3**

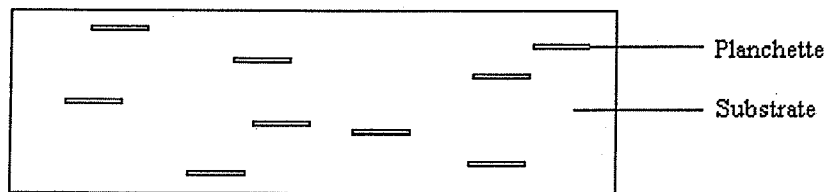


Figure 4

