(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 November 2014 (06.11.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/178067 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/IN2014/000212

(22) International Filing Date:
4 April 2014 (04.04.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2939/MUM/2012 8 April 2013 (08.04.2013) IN

(72) Inventor; and
(71) Applicant : PATEL, Shilpan, Pravinchandra [IN/IN]; 5-D, Laxmi Industrial Estate, New Link Road, Andheri (West), Mumbai-400053, Maharashtra (IN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: A HIGH SECURITY YARN OR THREAD FOR SECURITY PAPER

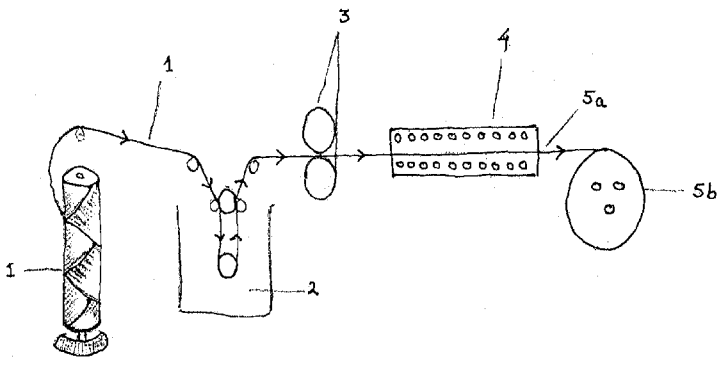

FIG 1

(57) Abstract: The invention relates to a hydrophilic yarn or thread which is soluble in hot water and which is coated or impregnated with hydrophobic materials or a combination of hydrophobic and hydrophilic materials. The coating medium includes, but is not limited to, binders such as polyvinyl alcohol (PVOH), guar gum, gelatine, carboxy-methyl cellulose (CMC), acrylic polymers, polyvinyl acetate (PVOHC), security pigments, dyes, machine readable taggants such as phosphors, PCR readable DNA tags, rare earths, magnetic particles, and X-ray readable particles, and the security yarn or thread so formed shall carry the security readable features in one or more varieties, and such security yarn or thread is subsequently inserted within a bed of paper pulp during the paper making process to form a high security paper, such as bank note paper, fiducciare paper, or passport paper. The security features carried by the yarn or thread can be extracted from, or detected in, the said yarn or thread in a suitably equipped forensic laboratory to, amongst other benefits, authenticate the manufacturing site at which such paper was produced.

WO 2014/178067 A2

High Security Yarn or Thread for Security Paper

Abstract

The invention relates to a hydrophilic yarn or thread which is soluble in hot water and which is coated or impregnated with hydrophobic materials or a combination of hydrophobic and hydrophilic materials. The coating medium includes, but is not limited to, binders such as polyvinyl alcohol (PVOH), guar gum, gelatine, carboxy-methyl cellulose (CMC), acrylic polymers, polyvinyl acetate (PVOHC), security pigments, dyes, machine readable taggants such as phosphors, PCR readable DNA tags, rare earths, magnetic particles, and X-ray readable particles, and the security yarn or thread so formed shall carry the security readable features in one or more varieties, and such security yarn or thread is subsequently inserted within a bed of paper pulp during the paper making process to form a high security paper, such as bank note paper, fiducciare paper, or passport paper. The security features carried by the yarn or thread can be extracted from, or detected in, the said yarn or thread in a suitably equipped forensic laboratory to, amongst other benefits, authenticate the manufacturing site at which such paper was produced.

For the purpose of this invention the following definitions are provided:

Definitions:

Yarn : Yarn is a spun strand using various fibers used for knitting, weaving, or sewing or making scrims. For the purpose of practicing the invention, we have used yarns made of polyester and polyvinyl alcohol of high mole value, polypropylene fibers, nylon (polyamide), or combinations thereof, although these examples are by no means limiting.

Tex

Tex is a unit of measure for the linear mass density of fibers and is defined as the mass in grams of 1000 linear meters of fibre.

Dtex

The unit code is "tex". The most commonly used unit is actually the decitex, abbreviated to "**dtex**", which is the mass in grams of 10,000 linear meters of fibre. When measuring objects that consist of multiple fibers, the term "filament tex" is sometimes used, referring to the mass in grams of 1,000 linear meters of a single filament. The diameter of a filament can be calculated, given its weight in dtex, with the following formula:

$$\varnothing = \sqrt{\frac{4 \times 10^{-6} \cdot \mathrm{dtex}}{\pi \rho}}$$

where ρ represents the material's density in grams per cubic centimeter and the diameter ø is in cm.

Tex (g/km)	Yield (metres)
550	823
735	617
1100	411
1200	378
2000	229
2200	206
2400	189
4400	103

PVOH (Polyvinyl Alcohol):

A resin formed by polymerizing vinyl acetate and then hydrolysing the resultant polyvinyl acetate. This process is employed for the commercial production of PVOH. Fibers formed from PVOH have been preferred for this invention due to features such as high affinity for water due to the presence of OH groups within the chemical chain of PVOH. It also has excellent mechanical properties because of its high crystallinity and high resistance to chemicals including alkaline and neutral conditions. This is no way a limiting factor.

Hydrophilic PVOH Fiber and Yarns

PVOH fiber is formed by a process of wet spinning an aqueous PVOH solution into a coagulating bath of concentrated aqueous sodium sulphate, followed by formation of the fiber thus spun.

Yarn:

A yarn is formed by spinning fibers in a spun process or by a process of filaments spinning together to form a strand of yarn

Thread:

For the purpose of this invention, thread shall mean one or more yarns twisted together on a twisting machine, in any form such as "S" twist or "Z" twist.

Security Yarn:

For the purpose of this invention, a security yarn is a yarn within which at least one strand is coated with, or impregnated within, one or more security elements, as described herein.

Security Thread:

For the purpose of this invention, a security thread shall mean any kind of security yarn containing at least one hydrophilic film having one or more security elements embedded within it or coated on its surface, and one or more such yarns are then twisted into a thread form in any form such as "S" twist or "Z" twist.

Security Scrim:

A rectangular or criss/cross formation using the security yarn or security thread as described above, to form a scrim with voids in between, for enabling an efficient dewatering process as required during the production of security paper.

PCR:

Polymerase Chain Reaction

Security Level 1, 2, 3 and 4:

Level 1 is an overt feature, which is citizen friendly and does not need any reader or light source. Level 2 is a feature which needs a light source which is easily available in the market like long wave UV light. Level 3 is a security feature which need a specific energy source , like but not limited to IR, short wave UV, up converters reader or a machine friendly high speed reader. Level 4 is a forensic security features, which need sophisticated, complex and custom based software with multiple pin codes, to irrevocably verify and certify the particular feature and the variable code hidden in the feature, like a complex DNA taggants, with unique pin code.

Use of Hydrophilic Security Thread in Security Papers

Security Paper, such as bank note paper, fiduciary paper, passport paper or visa paper, has seen continuous development due to the need to keep one step ahead of fraudsters.

The simple rule in security paper manufacture is "what you see is easy to copy". In recent years, various novel overt and covert security features have been introduced including those derived from rare earth materials, phosphors, fluorescent particles, synthetic DNA taggants with or without keys for identifying the primers to decode the DNA/taggant sequence, RFID based solutions, and machine readable features. However, inserting these satisfactorily within a security paper or within a web of such pulp has been a challenge. Furthermore, ensuring that a precise dosage, often required to ensure perfect verification, is included within each bank note and even further, at a pre-determined location within each bank note for subsequent automatic//PCR/computer detection (known as "in register") has been a challenge for security paper makers.

Another challenge foreseen by security paper manufacturers is cross contamination during the period of change from one denomination to another or during the change of specification of paper from one country's banknote paper to another. When taggants containing, for example, nano particles or DNA, are mixed in the pulp slurry or in the slice (pulp delivery unit), minute amounts of nano particles or DNA may contaminate the next batch of production, creating major security issues.

Another challenge is the cost and accountability of these taggants. During dewatering, taggants may be found in the water effluent system and in any reservoir of recycled water,

which not only may contaminate the next production cycle and create contaminated waste product but is a waste of a valuable element. It may also create environmental problems if water is released into the ground.

Various materials and methods have been used to provide a mechanism capable of delivering a security feature such as security nano particles at a precise location, in such a way that its presence can be subsequently identified online as the security paper is being produced, during printing of the security paper, and then offline by end users (2^{nd} level security) and by central banks, using forensic techniques to detect fraud.

PVOH security threads have been used as a novel method of so doing as have been previously described in patent applications.

Our invention is to coat each yarn with an overt and/or covert and/or a forensic level 4 machine confirmable feature (as a PCR can undeniably confirm a feature). All yarns according to the present invention, being hydrophilic, will adhere to the wet pulp and so do not require an external coating of adhesive.

Our invention comprises embedding or coating of a security feature within or upon the yarn and then either inserting the single strand of yarn (in case of a single security feature yarn) or twisting several strands of yarn into a thread, in case of a multiple security feature yarn (as shown in the experiments). In this way, a security paper can contain multiple security features within a single carrier yarn or thread. The materials of the yarn and thread being hydrophilic, their outer surfaces will provide a bonding adhesive during the process of wet pulp and then revert substantially to their original form, as the pulp bed goes through the dryers.

Hydrophilic threads and yarns made from various materials, including soluble polymers such as those based substantially upon poly-vinyl alcohol (PVOH), are well known to the industry. Such threads and yarns have been employed for applications such as garments, fish nets, stitching, roofing, and concrete strengthening. However, the use of such hydrophilic threads and yarns as disclosed herein has hitherto not been explored.

The invention describes how a yarn having hydrophilic properties, dissolving, at least in part, at temperatures above those encountered in paper making, has been used to include a precise dose of one of more security feature(s), and thereafter becomes embedded within a security paper. In case of bank notes, for example, the invention can be used to embed security features which can be identified during the paper making process, during the printing process, and during dispensing, as well as thereafter by citizens (first and second level security) and by security agencies using forensic instruments. In some cases, such as, but not limited to, DNA sequencing, a security feature can be registered with International security organizations such as Interpol and the Financial Action Task Force (FATF) or any such body or judiciary, so as to give legally verifiable proof of the origin of the security paper and/or the banknote. The carrier yarn or thread material, being hydrophilic, is preferred due to its characteristic high affinity for water, such as can be found for example in high molecular value PVOH. This

enables the yarn or thread of this invention to carry efficiently one or more security features in precise dosage and to deliver them, as per a registered design, as an embedded thread within the security paper.

The excellent mechanical properties of substantially PVOH based yarns and threads, their high crystallinity, their enhanced resistance to chemical damage, including to alkali materials such as surfactants used in paper making and detergents used in fabric washing, have not hitherto been exploited for security purposes.

Hydrophilic threads and yarns made from various materials, including PVOH, are well known to the industry. The said thread has been used for many uses such as garments, fish nets, stitching, roofing, and concrete strengthening. However, the use of a hydrophilic thread or yarn, as described in the present invention has not hitherto been explored.

Description of Invention

The invention describes the security coating of each yarn and the twisting together of the yarns to include thereby multiple security features and subsequently to embed the security yarn so produced between two layers of pulp web during the process of paper making.

The invention demonstrates a solution for the disadvantages of the previous film based security threads. The polyester and polypropylene threads as described in earlier patent applications by De La Rue and Giesecke & Devrient , need an external coating of adhesive on one or both sides so as to enable adherence to the pulp webs. But this method restricts delivery of many types of security features, for example lenticular security features, as shown in "Motion" thread of Crane, get's restricted, if an adhesive coating is done on the lenticels sides (as it gets filled in with the adhesives), and if the thread is not coated with adhesive, then the same can be cleanly removed (due to bad adhesion to pulp/paper).

Our invention shows that the hydrophilic properties of a hot water soluble yarn and threads made substantially therefrom, will provide an adhesivated outer surface for the purpose of bonding, taking advantage of the amount of water near the VAT mould, and yet return substantially to its original form, as it passes through the driers during the paper making process, due to heat and pressure, as well as being utilized as a carrier for the security features.

Objectives of Invention

The primary objective of the invention is to produce a high security paper having a security coated hydrophilic yarn, suitable for insertion between two pulp webs of a security paper during the process of paper making. The two such webs are typically produced on what is known as a long former and a short former.

Another embodiment is to combine one or more strand of polypropylene (PP) or polyester or nylon yarn along with a hydrophilic yarn, wherein the polypropylene or polyester or nylon yarn (non-hydrophilic yarns) will provide strength and carry the hydrophilic yarn for placement at a discreet location, within two layers of pulp. The non-hydrophilic yarn may be optionally coated with security elements for subsequent verification by forensic methods.

Another embodiment is to produce such a security coated hydrophilic yarn so as to ensure it is properly embedded within the two pulp webs by the end of the manufacturing process of the paper.

Another embodiment is to provide security elements embedded at the polymer stage and the fibers and /or yarn are extruded with the security elements contained therein providing, but not limited to, machine readable features.

Another embodiment is to produce such a security coated hydrophilic yarn which becomes tacky (gaining adhesion) when wet and yet regains its non tacky properties by the end of the manufacturing process of the paper.

Yet another embodiment is to produce a security coated hydrophilic yarn which carries specified security features within it or upon it during insertion or embedding between two pulp webs during the formation of a security paper.

Yet another embodiment is to produce a security web of scrim (waft and warp of two or more yarns or threads) using such security coated hydrophilic yarn, or thread, which carries specific security features along with it, during insertion or embedding into web of pulp, during the formation of paper.

Yet another embodiment is to verify the specific security features of the security yarn/thread, on line during the process of paper making.

Yet another embodiment is to verify the specific security features of the security yarn/thread, off line after the process of paper making.

Yet another embodiment is to verify the specific security features of the security yarn/thread, off line after the process of paper making and after the process of printing each unit, for example each bank note, so as to identify the individual bank note paper manufacturer, printer of the bank note and the region or the country of manufacture.

Yet another embodiment is to make use of multiple delivery of security features, using a thread made by twisting of specific security feature of one yarn to one of more security coated hydrophilic yarns, and then inserting such a thread into two webs of pulp to make a final security paper.

In one of the embodiments, a water-soluble film made substantially from high molecular weight PVOH (more than 90 degree hydrolysis) was selected and slit into strands of approximately 5 to 9 mm web width and then each such strand was twisted into yarns and threads, thus retaining the properties of hydrophilic adhesion to pulp webs, and delivery of

one or more security features, while overcoming the curling problems sometimes encountered in single layer hydrophilic films.

Yet another embodiment is manufacturing high security bank note paper by inserting such a thread or multiple yarns or a scrim using multiple security features, in between two webs of pulp to make a final security paper.

One more embodiment of this invention is to precisely verify various levels of overt/covert security features using matching readers and electronic and/or computer software as needed by various levels of security features.

Another embodiment is to mix nano particles such as DNA taggants which are difficult to verify in milliseconds (a time interval often needed by paper mills and online coating processes), into more robust and online machine verfiable security features, like first level UV features, to ensure the presence of such nano particles, when measured in forensic labs.

Another embodiment is to mix DNA taggants into micro-spheres, for online verification and amplification, as level 2 security, which does not contrast with common first level features, in common use at present.

One more embodiment is to mix PCR readable taggants like DNA taggants or polarized taggants, for example, with level 3 security features, like X- Ray machine readable taggants, which enables constant quality control, during process of yarn, thread and paper manufacturing.

One more embodiment is to mix PCR readable taggants like DNA taggants or polarized taggants, for example, with level 3 security features, like machine readable taggants, which emit audible values, which enables constant quality control, during process of yarn, thread and paper manufacturing.

One more embodiment is to mix PCR readable taggants like DNA taggants or polarized taggants, for example, with level 3 security features, like machine readable magnetic coatings, which enables constant quality control, as per coded signals, during process of yarn, thread and paper manufacturing.

Yet another embodiment is to ensure that the security yarn or thread is embedded within two layers of a pulp web in such a way that it is impossible to extract the feature or the carrier thread/yarn, without destroying the paper.

Summary of Invention

Inventive Steps

Delivery of security feature or features using a security hydrophilic yarn is not known to the security paper industry.

Delivery of non compatible security features, using one carrier, have not been known before. Using the present invention, a security paper manufacturer can deliver multiple security, in precise measurable dosages, in pre-register form in a given sheet layout, using different types of security coated yarns twisted into one thread and embodying this thread into the layers of pulp, during the paper making process.

Delivery of non compatible security features, using one carrier, have not been known before. Using the invention, a security paper manufacturer can now deliver multiple security, in precise measurable dosages, in pre-register form in a given sheet layout, using different types of securitty coated yarns or threads made into a scrim and delivering this scrim within the layers of pulp.

Security fibers have been known, but they are inevitably wasted in the pulp and waste/effluent water. Some security features are hazardous to the environment and flora and fauna.

Most DNA and nano particle based security features have a unique problem of cross-contamination. In the field of security paper, this is a major issue, as one country's security feature must not be detected in another currency, for example. This uncontrolled contamination can create long term problems to paper mills as well as to bank note security printers.

Delivery of security features using a hydrophilic film has its own problems of creasing and twisting during insertion. A hydrophilic film tends to gain elasticity in humid conditions (relative humidity can exceed 90% near the VAT mold), thus creating creases in the paper. Also, paper making machines run at very high speeds and may need long jointless micro tapes of hydrophilic film. This can be a challenge for the manufacturers of such films. The strength of such a narrow film is also an issue on high speed machines, whereas a hydrophilic yarn may be provided in long linear lengths and be wound in traverse wound bobbins of specific linear lengths as specified by paper makers. These problems are all avoided by using the present invention.

Scrims using different security features is easily possible using our invention, and yarn manufacturers are used to converting yarns/thread into scrims. This gives added strength to the paper, while allowing unhindered dewatering process.

Twisting of yarns into threads and thereby delivering multiple security features in one operation is possible using the present invention.

PVOH fibre has unique properties such as high tenacity, low elongation, high modulus, high alkali resistance, and high UV resistance etc., and is used as an industrial material. PVOH filament yarn and spun yarn are used for reinforcing of rubber hose for automobile and industrial uses, such as in civil materials, and in ropes. Its demand is increasing.

Experiments:

Raw Materials:

Hot water soluble Mewlon® yarn,
Optionally twisted into a fine thread
Binders
Security features
Winding cones

Experiment I

1. We took a cone (1)containing 10,000 linear meters of Mewlon® PVOH yarn.
2. We coated this strand of yarn with a solution(2) containing formulation A.
3. We dried the coated yarn(5a). The drier had hot air blowing at a temperature from 90°C to 120°C.
4. The dried coated yarn labelled "YA" was wound on a wide spoked wheel(5b)(Fig1)
5. After drying, the yarn was finished on a traverse winding machine.
6. We took this traverse wound cone (7) into a handmade paper making unit.
7. We cast a bed of pulp (11), mimicking a long former(9) VAT mold unit.
8. We squeezed the water to form a semi dry paper bed.
9. We laid an exact piece of yarn from step 5 and placed it in a precise location.
10. We cast another layer of pulp bed (mimicking a short former (8) of a VAT mould machine
11. We pressed the yarn and both the pulp beds together in order to squeeze out excess water.
12. The paper-pulp structure as received from step 11 was dried in a plate drier, having temperature range of about 120°C for 3 minutes, mimicking a hot steel cylinder in a paper making machine.

Experiment II

1. We took a cone (1)containing 10,000 meters of Mewlon® PVOH yarn.
2. We coated this strand of yarn with a solution (2)containing formulation B.
3. We dried the coated yarn. The drier had hot air (4) blowing at a temperature from 90°C to 120°C. The dried yarn was labelled "YB".
4. The dried coated yarn (5a) was wound on a wide spoked wheel(5b). The drier had hot air blowing at a temperature from 90°C to 120°C.(Fig-1)
5. We took 100 meters of yarn from Experiment I and placed them near the twisting machine,
6. The two yarns were twisted together on a yarn twisting machine to get two different types of security features on one thread "TC"
7. After twisting the yarns, the thread "TC" was put on a traverse winding machine.

8. We took this traverse wound thread "TC" on a cone (7) into a hand made paper making unit.
9. We cast a bed of pulp(11) (mimicking a long former (9)VAT mould unit)
10. We squeezed the water to form a semi dry paper bed.
11. We laid an exact piece of thread "TC", from step 7, and placed it in a precise location.
12. We cast another layer of pulp bed (mimicking a short former (8) of a VAT mould machine.
13. We pressed the thread "TC" and both the pulp beds together, to squeeze out excess water.
14. The paper-pulp structure as received from step 13, was dried in a plate drier, having temperature range of from 90°C to 120°C for 3 minutes, mimicking a hot steel cylinder in a paper machine.
15. Similarly, we did multiple yarns having multiple number of security features intertwined into a security thread, and made different types of security papers.

Experiment III

1. We took a cone(1) containing 10,000 linear meters of yarn.
2. We coated this strand of yarn with a solution (2) containing formulation B.
3. We dried the coated yarn, The drier had hot air(4) blowing at a temperature ranging from 90°C to 120°C. The dried yarn was labelled "YB"
4. The dried yarn (5a) YB was wound on a wide spoked wheel(5b). The drier had hot air blowing at a temperature ranging from 90°C to 120°C.(Fig-1)
5. We took 100 meters of yarn from Experiment I, and placed them near the twisting machine.
6. °The two yarns were twisted together, on a yarn twisting machine to get two different types of security features on one thread "TC"
7. After twisting the yarns the thread "TC" was put on a traverse winding machine.
8. We took this traverse wound thread "TC" on a cone(7) into a hand made paper making unit
9. We cast a bed of pulp(11) (mimicking a long former (9)VAT mould unit)
10. We squeezed the water to form a semi dry paper bed.
11. We laid an exact piece of thread "TC", from step 8, and placed it in a precise location.
12. We cast another layer of pulp bed (mimicking a short former(8) of a VAT mould machine
13. We pressed the thread "TC" and both the pulp beds together, to squeeze out excess water
14. The paper-pulp structure as received from step 13 was dried in a plate drier, having a temperature range of from 120C to 150 C, for 3 minutes (mimicking a hot steel cyliner in a paper machine

15. We cut these papers into different shapes, as per a pre-determined design layout, and then proceeded to our Security verification lab.

The security features as mentioned in formulations A, B, and C were verified and compared to the input verifications in a Security Lab, using the specified readers.

The results were found to be as shown below:

Security Feature	Experiment I	Experiment II	Experiment III	Experiment IV*	Experiment V**
Invisible UV Pigment (Red)	Seen bright red under UV lamp 365 nm, on both sides of paper		Observed criss-crosses of UV red and UV yellow in thread		Observed criss-crosses of UV red and UV yellow in thread
Invisible Flour Pigment (Yellow-Green)		Seen bright red under UV lamp 365 nm, on both sides of paper			
Invisible UV Pigment (Red) with DNA Taggant				Seen bright red under UV lamp 365 nm, on both sides of paper.	

* Test for extraction of DNA sequence was done by DNA taggant supplier using a PCR. Presence of the same sequence of DNA was reported in the red yarn in experiment IV

** Test for extraction of DNA sequence was done by DNA taggant supplier using a PCR. Presence of the same sequence of DNA was reported in the red yarn, and some migration of DNA was also reported in the yellow yarn, which may have been due to hydrophilic bonding of the two yarns and the DNA molecules during the process of paper making.

Formulation A

1. Take 1000 mls of water and heat to 95°C

2. Mix slowly, while stirring, 100 gms PVOH 173 (hot water soluble, mole value >90) and 100 gms of PVOH GH 17R (cold water soluble fully hydrolysed), stir for 2 hours until all PVOH resin has dissolved to form a clear solution
3. Mix 2 gms of Honeywell CD 105 into 50 ml of ethanol
4. Add and disperse slowly, while stirring, the solution received from step 3 and mix into the solution mixture of step 2.
5. Use this formulation to coat yarn for experiment I

Formulation B

1. Take 1000 ml of water and heat to 95°C
2. Mix slowly, while stirring, 100 gms PVOH 173 (hot water soluble, mole value >90) and 100 gms of PVOH GH 17R (cold water soluble fully hydrolysed). Stir until all PVOH resin has dissolved to form a clear solution
3. Mix 20 ml Sicpa Ink 803000C, invisible to yellow-green, into 200 ml of water
4. Add and disperse slowly, while stirring, the solution received from step 3 into the solution mixture of step 2.
5. Use this formulation to coat yarn for experiment II

Check both solutions individually under UV lamp of 365 nanometers (long wave UV lamp).

Formulation C

1. Take 1000 ml of water and heat to 95°C
2. Mix slowly, while stirring, 200 gms PVOH 173 (hot water PVOH, mole value >90). Stir for 2 hours until all PVOH resin has dissolved to form a clear solution.
3. Mix 20 ml Sicpa Ink 803000C, invisible to yellow-green, into 200 ml of water.
4. Add 1 ml of DNA taggant, as received from Tracetag UK, into 250 ml of distilled water
5. Add and disperse DNA solution as received from step 4, while stirring, into the solution received from step 3
6. Mix the solution as received from step 5 into solution received from step 2 to form a homogenous solution. Check with long wave UV lamp to see that the clear/hazy solution shows red colour
7. Use this formulation to coat yarn for experiment IV
8. Check the coated thread under long wave UV lamp to demonstrate red colour
9. Dissolve the thread in hot water to check the presence of DNA taggants, using a PCR method and appropriate computer software.

Process of coating of PVOH yarn employed during the experiments:

A drawing of yarn coating has been enclosed.

WE CLAIM:

1. A security yarn made substantially from hydrophilic resins and coated or impregnated with hydrophilic materials or a combination of hydrophobic and hydrophilic materials with one or more security features.
2. Coating medium, as claimed in claim 1 shall comprise of binders like polyvinyl alcohol (PVOH), guar gum, gelatin, carboxy-methyl cellulose (CMC), acrylic polymers, polyvinyl acetate (PVOHC).
3. A security thread made by twisting one or more yarns according to claim 1, coated with one or more security features, and twisted in "S" twist or "Z" Twist.
4. A security thread made by twisting one or more yarns according to claim 1, coated with one or more compatible or non compatible security features, and twisted in "S" twist or "Z" twist.
5. A security scrim formed by interweaving security yarns or threads according to any preceding claim in a warp and weft design.
6. A security paper incorporating a security yarn, thread or scrim according to any preceding claim.
7. A security paper according to claim 5 wherein security features are coated on one or more yarns and such yarns inserted between layers of pulp, during the process of paper manufacturing.
8. Security features as mentioned in any preceding claim, comprising overt, covert and machine readable features.
9. Security features as mentioned in any preceding claim, wherein matching readers and electronic and/or computer software is used to verify overt and/or covert security features.
10. Security features as mentioned in any preceding claim, comprising nano particles, whose presence may be detected in milliseconds, into robust and online machine verifiable security features.
11. Security features as mentioned in any preceding claim, comprising DNA taggants and micro-spheres for online verification and amplification, as a higher level security
12. Security features as mentioned in any preceding claim, comprising mixing PCR readable taggants or polarized taggants with level 3 security features like X- Ray machine readable taggants, thereby enabling continuous in-line quality control during insertion of security yarn or thread into a security paper.

13. Security features as mentioned in any preceding claim, comprising mixing PCR readable taggants with level 3 security features which emit audible values, thereby enabling continuous in-line quality control during insertion of yarn or thread into a security paper.

14. Security features as mentioned in any preceding claim, comprising mixing PCR readable taggants with level 3 security features, like machine readable magnetic coatings, thereby enabling continuous in-line quality control during insertion of yarn or thread into a security paper, as per coded signals.

15. A security paper substantially as herein described.

16. Security yarns and/or threads substantially as herein described.

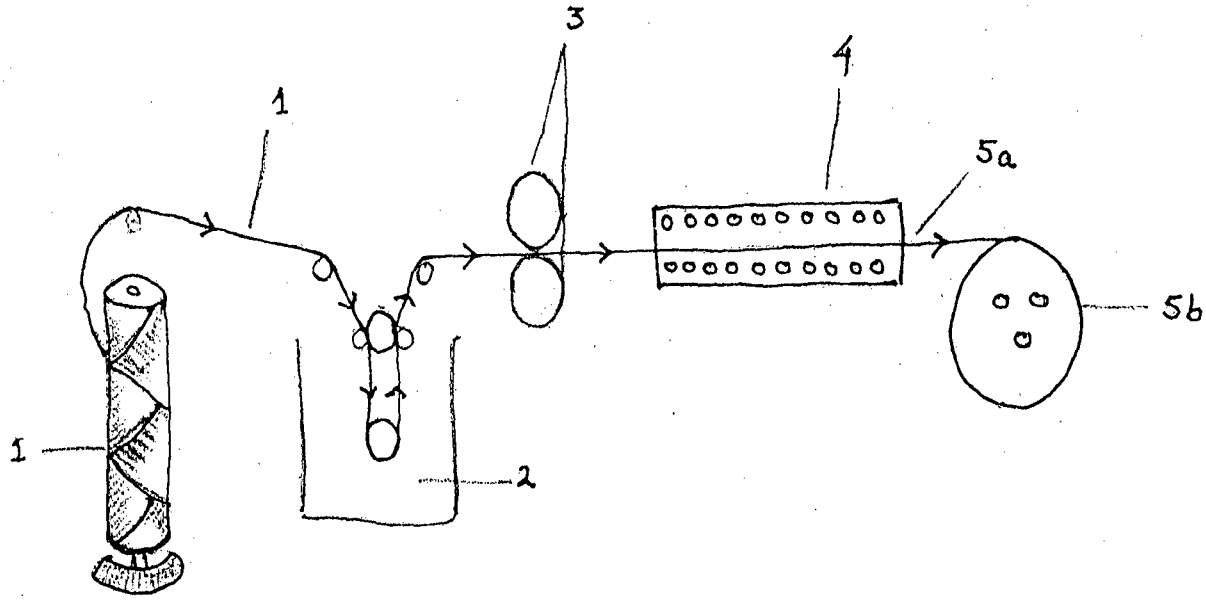

FIG 1

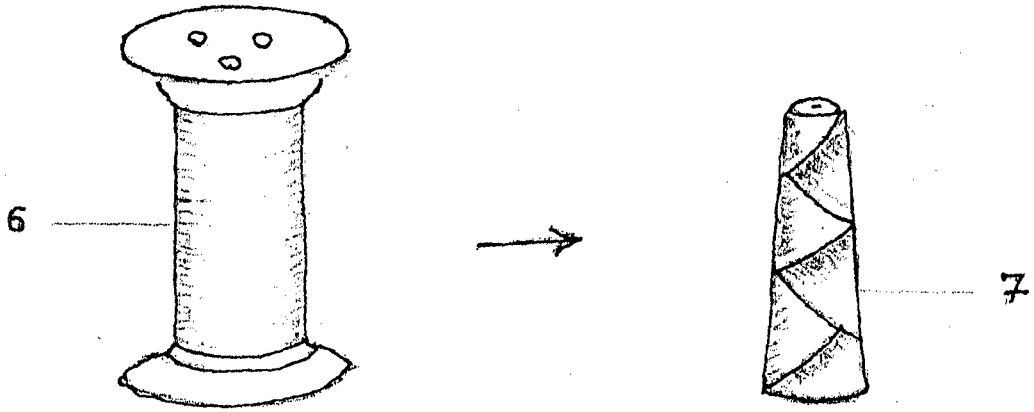

FIG 2

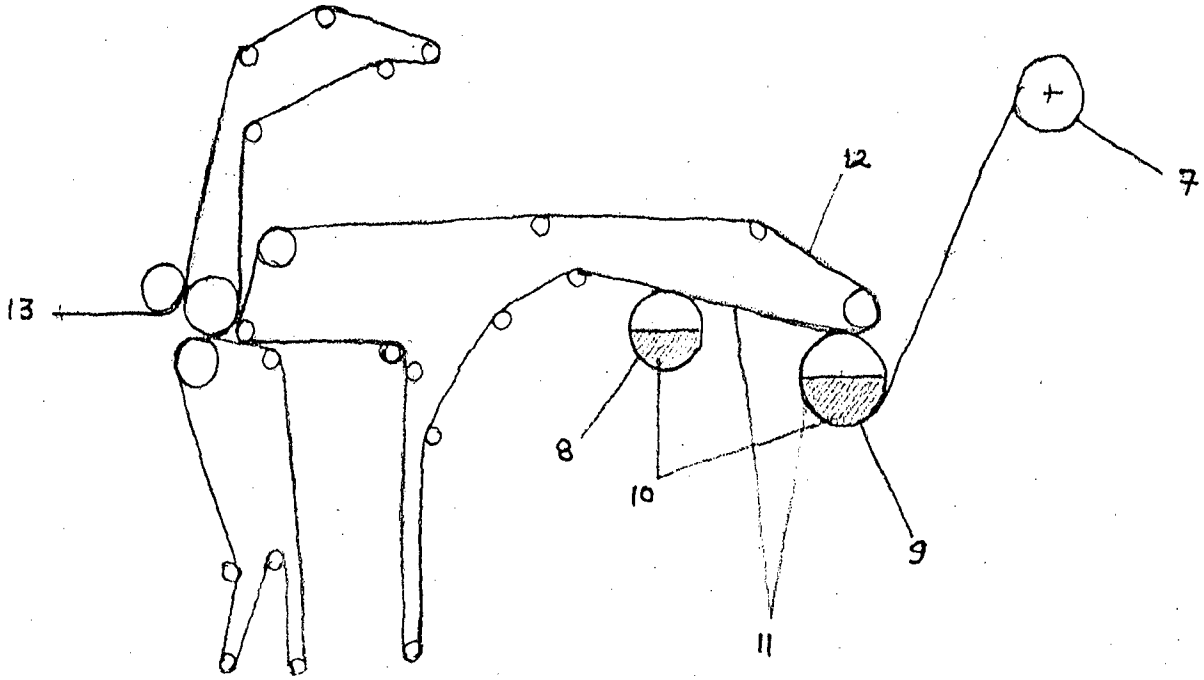

FIG 3