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UK CL (Edition X) **H4L**
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(54) Abstract Title: **Indicating device and method using triboelectric properties**

(57) An electrostatic charge indicating device comprises a plurality of conductive particles of predetermined dimensions suspended in substantially fixed positions, and in intimate contact with, a material (3) which exhibits a triboelectric property to define a triboelectric indicator. Electrostatic charge built up on the material with the triboelectric property will discharge through the conductive particles in response to a suitable action, the discharge generating a RF signal which can be detected.

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Fig.1.

More Positive	Dry Human Skin	*Materials more likely to give up electrons*
	Leather	
	Glass	
	Human Hair	
	Nylon	
	Wool	
	Lead	
	Silk	
	Aluminium	
	Paper	
	Cotton	
	Steel	
	Wood	
	Amber	
	Hard Rubber	
	Nickel Copper	
	Brass, Silver	
	Gold, Platinum	
	Polyester	
	Styrene	
	Saran Wrap	
	Polyurethane	
	Polyethylene	
	Polypropylene	
	Vinyl	
	Silicon	
More Negative	Teflon	*Materials more likely to take up electrons*

Fig.2.

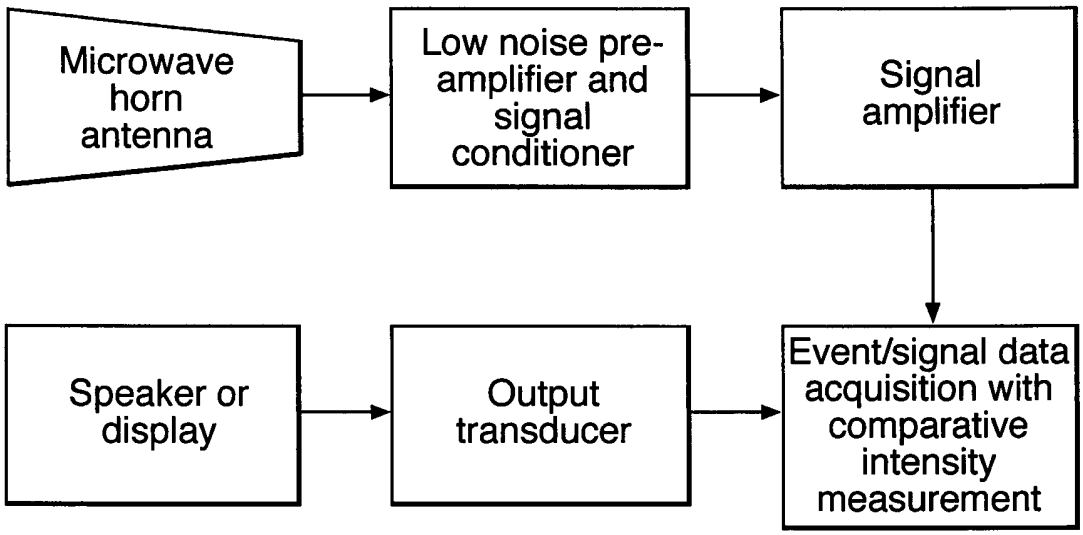

Microwave horn antenna
Low noise pre-amplifier and signal conditioner
Signal amplifier
Speaker or display
Output transducer
Event/signal data acquisition with comparative intensity measurement

Fig.3.

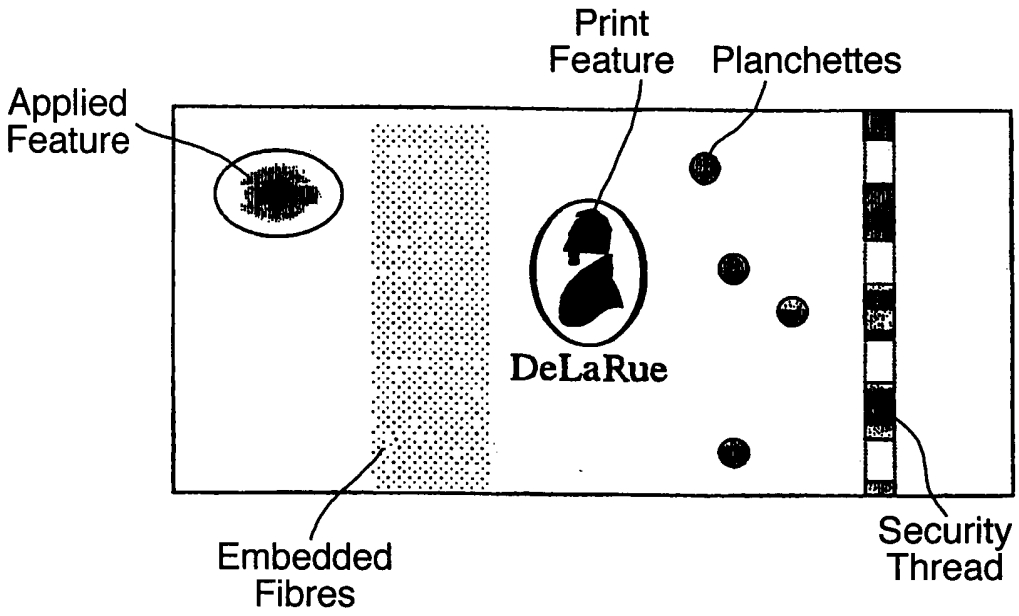

Print
Feature
Planchettes
Applied
Feature
DeLaRue
Embedded
Fibres
Security
Thread

Fig.4.

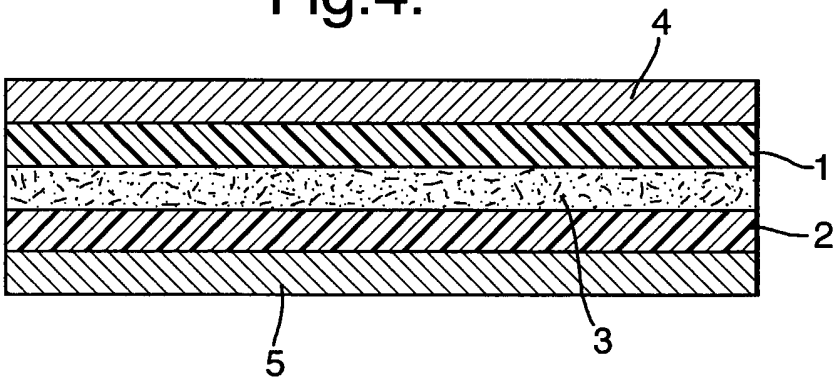

4
1
2
3
5

Fig.5.

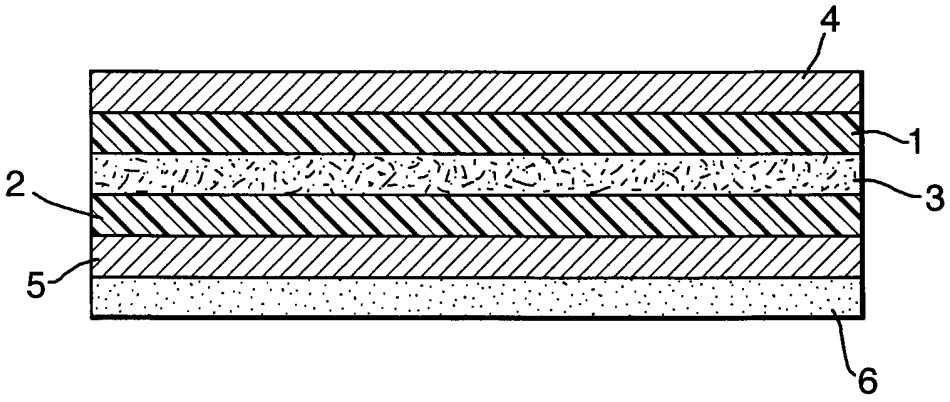


Fig.6.

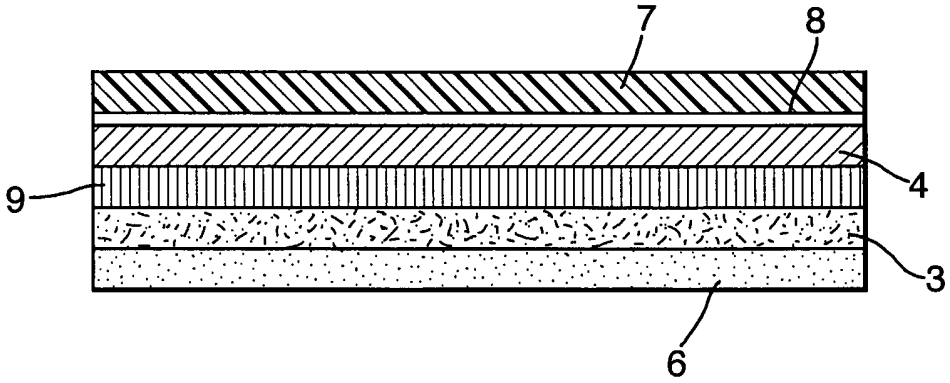


Fig.7.

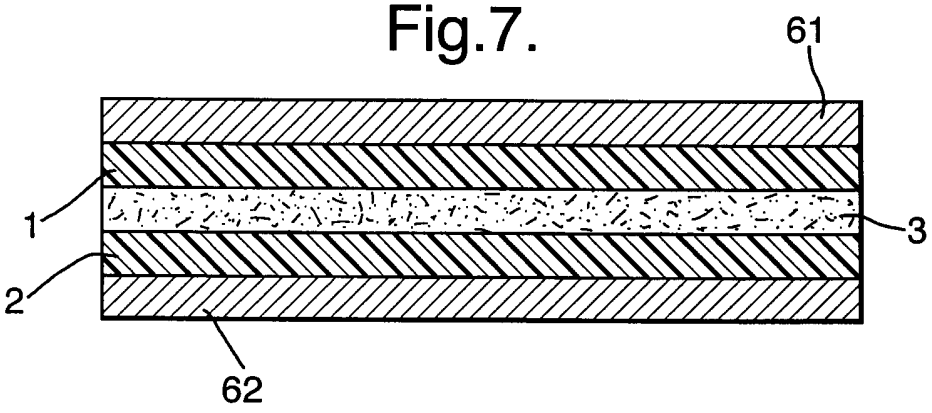


Fig.8.

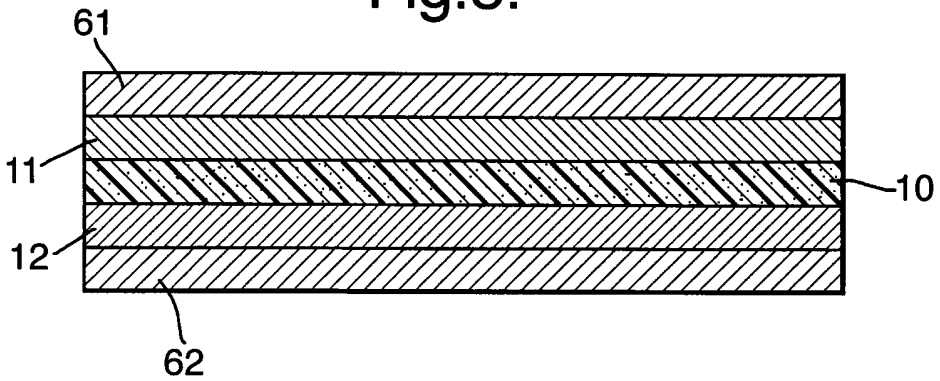


Fig.9.

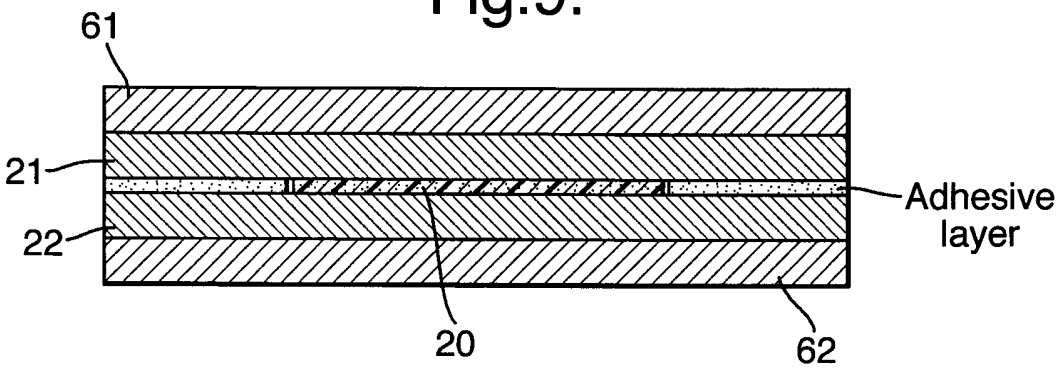


Fig.10.

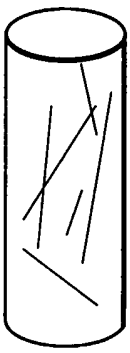


Fig.11.

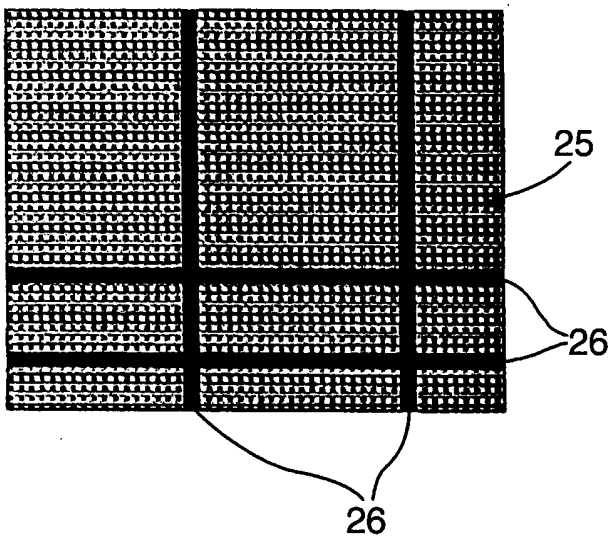


Fig.12.

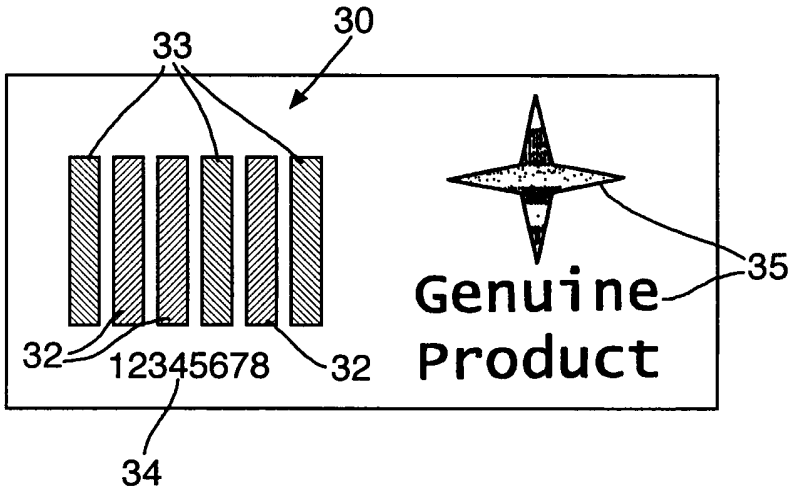


Fig.13.

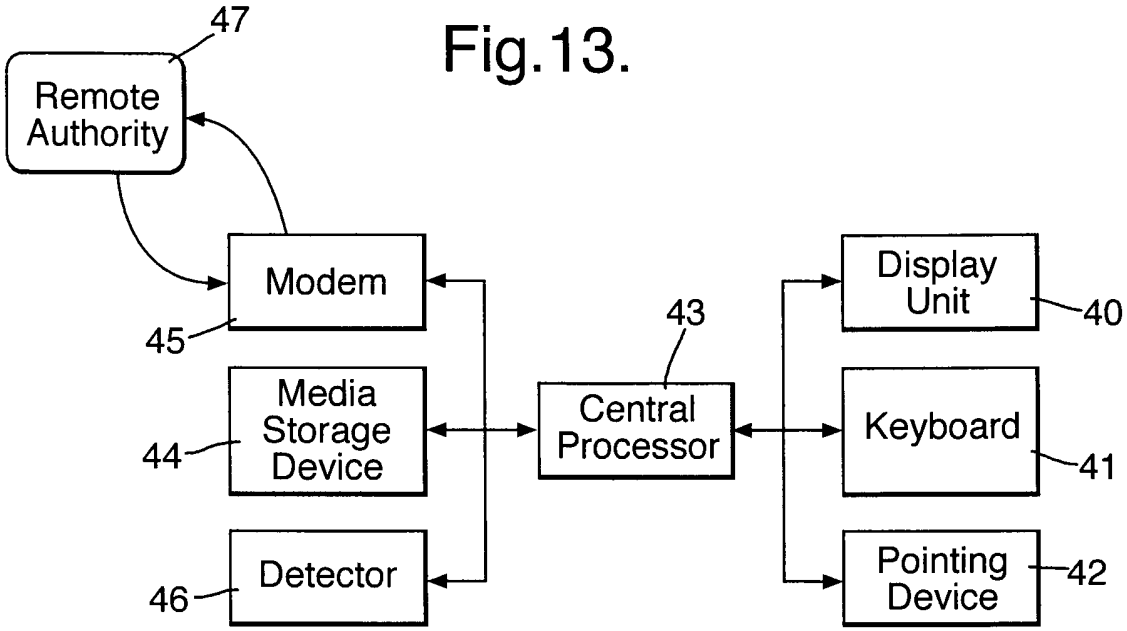
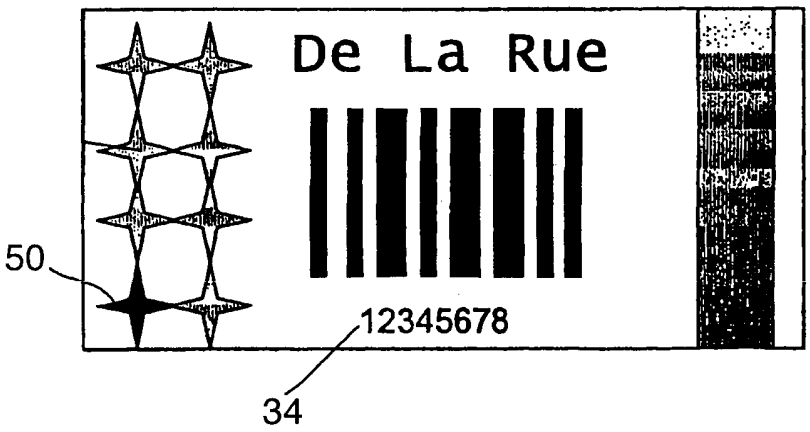

47
Remote Authority
Modem
45
Media Storage Device
44
Detector
46
43
Central Processor
Display Unit
40
Keyboard
41
Pointing Device
42

Fig.14.


De La Rue
12345678
50
34

INDICATING DEVICE AND METHOD

The current invention is concerned with an indicating device, for example for authentication of security documents and articles of value.

It is known to provide security documents and articles with various means to enable their detection. Such approaches included luminescent print workings, magnetic features, conductive features, embedded threads, fibres, planchettes all of which have been widely described within the prior art. Such approaches are used extensively and provide effective methods for detecting documents. However there is a need to remain one step ahead of those who seek to reproduce documents and articles for fraudulent and illegal gains.

In addition to this there is a constant need to simplify the detection process so untrained personal can easily and confidently make decisions as to the authenticity of a document or article. Many of the approaches described above require expensive machinery to allow detection or require the person doing the authentication to make a judgement of sorts. It would be desirable to provide a detectable feature that can both be authenticated rapidly and unambiguously by those that are relatively unskilled in inspecting security features.

The current invention is intended for use in many applications including on security documents and articles of value. This includes banknotes, postal stamps, fiscal stamps, vouchers, cheques, bonds, certificates of authenticity, tax documents, passports, identity documents, brand protection uses, security threads, applied security devices, and security labels.

According to a first aspect of the present invention, we provide an electrostatic charge indicating device comprising a plurality of conductive particles of predetermined dimensions suspended in substantially fixed positions, and in intimate contact with, a material which

exhibits a triboelectric property to define a triboelectric indicator such that electrostatic charge built up on the material with the triboelectric property will discharge through the conductive particles in response to a suitable action, the discharge generating a RF signal which can be detected.

We also provide methods for manufacturing indicating devices, articles formed by or including such devices, inks and detection methods.

It has been found that triboelectric effects can be used to provide a secure, rapid and simple device, for example, for detecting security documents. Prior to describing the invention in detail it is of some benefit to understand what is meant by triboelectric and how the effects occur.

A brief yet comprehensive summary of the phenomena can be found at http://www.school-for-champions.com/science/static_materials.htm. The term triboelectric literally means electricity generated by friction. Triboelectricity is the production of electrical charge by the interaction of two materials making and breaking contact. The making and breaking of contact causes the two materials to charge and discharge. This effect is more commonly referred to as static.

Static is not a direct result of friction between two surfaces but by an adhesive interaction at the molecular level. This adhesive interaction results in chemical bonds forming and when these bonds break an imbalance in charge can be left behind. Specifically where the bond is asymmetric (e.g. ionic) breaking it will result in one surface having a positive charge and the other a negative charge. Figure 1 illustrates the triboelectric series and shows materials in order of how likely they are to gain or give up electrical charge from other materials. For the purposes of this document those materials towards the bottom of Figure 1 i.e. those more likely to pick up electrons, are referred to as high TE. Those materials

towards the top of Figure 1, i.e. those more likely to give up electrons are referred to as low TE.

The current invention requires the combination of two materials, firstly a material from (preferably the more negative end of) the triboelectric series (high TE) in combination with closely located conductive fibres or particles e.g. metal, carbon. Here the more negative triboelectric (high TE) material attracts electrons, as a material property, and these electrons are then rapidly discharged through the metal fibres to achieve electric potential uniformity. As a result of the discharge process a current is formed in the fibre and this current has a characteristic radio frequency (RF) emission associated with it. This RF emission can then be detected and used as a means for authentication.

It has been found that low TE materials can also be used in combination with the conducting fibres but high TE materials are preferred. It is thought that the low TE materials work as charge distribution effects still occur, though to a lesser extent than for high TE materials.

A tag and method for detecting a tag employing these phenomena is described in WO03025831A2 assigned to Roke Manor Research Limited. Here a tag is provided comprising a container having therein particles that interact with each other and the container to emit an RF signature that can then be detected. The tag is characterised in that the particles are free to flow and move over each other. Such an approach is suitable for many applications but is not appropriate for the application with which we are concerned such as security documents.

The current invention relies on the surprising discovery that the triboelectric effects described can still be observed when the conductive particles are suspended in one of the high TE materials such that they cannot move freely. Consequently it has been found that substrates, inks, threads and applied devices can be produced that demonstrate the triboelectric effects

described earlier. The features according to the current invention can be made to emit an RF signal by impact, rubbing, flexing or stroking. It has also been found that they are particular effective if two areas containing a suitable material are rubbed together. These features may be located on the same carrier or on different carriers. If they are both present on a document the document may be folded over on itself. If present on two different carriers the two carriers can be rubbed together.

It has been found that large scale movement of the conductive metal particles in a polymer container, though beneficial, is not necessary as taught by WO03025831A2. For example it has been found that metal fibres or particles can be laminated between two layers of PVC such that they are no longer mobile and the effect can still be observed. The effect can be explained, in this case, by the fact that the insulators (PVC layers) when triboelectrically charged will not have not have a fully uniform charge distribution. Their high electrical Ohmic resistance value prevents it. Nonetheless, simple mechanical flexing of the PVC will encourage the movement of this non uniform charge potential some of which will then transfer to the metal fibres laminated between the two PVC layers. The excess charge then rapidly discharges and results in the characteristic RF emission as before. It has also been found that by selecting the type, length and size of the metal fibres some control can be imparted on the frequency of the RF emission. This in turn leads to the possibility of differentiation or coding.

It has been found that the emission signal can be controlled to some extent. There is limited opportunity to control the rate of discharge, typically 0.1ns at a power of 100mW effective radiated power. Nonetheless the frequency and intensity of the emission can be controlled.

The frequency can be controlled by controlling the effective resonant length of the fibres. That is fibres of equal length and dimension prepared in a uniform and unbent

or curved manner, such that they resemble straight rods, will result in emission frequencies of preferred frequency or frequencies. If the fibres are allowed to be of inconsistent length, dimension or if they are tangled, bent or otherwise non uniform in length, then a broad band frequency emission will result. It is preferred that the emission frequency spectra be as sharp as possible. It is also thought that the ability to control the resonant length of fibres allows for a sharper pulse width. It is preferred that the pulse width be as sharp as possible. However this requires the use of rigid rod like fibres which is not always compatible with production issues. There is consequently a compromise between pulse width and manufacturing capability.

The intensity of the emission is directly correlated to the number of fibres present. A higher concentration of fibres results in a greater signal intensity. The more fibres that are present the greater the number of charge dissipation events so the larger the amount of RF given off.

Either the frequency or intensity of emission could be used for authentication or coding purposes. Alternatively a more complex system might use a combination of both intensity and frequency.

So it is possible to interrogate devices according to the invention at three different levels dependent upon user requirements. A simple threshold detection set up can determine a simple yes/no presence. In this example the mere presence of the feature would be sufficient to trigger a response from a detector providing a signal threshold is reached.

A higher level of discriminatory authentication can be achieved by looking both for presence and interrogating the nature of the emission. That is by looking at the intensity or frequency of the emission it is possible to differentiate between emissions.

Finally coding is possible by providing a mixture of two or more lengths of conductive fibre to provide multiple frequency responses. As an alternative a barcode like structure can be produced. Such a structure will be described in detail later in this document.

Thus far we have described the principles behind the generation of the triboelectric RF emission. It is also important to understand a little about how the emission is detected. It has been found that the peak in the RF emission spectra is approximately one half wave resonance for the particles and fibres under consideration here. That is frequencies in the range 1 to 100 GHz and higher. Nonetheless the peak in the emission spectra is accompanied by a broader band emission, which can be inexpensively and simply detected by a relatively monochromatic but high sensitivity detector, tuned to detect RF emission in the frequency range 11-12 GHz.

Figure 2 illustrates a suitable detection arrangement for the current invention. The detector arrangement consists of a standard detection system design that will be familiar to those skilled in the art. At the frequencies of interest here, that is in the microwave range, a detector horn or similar is used to concentrate emitted radiation into a low noise detector head and pre-amplifier. This detector head and preamplifier can be tuned to detect frequencies within a specific range if required. The relatively low intensity signal detected is then conditioned into a form suitable for further amplification by conventional means into a signal for use in a comparator circuit. This comparator circuit is used to discriminate real signals from background noise. The output from the comparator circuit is then used to switch a transducer output, such as a light, buzzer or other similar device that will indicate to the user of successful detection of RF radiation of interest.

The invention will now be described in more detail by way of examples and by reference to the following Figures, in which:-

Figure 1 illustrates the triboelectric series with showing materials and their relative affinity for electrons;

Figure 2 shows a schematic diagram of a detector assembly;

Figure 3 shows a security document comprising an example of a device according to the invention;

Figure 4 shows a cross section of a security thread including a device according to the invention;

Figure 5 shows a cross section of a tear tape construction according to the current invention;

Figure 6 shows a transfer foil according to the current invention;

Figure 7 shows a laminated polymer substrate suitable for identity cards or other security document applications;

Figure 8 shows an extruded polymer substrate suitable for identity cards or other security document applications;

Figure 9 shows how the invention might be incorporated into a front or back page of a passport;

Figure 10 shows a stitching thread could be used for stitching passport pages into a passport book;

Figure 11 shows a woven fabric designed to demonstrate an effect in accordance with the current invention;

Figure 12 shows how a barcode like structure could be provided using the current invention;

Figure 13 shows a first application of the current invention in the context of the authentication of computer software; and,

Figure 14 shows a label for a software product suitable for detection according to the current invention.

Figure 3 illustrates how the current invention might be used on a security document or label application. The invention might be applied or included in the document either during the formation of a substrate or during one of

the subsequent conversion processes. The invention may be included during the process as an embedded or partially embedded feature such as a thread, fibre, planchette or aperture type feature. Alternatively a conversion process such as lamination, applying a foil stripe or patch, a printing process or coating process may add to the invention. As a further alternative the substrate for the document may itself function according to the invention. This is particularly the case where the substrate is laminated, extruded or cast in some way.

A first example of the invention will now be described in more detail with reference to Figure 4. Figure 4 shows an example cross-section through a security thread according to an example of the invention. Here two polymer layers 1,2 are laminated together using a laminating adhesive 3 containing metallic fibres. Security threads are typically produced using polyester and though applicable here it is preferred that bi-axially orientated polypropylene (BOPP) is used as it is a higher TE material than polyester. Other polymer high TE substrates can also be used but BOPP is preferred as it is known that its mechanical properties are suitable for the manufacturing processes commonly involved in security thread production. In the current example two 20μm BOPP polymer layers 1,2 (e.g. Trespaphan GND20 film) are laminated together using a suitable pressure or heat sensitive adhesive 3 containing the conductive fibres. In this example 10% by weight of fibres were added to the adhesive. In this preferred example steel fibres were used having an average length of 5mm and width of 50μm. Alternatives to steel metal fibres include stainless steel flakes in either leafing grade or water grade, nickel flake, gold, silver or platinum fibres/flakes or any material with good conductivity that is metallic or non-metallic. It has also been found that pieces of metallised PET can also be used if cut into the correct dimensions. As mentioned above flakes can be used but it is very much preferred to use fibres or more

preferably rigid rod like structures. Dimensions for the materials should fall in the range 0.1-40mm in length and 10-1000μm in width. Such materials should be added to the adhesive anywhere between 1 and 70 weight % and more preferably between 5 and 50 weight %. Though in principle the effect could be achieved by simply having two metallic fibres or particles in close proximity. Pressure and heat sensitive adhesives are widely known to those skilled in the art. In a preferred example an adhesive or binding agent with a high TE should be used, one example being Sericol Seristar SX Screen Binder.

As an alternative to using the same polymer material on either side of the thread construction two different polymer materials could be used. Specifically one of the materials should be high TE e.g. BOPP and the other a low TE e.g. nylon. The two are then laminated together by a suitable adhesive (preferably high TE) containing the metallic fibres. This construction can be more effective as the low TE material gives electrons up to the high TE material thus allowing for a stronger signal.

As will be clear from the above example the conductive fibres are not free flowing and unable to move over one another unlike in the prior art document WO03025831A2. The above example functions despite the fibres or particles forming part of a laminate comprising two layers 1,2 of BOPP adhesively bonded together such that they are no longer mobile. The effect can be explained, in this case, by the fact that the insulators (BOPP layers) when triboelectrically charged will not have a fully uniform charge distribution. Their high electrical Ohmic resistance value prevents it. Nonetheless, simple mechanical flexing of the BOPP laminate construction will encourage the movement of this non-uniform charge potential some of which will then transfer to the metal fibres within the adhesive 3 bonding the two BOPP laminate layers 1,2. The excess charge then rapidly discharges and results in the characteristic RF emission as described earlier.

As a further alternative (not shown), rather than laminate the fibres between the two polymer layers 1,2 the fibres may be provided as part of the polymer layer itself. For example the fibres may be mixed into the molten polymer prior to extrusion or casting. This substrate can then be used for manufacturing threads in the same manner as normal PET is used currently.

In more complex constructions one or more additional functional layers 4,5 may also be provided to the thread construction. Such functional layers are widely known to those skilled in the art of security threads and may be used to provide additional public or machine-readable security. The basic construction described above could in principle be used as an alternative substrate for use in any of the known thread constructions reported in the prior art. Examples of prior art thread constructions are described in EP319157, WO9844199, EP748896, EP407550, EP516790, EP961996, GB2325883, WO9833648, EP303725, EP998396, GB2274428, WO0054985 and EP1156934.

Once the thread has been produced it is proposed that it be embedded into a substrate by any of the known techniques. The thread may be wholly embedded, partially embedded or even exposed along its full length. Methods for the inclusion of threads into substrates can be found in EP860298, EP70172, EP59056, EP229645, EP625431, WO0039391 and WO03040466.

A second example of the invention is illustrated in Figure 5. This example relates to tear tapes for packaging and brand protection applications. The construction is similar in many ways to that for a security thread (Figure 4) with the exception that the lower polymer layer 2 is optional and no longer required. It is also usual to use mono-axially oriented polypropylene (MOPP) rather than BOPP. Also an additional pressure sensitive adhesive layer 6 is applied to the lower surface to allow adhesion of the tear tape to filmic or paper packaging. It has also been found that if the optional second polymer layer 2 is not

present and the optional functional layer 5 is also not present then the adhesive layer 6 with the metal fibres can also be used to adhere the tear tape to filmic or paper packaging.

Again optional functional layers 4,5 can be applied as described in the prior art. Examples of suitable functional layers can be found in EP585076, EP1050484, and EP1050485.

A third example of the invention illustrated in Figure 6 and relates to a foil transfer device. Foil transfer devices are widely used on security documents and may be plain metallic, demetallised, holographic or have other special optical effects. Other optical effects include colour shifting, polymer liquid crystal and the like. In addition to optical effects other machine readable features may be applied e.g. luminescent, magnetic or IR readable inks

The basic construction is shown in Figure 6. A 12μm PET carrier layer 7 is treated with a release coating 8. Onto this an optional functional layer 4 might be applied. In this instance this functional layer 4 might be holographic, colour shifting, polymer liquid crystal, thermochromic, photochromic, luminescent etc. Approaches for applying such layers are widely described in the prior art and will not be discussed in detail here. Onto to this functional layer 4 (or if the functional layer is not present onto the release layer 8) a reflection enhancing layer (REL) 9 is applied. The REL 9 is usually a mirror reflective metal layer or a high refractive index material such as ZnS. The REL 9 may be applied as a continuous layer or in a discontinuous manner. For a metal reflection layer it is not uncommon to apply the metal as a continuous layer and then demetallise in selected regions by any of the known techniques. Onto this is applied an adhesive or lacquer layer 3 containing metal fibres as previous described. In this instance it is essential that the adhesive used should be a high TE material. A further

layer 6 of hot melt or pressure sensitive adhesive is then also applied, though in some circumstances this may also be optional. It is preferable that if this additional adhesive layer 6 is applied it is also a high TE material.

A fourth example of the invention is shown in Figure 7 and relates to the production of a laminated polymer substrate. Such substrates are typically used for identity or transaction cards but could also be used as substrates for other types of security documents such a banknotes, certificates, vouchers and cheques. Here two polymer layers 1,2 are laminated together with a laminating adhesive 3 containing the metal fibres. Polymer materials suitable in this application can include BOPET, Teslin™ and PBT. Outer surfaces of the layers 1, 2 are optionally provided, for example printed with information as diagrammatically indicated at 61, 62.

As an alternative and a preferred embodiment the two polymer layers 1,2 are PVC. Where the two polymer layers are PVC there is no longer a need to use a laminating adhesive. Other materials that do not need a lamination adhesive are PETG and PC. For a PVC card metal fibres (not shown) are first placed on the first layer 1 of PVC. Onto this the second layer 2 of PVC is placed such that the metal fibres are sandwiched between the two. The sandwich is then exposed to heat and pressure such that the PVC begins to melt and flow over the fibres and binds the two PVC layers 1,2 together (no adhesive layer 3 is used). The lamination of PVC cards is widely known within the prior art and has been found to be a particularly suitable approach for the current invention. Once formed the polymer substrate can then be printed onto by any of the known techniques including gravure, flexo, intaglio, litho, screen, dye diffusion, thermal, ink jet, laser, and toner transfer.

As an alternative to laminating, a polymer substrate can be extruded. Example 5 shown in Figure 8 illustrates an example of a card manufactured by extrusion. Here the

metal fibres are added to the molten polymer e.g. polyester prior to extrusion. The molten mix of polymer and fibres is then extruded through an extrusion die to form a flat sheet 10. Optionally this sheet may also have additional extruded or laminated skin layers 11,12. These skin layers may be used to provide opacity, or other functional benefits such as print receptivity. An example of a co-extruded polymer substrate that could be used for the current invention is described in WO9946133. Once formed the polymer substrate can then be printed onto by any of the known techniques including gravure, flexo, intaglio, litho, screen, dye diffusion, thermal, ink jet, laser, and toner transfer.

As a further alternative the current invention is also suitable for inclusion into polymers for injection moulding.

In example 6, illustrated in Figure 9, it is shown how a passport book or similar document can be produced in accordance with the invention. Here an adhesive or polymer insert 20 containing metal fibres is laminated between two further layers 21,22. These layers are typically paper but could be polymeric. Such a construction is particularly suited for the back or front page of passport books. Where the fibres are included into an adhesive it is essential that the adhesive is a high TE material. In the alternative example where the polymer insert is used containing the fibres the polymer may be produced according to examples 4 and 5 or the insert may even be as described for the first example. Essentially the insert comprises a high TE polymer in intimate contact with the metal fibres.

Once formed the laminate construction can be printed or treated as if it were a normal passport front or back page. The invention is particularly suited to passport and identity applications due to the ease and speed of authentication. It has been found that the simple acts of opening a passport book or handling an ID card is sufficient to stimulate an RF emission strong enough to be

detected. This is of great benefit to staff working at immigration desks, as no additional action is required to authenticate the document aside from the handling they already undertake. Current features require the passport or ID card to be swiped or passed through a reader or placed under a lamp of some sort. This takes time and delays the processing of individuals through immigration.

Example 7 shown in Figure 10 shows how the current invention might be incorporated in to a stitching thread. Stitching threads are used extensively for the stitching of passport pages in to passport books. Such passport threads are typically made out of cotton and in some instances are luminescent. In the current example it is preferred that the stitching thread be manufactured from a high TE material such as polypropylene. The metal fibres are simply interwoven into the thread. Typically the metal fibres are 1-30mm but shorter or longer fibres can be used. The metal fibres are added as part of the stitching thread forming process, specifically the short lengths are interwoven into the stitching thread as it is formed.

The stitching thread can then be used as per normal with the additional benefit it can be detected remotely and rapidly.

As an alternative to using the above thread for stitching passport pages it is also possible to interweave it into fabric. This is illustrated in Figure 11. Here a piece of fabric 25 has stitched into it lengths 26 of the special thread described above. It is possible that the fabric is a high TE material in its own right, and so the metal fibres can be woven into it directly. The fabric may form part of a garment or a label in a garment. In a preferred embodiment the thread is imperceptible and allows customs or trading standards inspectors to identify genuine garments from counterfeits.

It is well known to provide special fibres into the furnish of security and synthetic papers, one example of this is given in WO0148311. This example has the further

advantage that the fibres are present in the form of a coding. A substrate suitable for use with the current invention can also be produced by the addition of conductive fibres into the furnish of the paper during papermaking. The paper may be made using cotton, wood, or other suitable natural fibres. Alternatively, and preferably it is known to produce paper wholly or partially comprising synthetic fibres, such substrates are also suitable for the current invention. In this instance rubbing the paper web/sheet containing the fibres against itself stimulates the RF emission. In the case of paper it may be necessary to use a suitable size agent or coating on the paper to overcome the problem of its water content.

As a further alternative this first paper web/sheet containing the conductive fibres can be slit into lengths. These lengths can then be embedded into a second paper web/sheet as previously described for example 1 shown in Figure 4.

In another example the conductive fibres can be suspended in a suitable ink vehicle and printed by any of the known processes. The ink vehicle exhibits the triboelectric effect and is for example Seristar SX screenbinder from Sericol. Preferred printing processes are those capable of laying down a thick ink film, screen-printing and intaglio are particularly suitable. Rubbing two ink regions against each other then activates the feature. Intaglio is particularly suitable as the ink can be printed as a relief structure thus increasing the effective surface area that can be contacted when two regions are rubbed together. For ink applications it is preferable to use shorter fibre lengths, as these are more compatible with the printing process. For ink applications fibres should preferably be no more than 100μm in length.

It is also possible to apply the current invention as a coding. As discussed previously this can be achieved by controlling the intensity and frequency of emission. This approach, though satisfactory, does not provide the range

of coding possibilities necessarily required for all applications. An alternative approach has been developed based on bar-coding. Figure 12 shows a label with a barcode 30. Here at least two of the bars 32,33 have a different intensity or frequency response. Thus the sequence of say high and low intensity RF emission defines a code. Thus as a user rubs or strokes the code each bar emits in sequence. This sequence can be detected and the code determined. The complexity of the code with is defined by the total number of bars and the number of individual different frequency or intensity bars. The barcode could be unidirectional or bi-directional. The label is printed with other conventional features such as a serial number 34 and security print 35.

By way of further explanation the invention will now be described in the context of some specific applications. The first relates to the authentication of computer hardware, software, peripherals and consumables. Considerable expenditure is being incurred by computer software and hardware manufacturers to reduce the problem of software piracy. One successful approach has been to package genuine software carriers such as CD ROMs and DVD ROMs in secure packaging which includes a security feature such as a hologram enabling the purchaser to confirm that the contents are genuine while allowing computer software manufacturers to police retailers to check that they are only selling genuine versions of the software.

There is a need, however, to decrease still further the ability to supply non-genuine electronic data carriers (CD ROMs, DVD ROMs, Compact flash cards, ZIP drives etc) while there is also a need to be able to achieve authentication remotely when the security feature supplied with a genuine electronic data carrier cannot be viewed by the authenticator.

The processing assembly shown in Figure 13 is based on a conventional PC and includes a monitor 40, keyboard 41 and mouse 42 all connected to a central processor 43. The

central processor 43 also supports a media storage device 44 and a modem 45. In addition to these components, the PC is also provided with an additional detector module 46 similar to that shown in Figure 2 and configured to allow detection of a feature according to the current invention.

In a first example, the authentication of a CD ROM carrying a program such as a game-playing program will be described. The CD ROM will also carry authentication algorithm software and be preferably packaged with a manual, certificate or label having security features of the type illustrated in Figure 3 one of which is in accordance with the current invention. This feature may be visible to the naked eye or invisible dependent upon how it is applied. As a further alternative the current invention may form part of the CD ROM construction itself either as a layer in a laminate or as an additive to the polycarbonate of the CD ROM. The current example assumes that the security feature is provided on a security label as illustrated at 50 in Figure 14.

When the CD ROM is loaded into the media storage device and the user instructs installation, initially only the authentication algorithm software is downloaded into the processor. This algorithm then runs and instructs that the user should rub or flex the security label. The rubbing or flexing of the label causes the appropriate RF radiation to be emitted by the feature 50 and then detected by the detector 46. The detector 46 processes the detected signal and then sends an appropriate signal to the central processor 43, which provides a "feature present" signal. The current invention is particularly beneficial, as the user is not required to align the feature 50 with the detector 46. The feature present signal may be presented as an audible sound via a speaker built in to the PC or displayed visually via the PC display 40. A different and characteristic response may be generated by appropriate material selection which is specific to a particular software set, version or variant.

In this simple example, the algorithm carried out by the detector 46 simply determines that the feature has been detected and then authorises further processing of the software. Typically, this will be a one-off process and this existence of a successful match will be recorded permanently against the software loaded onto the PC. As an alternative to a one-off match, the feature may be interrogated periodically. In this example it is preferred that the feature be printed/applied onto or be part of a memory card or other storage device required to utilise the software. In one particular example the feature could be a hologram applied to a memory card supplied with a game. In particular it is known to provide memory cards that vibrate at certain points during game play. Periodically the software interrogates the feature to ensure that the memory card is present and someone has not merely installed the software and authenticated it once.

In another example in addition to the authentication algorithm software, the CD ROM includes a code that is downloaded into the central processor 43. This code acts as a key allowing the authentication algorithm to be performed.

As a further alternative, the key could be supplied via the modem 45 from a remote source 47 such as the software provider.

The authentication algorithm could also operate on a code defining the content of a CD ROM, for example identifying the software. In these more sophisticated examples, the result of the authentication algorithm may not in itself establish authenticity or a successful match. Instead, the algorithm may generate a further code that must then be authenticated, typically at a remote location, for example via the modem 45. Following authentication, an access code is then transmitted to the central processor allowing further use of the software. In this instance the remote location 47 may also store details of the event to create a log that can be referred to at a later date.

As an alternative the inventive feature could be provided as a code. In this case, the reading device obtains sufficient information from the security feature to determine the code number. The authentication algorithm may then simply compare the code number obtained from the CD ROM with the code number defined by the feature and if they are the same authorise activation of the software. Alternatively, the code number could be used within the authentication algorithm.

In a further alternative an optional card reader (not shown) could be coupled to the central processor 43. This would be used to read a smart card or some form of memory card (not shown) supplied with the CD ROM. The smart card will carry a T.E. code or software that is required by the central processor in order to run the authentication algorithm and/or operate the security feature reading device. This could be required on a one-off basis to achieve initial running of the software or alternatively could be required to be present on each occasion on which the software is to be run.

The smart card may be supplied with the CD ROM so that they must be used together to achieve full authentication. Alternatively, the smart card may already be in the possession of the user for other purposes such as monetary transactions or the like and can be loaded with the appropriate data when the user purchases the software.

It should also be recognised that the application described above is not limited to personal computers. There are a great many devices available now that run software applications. For example mobile phones personal digital assistants (PDA's), pocket PC's, digital television receivers, MP3 players all of which could make use of the current invention to authenticate locally or via a link to a network on internet link. Alternatively the label might be associated with peripheral devices which themselves do not store software applications but the manufacturers may still wish to have registered. For example ink jet or

laser printers, scanners and the like. Here the label could be authenticated as part of the registration process to enable the warranty for the peripheral device. This concept may be further extended to consideration of consumables such as toner or ink jet cartridges. In some instances a manufacturers warranty will be invalidated if a user uses a generic printer cartridge rather than a genuine accredited product. Generic products are generally seen as being of inferior quality and can damage the equipment. If a user is required to authenticate a cartridge when it is installed via the inventive feature on a label or as part of the packaging the manufacturer can keep track and ensure that the warranty is valid. It is not intended that a user be prevented from using non-accredited products merely a track is maintained for warranty proposes.

In a second example application a feature according to the current invention is utilised at point of sale (POS) within a retail store. It is proposed that articles for sale within the retailer are provided with features according to the current invention. The feature may be applied as a label, a print working, or some other applied feature such as an optically variable device. It is proposed that when the purchaser takes the item to the POS the teller can present the item to a detector (similar to Figure 2) to provide confirmation to the purchaser they are buying a genuine article. The detector may be a self-contained dedicated unit or incorporated in a consumer electronics device such as a mobile telephone or Personal Digital Assistant (PDA). This is a simple test but can provide a degree of confidence to the purchaser that they are buying a genuine product. This is particularly important for pharmaceutical or other health related products where the user might come to harm if purchasing counterfeit goods.

As a further alternative, if the feature was provided on a banknote it could be utilised by a cashier in a

retailer or a bank teller as a simple and rapid test for authenticity. The current feature is particularly suited to situations where lighting might be poor, e.g. bars and nightclubs, or where speed is of the essence e.g. supermarkets. It also has value as the inspection could be done in such a way that the customer is unaware. Currently it is increasingly common for a teller or cashier to visually inspect features such as threads or watermarks. In some instances, such as for large denominations, a supervisor might be required. This not only causes delays but also can lead to embarrassment for the customer. The current invention requires no visual inspection and the simple process of handling the notes can be sufficient to trigger a response from the detector. In this instance the response could simply be a message on a display to the cashier or teller stating the notes are valid. As a further enhancement if the notes are provided with denomination specific coding the detector could also determine the value of notes being passed provide an additional level of security.

As well as the applications mentioned above, the invention can be utilized in a number of further applications.

A device of the form shown in Figure 4 (or possibly Figure 8) could be incorporated into a tape for affixing to a road surface or the like so as to indicate the passage of vehicles or pedestrians. The tape would be thicker than a conventional tear tape for robustness and durability. When stuck to a floor surface or the like, it may physically warn of a hazardous or no-go area with suitable indicia but has the added function of enabling an audible alarm/ flashing light to be activated if a person or vehicle moves over it. Such a tape could be used also to cordon off areas in shops or warehouses and any other applications where such tapes are used conventionally.

Such a tape could be provided with retro-reflective materials, materials that glow or luminesce for extended periods of time, or a simple print.

Instead of a tape, an ink of the inventive type described above could be used in the form of a paint or coating on a floor or road surface.

In another application, the device is formed into small polymer beads or the like which have a typical diameter not exceeding 20mm and can be disguised to look like gravel or stones. Displacement of these beads as a result of the passage of a person or vehicle will result in the generation of a signal. These beads could be formed by breaking up one of the thread or card constructions described above. A thread of the type shown in Figure 10 could be cut up into small particles or the particles could be woven into carpet squares or material of a suitable type.

We have described above in connection with Figure 11 the incorporation of particles into a fabric and this could be used as a safety measure when in the form of clothing to detect when a person has stopped moving, for example through injury. Examples include ski wear in which the movements of an injured person would generate the required signal which could be detected. Experiments have shown that signals can be detected at more than 10m and in theory many hundreds of metres. Alternatively, the movement sensor could be in the form of a patch or label attached to a garment or placed in a badge holder. Suitable examples have been described above.

Further examples include the incorporation of metal particles into the clothing of firemen or workers in other hazardous situations.

The use of the invention on commodity articles where the invention may be in the form of stickers or labels allows the articles to be checked remotely as, for example, they pass along a conveyor and the like.

In another application, the conductive particles could be included in a material subject to wear in use. For example, metal fibres could be included in a tyre moulding to a certain depth from the outer surface. After a certain period of wear, these metal fibres will disappear and the absence of a signal from the tyre would indicate the need to replace the tyre. A similar approach could be used with brake pads or brake shoes and the like. A suitable receiver could be placed in the vehicle concerned.

Devices could be printed, adhered, painted onto a moving device so that it will continually emit pulses while the device is moving and working correctly but stop pulsing when the device fails. Examples include cooling fans, pump motors, electric motors, alternators, bearings and the like.

Finally, the device could be used in a wrist band or when in the form of an ink, painted directly onto a person's skin so as to be used as a pass into and out of a venue such as a concert.

CLAIMS

1. An electrostatic charge indicating device comprising a plurality of conductive particles of predetermined dimensions suspended in substantially fixed positions, and in intimate contact with, a material which exhibits a triboelectric property to define a triboelectric indicator such that electrostatic charge built up on the material with the triboelectric property will discharge through the conductive particles in response to a suitable action, the discharge generating a RF signal which can be detected.

2. A device according to claim 1, wherein the particles comprise fibres or flakes.

3. A device according to claim 2, wherein the fibres have a length in the range 0.1-40mm.

4. A device according to claim 2 or claim 3, wherein the fibres have a width in the range 10-1000 microns.

5. A device according to any of the preceding claims, wherein the concentration of the particles in the material is in the range 1-70 WT%, preferably 5-50 WT%, most preferably substantially 10 WT%.

6. A device according to claim 5, wherein the particles have substantially the same size.

7. A device according to any of the preceding claims, wherein the particles are made of carbon, a metal, or include a metallic component.

8. A device according to claim 7, wherein the metal comprises one of steel, stainless steel, nickel, gold, silver and platinum.

9. A device according to claim 7, wherein the particles comprise a metallized polymer such as PET.

10. A device according to any of the preceding claims, wherein the material of the triboelectric indicator has a high TE.

11. A device according to any of the preceding claims, wherein the material of the triboelectric indicator is an electrical insulator.

12. A device according to any of the preceding claims, wherein the triboelectric indicator is a self-supporting layer.

13. A device according to any of the preceding claims, wherein the material of the triboelectric indicator comprises an adhesive.

14. A device according to any of the preceding claims, wherein the triboelectric indicator has been formed by extrusion or casting.

15. A device according to any of the preceding claims, the device comprising a laminate, one of the layers of the laminate being defined by the triboelectric indicator.

16. A device according to claim 15, in which the laminate includes a triboelectric material layer in addition to the triboelectric indicator layer.

17. A device according to claim 15 or claim 16, wherein the laminate comprises three layers, each having a triboelectric effect, the triboelectric indicator layer comprising an adhesive sandwiched between and joining the other two layers.

18. A device according to claim 17, wherein the other two layers have a low TE and a high TE respectively.

19. A device according to any of the preceding claims, wherein the material of the triboelectric indicator or other triboelectric layer is a polymer.

20. A device according to claim 19, wherein the polymer is one of BOPP, MOPP, PPC, BOPET, PBT, PETG, PC, nylon and Teslin™.

21. A device according to claim 17, wherein the two other layers comprise paper.

22. A device according to any of claims 17 to 21, wherein the laminate includes a reflection enhancing layer.

23. A device according to claim 22, wherein the reflection enhancing layer comprises a metal or a high refractive index material.

24. A device according to claim 23, wherein the reflection enhancing layer comprises a discontinuous metal.

25. A device according to any of claims 15 to 24, wherein the laminate includes one or more functional layers.

26. A device according to claim 25, when dependent on claim 23 or claim 24, wherein the reflection enhancing layer is provided between a functional layer and the triboelectric indicator layer.

27. A device according to claim 25 or claim 26, wherein the functional layer comprises one of an holographic, colour shifting, polymer liquid crystal, thermochromic, photochromic, and luminescent layer.

28. A device according to any of claims 15 to 27, wherein the laminate includes a carrier layer releasably attached to the other layer(s) to enable the other layer(s) to be transferred onto a substrate.

29. A device according to any of claims 15 to 28, wherein the laminate includes an adhesive layer to enable the laminate to be secured to a substrate.

30. A device according to any of the preceding claims, further comprising indicia on one or more outer surfaces of the device.

31. A device according to claim 30, wherein the indicia are printed on the device.

32. A device according to claim 30 or claim 31, wherein the indicia comprise security indicia.

33. A device according to any of the preceding claims, the device forming or being incorporated in one of a security thread, label, tear tape, identity or transaction card, security document or article of value such as a banknote, postal stamp, fiscal stamp, voucher, cheque, bond, certificate of authenticity, tax document, passport, identity document, brand protection use, security thread, applied security device, and security label.

34. A device according to any of claims 1 to 11, wherein the triboelectric indicator comprises a paper substrate containing the conductive particles.

35. A device according to claim 34, wherein the paper has been made from one of cotton, wood and synthetic materials.

36. A device according to claim 34 or claim 35, wherein the device constitutes a security document or article of value such as a banknote, postal stamp, fiscal stamp, voucher, cheque, bond, certificate of authenticity, tax document, passport, identity document, brand protection use, security thread, applied security device, and security label.

37. A device according to any of claims 1 to 11, wherein the triboelectric indicator comprises the conductive particles suspended in an ink vehicle which has been printed, coated or otherwise provided onto a substrate.

38. A device according to any of claims 1 to 11, wherein the triboelectric indicator comprises a stitching thread into which the conductive particles have been woven.

39. A device according to claim 38, wherein the conductive particles comprise fibres having a length in the range 0.5-40mm, preferably 1-30mm, most preferably 1-10mm.

40. A device according to claim 38 or claim 39, wherein the stitching thread is woven into a book or fabric.

41. A device according to claim 40, wherein the stitching thread is woven into a passport book.

42. A device according to any of claims 1 to 11, wherein the triboelectric indicator comprises a fabric in which the conductive particles have been provided, for example woven.

43. A device according to any of claims 1 to 12, wherein the triboelectric indicator is in the form of a small object.

44. A device according to claim 43, wherein the diameter of the object is less than 20mm.

45. A method of manufacturing an electrostatic charge indicating device, the method comprising forming a triboelectric indicator in which a plurality of conductive particles of predetermined dimensions are suspended in substantially fixed positions, and in intimate contact with, material which exhibits a triboelectric property, whereby electrostatic charge build-up on the material will discharge through the conductive particles in response to

a suitable action, the discharge generating a RF signal which can be detected.

46. A method according to claim 45, wherein the triboelectric indicator comprises a self-supporting layer.

47. A method according to claim 45 or claim 46, wherein the triboelectric indicator is formed by extrusion or casting.

48. A method according to any of claims 45 to 47, further comprising laminating the triboelectric indicator layer to one or more other layers exhibiting a triboelectric effect.

49. A method according to any of claims 45 to 48 for manufacturing a device according to any of claims 1 to 44.

50. An article carrying, incorporating or forming an indicating device according to any of claims 1 to 44 or manufactured according to any of claims 45 to 49.

51. An article according to claim 50, wherein the article comprises a security document or article of value such as a banknote, postal stamp, fiscal stamp, voucher, cheque, bond, certificate of authenticity, tax document, passport, identity document, brand protection use, security thread, applied security device, and security label.

52. An article according to claim 50, wherein the article comprises an electronic memory.

53. A device according to claim 52, wherein the electronic memory comprises one of a floppy disk, CD ROM, DVD ROM, compact flash card, and ZIP drive.

54. An article according to claim 50, wherein the article comprises a peripheral device such as a printer or scanner.

55. An article according to claim 50, wherein the article comprises a consumable product such as a toner or ink jet cartridge.

56. An article according to any of claims 50 to 55, the article carrying more than one indicating device.

57. An article according to claim 56, wherein the indicating devices define a barcode.

58. An article according to claim 56 or claim 57, wherein each device generates a RF signal at a respective unique frequency and/or unique intensity.

59. An article according to claim 50 or any of claims 56 to 58, wherein the article wears in use.

60. An article according to claim 59, the article comprising a vehicle tyre, brake pad or brake shoe.

61. An article according to claim 59, the article comprising a bearing.

62. An article according to claim 50, wherein the article comprises an object intended to move in use, for example a fan, pump, rotor, electronic motor or alternator.

63. An ink comprising an ink vehicle exhibiting the triboelectric effect containing a plurality of conductive particles of predetermined dimensions and concentration such that when the ink is deposited on a surface, the conductive particles are suspended in substantially fixed positions, and in intimate contact with, the ink vehicle such that electrostatic charge built up on the ink vehicle will discharge through the conductive particles in response to a suitable action, the discharge generating a RF signal which can be detected.

64. A surface carrying an ink according to claim 63.

65. A surface according to claim 64, the surface comprising a road surface, rail, floor or the surface of an article.

66. A method of detecting the presence of an electrostatic indicator device according to any of claims 1 to 44 or manufactured according to any of claims 45 to 49, or provided in an ink according to claim 63, the method comprising causing a transfer of static charge to the conductive particles; detecting a resulting RF signal; and determining the presence of the electrostatic indicating device if the detected signal satisfies predetermined conditions.

67. A method according to claim 66, wherein the predetermined conditions comprise a predetermined frequency or frequency range within which the detected signal falls.

68. A method according to claim 67, wherein the predetermined conditions are satisfied if RF signal frequencies are detected within a respective plurality of predetermined frequency ranges.

69. A method according to any of claims 66 to 68, wherein the predetermined conditions include a predetermined intensity or intensity range within which the detected signal falls.

70. A method according to any of claims 66 to 69, wherein the step of causing a transfer of static charge comprises impact, flexing or rubbing the device.

71. A method according to claim 70, wherein the step is caused by human or animal manipulation.

72. A method according to claim 70, wherein the step is caused by wear or use of the device or an article carrying the device.

73. A method of authenticating an article in or on which an electrostatic indicating device according to any of claims 1 to 44 or manufactured according to any of claims 45 to 49 is provided, the method comprising carrying out a method according to any of claims 66 to 72, and authenticating the article if predetermined conditions are satisfied.

74. A method according to claim 73, wherein the article comprises an electronic memory, the method further comprising authorizing use of the memory if the predetermined conditions are satisfied.

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Application No: GB0502359.3 **Examiner:** Mr Richard Howe

Claims searched: 1-74 **Date of search:** 1 August 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	1	GB2381704 A Roke Manor - see whole document

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Online : wpi ; epodoc ; paj