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(71) Applicant: ARJO WIGGINS S.A.
92130 Issy-les-Moulineaux (FR)

(72) Inventors:
• Robertson, Paul
PA Consulting Group
Royston Herts SG8 6DP (GB)
• Burrell, Jon
PA Consulting Group
Royston Herts SG8 6DP (GB)

• Fischer, John
PA Consulting Group
Royston Herts SG8 6DP (GB)
• Doublet, Pierre
77160 Saint-Brice (FR)

(74) Representative: Domange, Maxime
Société Arjo Wiggins S.A.,
Département Propriété Intellectuelle,
117 quai du Président Roosevelt
92442 Issy-les-Moulineaux Cedex (FR)

(54) Substrate comprising magnetic particles, security document and method for detecting them

(57) A method for detecting the presence of magnetic particles in a substrate the base material of which has magnetic properties substantially differing from the corresponding magnetic properties of the particles. The particles have such a long and thin form that their demagnetisation factor N is smaller than 1250, they have a diameter smaller than 30 micrometer and a magnetic saturation field ranging from 100 to 1000 A/m. The method comprising following steps :

- (a) emitting an electromagnetic source signal of one or more particular base frequencies to said substrate so that any present magnetic particles go into a non-linear part of their B-H curve for at least part of a cycle of the source signal ;
- (b) detecting an electromagnetic detection signal emanating from said substrate ;
- (c) testing the detection signal for the presence of particular higher harmonics of said base frequencies or of any linear combination of said base frequencies, said particular higher harmonics being indicative of the presence of said magnetic particles.

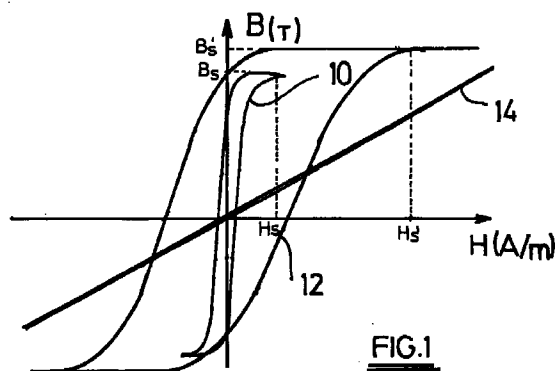


FIG.1

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Description**Field of the invention**

5 The present invention relates to a method and an apparatus for detecting the presence of particles in a substrate the base material of which has electromagnetic properties substantially differing from the corresponding electromagnetic properties of the particles. The invention also relates to the particles and to the substrate comprising such particles which allow to recognise easily a document as being a genuine security document in order to prevent the document from being copied or in order to contribute to its authentication.

10 The invention is intended primarily to be used in the identification or authentication of all type of security documents having a paper or synthetic base material such as bank notes, cheques, passports, credit-cards, tickets, lottery-tickets and bonds which comprise the above particles, but it is also applicable to other applications in which objects need to be recognised.

Background of the invention

The prior art has already dealt in an extensive way with the identification of security documents.

Some prior art solutions go in the direction of recognition of possible characteristic patterns printed at the surface of some security documents.

20 In order to prevent genuine security documents from being falsely copied by means of high-resolution colour photocopying apparatus, the prior art has also proposed to add to the fibrous structure of the base material of the substrate or to the surface of the document one or more security elements allowing the identification and/or making difficult the manufacturing of the document.

25 US-A-4 114 032 (priority date 1973) and US-A-4 218 674 (filing date 1975) disclose a similar system where the security documents have fibres which are coated with a magnetic or magnetizable material embedded therein. The mere presence of the magnetic fibres inside the security documents is tested or, as an improved feature, the distribution of the magnetic fibres in the security document is measured so that every single security document can be given a unique mark.

30 Up to 500 million different possible combinations may be obtained. EP-A-0 625 766, EP-A-0 632 398 and EP-A-0 656 607 (all filing date in 1993) disclose a system where the fibres consist of magnetic powder as core of a polymer sheath. Magnetic detection is done by DC current used to excite a coil. Because of magnetic prehistory or disturbing of magnetic fields or deformations of the security documents, however, the repetitivity of such a magnetic scanning system is not ensured and accurate discrimination between genuine security documents and counterfeit documents is not always guaranteed. So detection is not always distinctive. Moreover, if characters on the security document have been printed by means of a magnetic ink which is detectable by means of a sorting apparatus, there may be interference between the magnetic fibres and the magnetic ink of the characters.

Other embodiments disclosed in the prior art are based on the detection of particular electromagnetic properties of the security elements. FR 2 425 937 discloses a method of dispersing metallic fibres, more particularly stainless steel fibres, inside the fibrous structure of paper in order to allow the identification by means of microwaves.

40 US-A-4 820 912 (priority date 1985) discloses an alternative system where the security documents comprise randomly distributed electrically conductive fibres. By scanning the documents by means of microwaves the unique distribution of the fibres inside the security document can be obtained. Up to 64^{320} different possible combinations of the mark characterising this distribution can be obtained. Application of this microwave technique to reproduction apparatus such as photocopying apparatus in order to prevent security documents from being copied, such as disclosed in WO-A- 95/24000 (priority date 1994) fails to distinguish security documents from printed circuit boards (PCB's) or from greeting cards having decorative metal foils on its surface. On the other hand, the system does not discover the presence of the fibres if a metal plate is put above a genuine security document. Particular cover lids of photocopying apparatus or metallic parts in the neighbourhood of the photocopying apparatus, may disturb the system. As a consequence, these systems are not completely reliable.

50 The prior art has also provided a number of optical authentication systems. Some of them have been disclosed already in US-A-3 313 941 (filing date 1963) and in US-A-3 449 585 (filing date 1966). All optical systems, however, suffer from the major drawback that wear or damage or dirt on the surface of genuine security documents can cause the security documents as being no longer recognised as authentic.

Summary of the invention.

It is an object of the present invention to avoid the drawbacks of the prior art. It is another object of the present invention to provide for a robust recognition system that allows to distinguish genuine security documents from other

objects or documents. It is also an object of the present invention to provide for a system which prevents genuine security documents from being copied. It is still an object of the present invention to provide for a system that does not interfere with conventional magnetic character readers.

It is a further object of the present invention to provide for a substrate such as a security document, more particularly a banknote, including security elements easily detectable in an anti-photocopy system.

According to a first aspect of the present invention there is provided a method for detecting the presence of magnetic elongated particles in a substrate the base material of which has magnetic properties substantially differing from the corresponding magnetic properties of the elongated particles. Preferably the base material is made of a non-magnetic material. The elongated particles have such a long and thin form that their demagnetisation factor N is smaller than $1/250$, preferably $1/1000$. Their cross-sectional diameter is smaller than 30 micrometer and their magnetic saturation field H_s ranges from 100 to 1000 A/m. The terms "cross-sectional diameter" herein refer to the maximum cross-sectional dimension. The method comprises following steps :

(a) emitting an electromagnetic source signal of one or more particular base frequencies to the substrate so that any present magnetic particles go into a non-linear part of their B-H curve for at least part of a cycle of the source signal ;

(b) detecting an electromagnetic detection signal emanating from the substrate ;

(c) testing the detection signal for the presence of particular higher harmonics of the base frequencies or of any linear combination of the base frequencies as well as the harmonics, where the particular higher harmonics are indicative of the presence of the magnetic elongated particles.

Using the non-linearity of the magnetisation properties of the labelling material, i.e. the change in magnetic flux density B with applied magnetic field H as an effective parameter for detection is a technique which is known as such in electronic article surveillance (EAS) or anti-theft systems. The signals which can be obtained from this approach are very distinctive and the electronics and signal processing can be straight forward. EAS systems have been disclosed in an extensive way in the patent literature. Some examples are FR 763 681 (filing date 1933), US-A-3 631 442 (filing date 1967), US 3 990 065 (filing date 1975) and EP-A-0 153 286 (priority date 1984).

A number of substantial differences between EAS systems and the present invention are, however, apparent.

In EAS systems anti-theft labels are used to trigger alarms at the exit areas of shops if the products have not been offered at the pay-desk. The exit area of a shop is much larger than the volume required for detection of magnetic elongated particles in security documents. A typical exit gate has a width of about 1 m, while in the present invention distances of only a few cm between the magnetic field and the magnetic elongated particles are sufficient to perform the detection. This basic difference leads to a number of properties which are different for application of the present invention :

1) The magnetic material of EAS labels is rather bulky, since it must be present in a sufficient volume to trigger off the alarm in the relatively large exit area ; a typical cross-sectional dimension is about 1 mm and the length can be several cm long. In contradistinction herewith, the magnetic elongated particles according to the present invention have a much smaller volume. Their demagnetisation factor N is smaller than $1/250$, preferably smaller than $1/1000$ and their cross-sectional diameter is smaller than 30 micrometer, preferably smaller than 15 micrometer and most preferably ranging from 1 to 10 micrometer. The maximum value for the demagnetisation factor N is chosen so that the magnetic elongated particles can be detected by apparatus with acceptable coil dimensions and power dissipation so that they can be installed in a photocopier or a bank note counting machine. Preferably, the demagnetisation factor N is greater than $1/100000$ in order to avoid setting off EAS alarms.

2) The magnetic material of EAS labels can be classified as very soft magnetic material, i.e. material having a very small coercive force H_c and a relatively high dynamic permeability μ_r , since small magnetic fields H covering the exit area of a shop must be able to saturate the EAS labels. In contrast herewith, the magnetic elongated particles according to the present invention, although still being classified as soft magnetic materials, have such a shape and/or composition and/or structure that they are effectively magnetically hard enough to stay below the saturation point of their B-H loop in the fields used in the shop systems so that they do not generate high enough signals to activate the shop alarms. In comparison with EAS labels, the magnetic elongated particles according to the present invention have preferably a lower effective permeability and therefore require a substantially higher magnetic field to reach saturation. The magnetic saturation field H_s of magnetic elongated particles according to the present invention ranges from 100 to 1000 A/m, the lower value being chosen not to trigger off EAS alarms and the higher value being chosen so that it can be achieved by detector apparatus with acceptable coil dimensions and power dissipation that can be built in a photocopier. The inventors have experiences so far that anything over 1000 A/m will be difficult to achieve with an air cored coil. The magnetic saturation flux preferably ranges from 0.1 to 1 Tesla,

more preferably from 0.1 to 0.5 Tesla and the dynamic permeability μ_r' ranges from 100 to 10000. Within the context of the present invention, all these magnetic properties have been determined by use of an alternating current magnetometer at frequencies from 10 kHz to 100 kHz.

3) Due to the bulky material of EAS labels, the frequencies applied are limited in order to reduce eddy current losses. In contradistinction herewith, much higher frequencies (higher than 1 kHz) can be applied in the present invention, since the magnetic elongated particles have a much lesser volume. The corresponding harmonics have also a much higher frequency (higher than 10 kHz) and typical harmonics have an order of ten or higher.

4) In EAS systems the problem of covering the large volume of the exit area of a shop and the problem of orientation-sensitive EAS labels (the existence of the so-called easy axis) has led to a number of embodiments where two or more base frequencies are used or to the use of an additional rotating magnetic field in order to create a global spatial magnetic field which is insensitive to the orientation of the EAS. Due to the much more limited sizes of the volumes required for the present detection method, such complications are not necessary for the present invention. A source signal of a single base frequency has proved to be sufficient.

In one embodiment of the present invention the method comprises the additional step of :

d) generating a signal which prevents from taking a true copy in case said particular harmonics are present.

According to a second aspect of the present invention, there is provided a detection apparatus for detecting the presence of magnetic elongated particles in a substrate the base material of which has magnetic properties substantially differing from the corresponding magnetic properties of the elongated particles. Preferably the base material is made of a non-magnetic material. The elongated particles have such a long and thin form that their demagnetisation factor N is smaller than 1/250, preferably smaller than 1/1000. Their cross-sectional diameter is smaller than 30 micrometer and their magnetic saturation field H_s ranges from 100 to 1000 A/m. The apparatus comprises :

- (a) an oscillator for emitting an source signal of one or more base frequencies to the substrate ;
- (b) a detector for detecting an detection signal emanating from the substrate ;
- (c) a signal processor for examining the detection signal on the presence of any particular higher harmonics of the base frequencies or of any linear combination of the base frequencies, where the particular higher harmonics are indicative of the presence of the magnetic particles.

According to a particular embodiment of the apparatus, both the source signal and detection signal are electrical signals and the apparatus further comprises a drive coil for converting the source signal into a magnetic drive field, and a detection coil for converting a detection magnetic field into the detection signal. The coils are so arranged to null out the magnetic drive field in the detection coil in order to avoid saturating the amplifier and to minimise any cross-coupling which can occur with conducting materials.

The apparatus according to the second aspect of the present invention can be used in automatic vending machines, bank note counting machines and reproduction apparatus.

1) With respect to the use in reproduction apparatus, in order to detect the presence of any security documents in the whole scanning region, following embodiments can be used :

- 2) the use of more than one drive coil and more than one detection coil ;
- 3) drive coils and detection coils forming a daisy chain ;
- 4) the use of only one drive coil and one detection coil, both having an elongated form ;
- 5) The use of one drive coil and more than one detection coil.

According to the third aspect of the present invention, there is provided a magnetic elongated particle for being incorporated in a base material of a substrate where the base material has magnetic properties differing substantially from the corresponding magnetic properties of the particle. Preferably the base material is made of a non-magnetic material. The particle has such a long and thin form that its demagnetisation factor N is smaller than 1/250, preferably smaller than 1/1000. The diameter of the particle (i.e. its maximum cross-sectional dimension) is smaller than 30 micrometer, preferably smaller than 15 micrometer, preferably ranging from 1 to 10 micrometer and its magnetic saturation field H_s ranges from 100 to 1000 A/m.

ration field H_s ranges from 100 to 1000 A/m.

The magnetic field strength inside the material is given by

$$H_{in} = H_{app} - N \times M$$

where M is the magnetisation of the material H_{app} is the applied magnetic field and N is the demagnetisation factor. With uniform magnetisation this reduction in the internal field strength can be considered as a reduction in the apparent permeability from its true value of μ , which is the so-called bulk magnetic permeability or magnetic permeability of the material, to the magnetic dynamic permeability μ_r' , where

$$1/\mu_r' = 1/\mu_r - N \text{ or}$$

$$\mu_r' = \mu_r / (1 + N\mu_r)$$

The effect of the reduction in permeability therefore causes the B-H loop to shear into a shape which has a higher saturation field and lower remanence. In case of a sphere, the demagnetisation factor $N = 1/3$. Whereas for long, thin ellipsoids (approximating to cylinders represented by the elongated particles such as fibres) N is given by :

$$N = [\ln(2p - 1)]/p^2 \text{ where } p \text{ is the length to diameter ratio.}$$

For a fibre of 8 micrometer diameter and 3 mm length, N is equal to $1/22000$.

Based on these equations, if, as an example, we take a material with a bulk permeability μ_r of 100000 then a sphere of identical material would appear to have a magnetic dynamic permeability μ_r' approximately 6000 times smaller than a fibre with the dimensions shown above. This will then have a direct effect on the magnitude of the field required to saturate the material in each case. Thus spheres, or powders of approximately spherical form would not be suitable for the application described herein.

Preferably, the magnetic saturation flux B_s of the magnetic elongated particle ranges from 0.1 to 1 Tesla, preferably from 0.1 to 0.5 Tesla.

Preferably the magnetic dynamic permeability μ_r' of the magnetic elongated particle ranges from 100 to 10000. The magnetic dynamic permeability μ_r' is herein defined as the ratio of the saturation flux B_s to the magnetic field H_s at saturation multiplied by the constant μ_0 or, if the elongated particles do not saturate, the same ratio at the maximum field used in the magnetometer (1000 A/m).

The terms "magnetic elongated particle" refer to an elongated particle itself made of a magnetic material and possibly being coated or encapsulated with a non-magnetic material or to a elongated particle being made of a non-magnetic material being coated or encapsulated with a magnetic material. The thickness of the coating may range from 1 to 5 micrometer. The magnetic material can be made starting from an alloy comprising components chosen among Fe, Co, Cr, Ni, Cu, Mo, Mn, Nb, B, V, Si and P and more particularly Ni, Fe, Mo, Mn, Cu. Soft magnetic materials have been disclosed for example in EP-A-0 295 028 and in US-A-4 298 262.

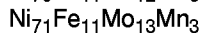
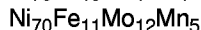
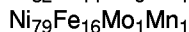
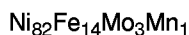
A suitable alloy composition responds to the general formula :



wherein a to l represent integers.

More particularly alloy compositions have 52 to 85 % of nickel (Ni) and varying amounts of other components and more particularly 5 to 20 % of Fe.

Typical compositions are:



Some of these compositions are commercialised under names as μ -metal, Permafi, Permalloy, Supermalloy, Vitrovac and Metglas. As non-magnetic and non-metallic material, glass, carbon or synthetic material such as polymers especially polypropylene and polyethylene can be mentioned.

According to a preferable embodiment of this third aspect of the present invention, the elongated particle is a fibre which can be a metallic fibre, or a non-metallic fibre coated with a magnetic substance.

The fibres can be uniformly distributed all over the substrate and therefore not easily missed by the detection system. Moreover, the fibres can be uniformly and individually dispersed inside the base material of the substrate in order to prevent the formation of agglomerates of fibres. Magnetic fibres inside the fibrous structure of the paper may form a magnetic "mass" which is at least double as great as the magnetic mass of the characters in magnetic ink and may confuse completely the lecture of these characters. Additionally, since the fibres are dispersed inside the substrate, they are not easily removable by the counterfeiters who would like to remove them before making a photocopy and reinstate them inside the substrate after photocopy thereof.

The fibres are preferably hard drawn or work hardened metal fibres, e.g. manufactured according to the technique of bundled-drawing which is well known as such. This manufacturing technique has the advantage of yielding a much higher production rate than hot melt production techniques. The inventors have found that the effective permeability of the hard drawn fibres can be doubled by annealing. This skill keeps the saturation field H_s sufficiently high, but makes the fibres more sensitive.

The magnetic elongated particles may also be amorphous metal fibres.

According to a fourth aspect of the present invention, there is provided a substrate comprising a base material and elongated particles inside the base material. The magnetic properties of the elongated particles differ from the corresponding magnetic properties of the base material. Preferably the base material is made of a non-magnetic material. The elongated particles have such a long and thin form that their demagnetisation factor N is smaller than $1/250$, preferably smaller than $1/1000$. Their diameter is smaller than 30 micrometer and their magnetic saturation field ranges from 100 to 1000 A/m. Preferably the base material is a non-magnetic material such as a fibrous structure like paper, paper or plastic.

Preferably the particles have a magnetic saturation flux ranging from 0.1 to 1 Tesla preferably from 0.1 to 0.5 Tesla and a magnetic dynamic permeability μ_r' ranging from 100 to 10000.

Summarizing, the combination of shape, composition and structure of the magnetic elongated particles is such that

- the magnetic field required to achieve saturation of the flux density in the particle is sufficiently greater than that produced in EAS systems and sufficiently lower than that required to saturate hard ferromagnetic material such as iron, steel or plate, and
- the magnetic remanent flux is sufficiently lower than those of magnetic ink used in the magnetic coding system as defined in the international standard for magnetic ink character recognition ISO 1004.

These properties are fulfilled when the combination of shape, composition or structure of the magnetic elongated particles is such that the elongated particles have :

- i) a saturation field ranging from 100 to 1000 A/m ;
- ii) a saturation flux density ranging from 0.1 to 1 Tesla, preferably 0.1 to 0.5 Tesla ;
- iii) a magnetic dynamic relative permeability μ_r' ranging from 100 to 10000.

Preferably the magnetic elongated particles have a D.C. magnetic remanence smaller than 0.3 Tesla.

The magnetic elongated particles, especially the fibres, have a mean cross-sectional diameter ranging from 1 to 30 micrometer particularly from 5 to 15 micrometer and a length ranging from 1 to 20 mm, preferably from 2 to 10 mm.

Most preferably the elongated particles are hard drawn or work hardened metal fibres, but can also be amorphous metal fibres.

The magnetic elongated particles can be made of an alloy comprising components chosen among Ni, Fe, Cu, Cr, Co, Mo, Mn, Nb, B, V, Si and P, and more particularly Fe, Ni, Mo, Mn, Cu.

The base material of the substrate can be made of paper or of a synthetic material, especially plastic as polypropylene or polyethylene.

The magnetic particles can also be made of magnetic and non-magnetic material.

Preferably the substrate according to the fourth aspect of the present invention, has a quantity of magnetic elongated particles ranging from 0.1 to 5 per cent, most preferably from 0.5 to 1.5 per cent by weight relative to the weight of said substrate.

Preferably the elongated particles, especially the fibres have a colour near to the colour of the base material. This can be realised by the deposit of a covering or a coating providing to the fibres the wished colour. A method of depositing such a coating has been disclosed in French patent application FR 95 02868 and in international application PCT/FR/96 00390.

The present invention provides security documents comprising said magnetic elongated particles uniformly dispersed inside said substrate, said substrate comprising a paper or plastic sheet. More particularly the magnetic elongated particles are made of metallic fibres, the quantity of magnetic fibres in said substrate ranging from 0,2 to 2 %, the substrate being a paper sheet, especially of 20 to 300 μm of thickness, preferably banknotes of 80 to 120 μm .

Short description of the drawings.

The present invention will now be illustrated in more detail with reference to the accompanying drawings wherein

- 5 - FIGURE 1 compares the B-H curve of a magnetic particle according to the invention with B-H curves of other objects ;
- FIGURE 2 schematically illustrates a configuration of a detection apparatus according to the present invention ;
- FIGURE 3 shows how a drive coil and a detection coil of an invention apparatus can be arranged ;
- FIGURE 4, FIGURE 5 and FIGURE 6 all illustrate embodiments of drive coil and detection coil for use in a repro-
10 duction apparatus.

Detailed description of a preferable embodiment.

15 Reference number 10 in FIGURE 1 refers to a B-H curve of an EAS label which can be designated as "very soft magnetic". It is characterised by a very low saturation field H_s and a rather high level of magnetic dynamic permeability. Reference number 12 refers to a B-H curve of a magnetic elongated particle which is to be embedded in a substrate according to the present invention. Although being also a soft magnetic material, it is not that "very soft" as is an EAS label. The saturation field H'_s is higher and the corresponding values of an EAS label. Reference number 14 refers to the B-H curve of a mild steel plate clearly showing a saturation field H''_s that is much larger than H_s and H'_s .

20 It will be clear from FIGURE 1 that the low magnetic fields applied in EAS systems to saturate the EAS labels do not saturate the magnetic particles according to the present invention and do not trigger the alarm systems in shops. It will also be clear from FIGURE 1 that magnetic fields applied in the present invention to saturate the magnetic particles are still in the linear part of a B-H curve of a mild steel and will not create the same series of higher harmonics. This difference can be used in order to discriminate between the two types of materials and even to detect the marker tag in
25 the presence of large Ferro-magnetic objects.

The following table shows an experimental comparison of actual markers and examples of common magnetic objects measured in a magnetometer at between 5 to 20 kHz.

Table

Type of material + geometric dimensions	saturation flux B_s (Tesla)	saturation field H_s (A/m)	dynamic permeability $\mu_r' [B_s/(\mu_0 H_s)]$
EAS label 32 mm x 0.8 mm x 25 μ m	0.35	30	10000
35 paper clip		> 1000	60
mild steel pate 12 mm x 9 mm x 1 mm		>> 1000	30
40 hard drawn magnetic metal fibre 3 mm length x 8 μ m diameter	0.55	600	730

The magnetic metal fibre had an a.c. remanence of 0.3 Tesla in the measurement. In practice the d.c. remanence would be lower than this so that no significant electromagnetic noise signals are generated which interfere with other magnetic code systems. In particular, the fibres did not give any significant signal with a standard magnetic character
45 reader reading characters made in magnetic inks. In other words, using the measurement method and definition of maximum residual signal levels as defined in the International Standard for magnetic ink character recognition, ISO 1004, the effect of remanent flux is acceptable.

Experimental results show that it is possible to detect a good signal amplitude at high harmonics from the fibre mentioned in the above table and that at high frequencies there is very low interference from harmonics from the drive
50 electronics. With the small cross sectional area of the fibres the eddy current losses are small up to quite high frequencies and the output signals are increased by the fact that the detected voltage is proportional to the rate of change of flux. With bulk ferromagnetic materials the eddy current losses are much higher at high frequencies and so they don't generate very high harmonics. Using a base frequency to sweep the fibres (which are characterised in the table above) around their B-H loop at 20 kHz, and a peak field greater than 600 A/m it was found that at frequencies between 100
55 kHz and 1 MHz there was a stream of harmonics from the fibres and very much smaller signals from other common electrically conducting objects including for example aluminum or steel objects, plates and slabs, printed circuit boards and metallic foil greeting cards. In practice the base frequency and the detection frequency or frequencies can be selected to maximise the signal from the particular fibre marker and minimise signals from other common objects and

signals generated from the apparatus in which the system is installed.

Tests carried out by the invention have proved that the invention system provides a good discrimination between a security document with magnetic elongated particles and paper, books, hands, printed circuit boards, foil greeting cards, non metallic bindings of documents, spiral metal bindings of documents, paper clips, metal plates and photocopy-
 5 lid materials. A security document lying under a non-magnetic metal plate could be easily identified (this in great contrast with a microwave system where the metal plate conceals the magnetic fibres for the microwaves).

A suitable drive and detection circuit is shown in FIGURE 2. A resonant drive power oscillator 16 is used to minimise harmonic generation and the oscillator 16 is driven by a frequency which is divided down from the selected harmonic. As an example, the inventors have found that, amongst other harmonics, the 19th harmonic of 20 kHz, at 380
 10 kHz may be a good choice as it gives good signals from fibres with very small signals from common Ferro-magnetic materials such as mild steel. The oscillator 16 generates an electrical source signal which is fed to a drive coil 18 which transforms the electrical source signal into a magnetic drive signal. A detection coil 20 suitably arranged with respect to the drive coil 18, detects any field emanating from magnetic particles and transforms this into an electrical detection signal. A high pass filter 22 is used to reduce the fundamental frequency, as this can be coupled between the coils by
 15 conducting metals and overload the amplifiers. A phase sensitive detector 24 is used to provide good signal-to-noise ratio. Oscillator 26 operates at the frequency of the selected harmonic, and frequency divider 28 divides the frequency in order to obtain the base frequency. Other high harmonics are also suitable and it is an advantage to combine several to derive the final detection signal.

FIGURE 3 illustrates how the drive coil 18 may be advantageously arranged with respect to the detection coil 20. The direction of the magnetic field generated by the drive coil is shown in hatched lines, except for that part of the mag-
 20 netic field that goes through the detection coil 20, which is shown by means of arrows 30 and 32. Drive coil 18 and detection coil 20 partially overlap and are so arranged that the part of the magnetic flux which goes in one direction (arrow 30) through detection coil 20 is almost equal to the part of the flux which goes in the other direction (arrow 32) in order to null-out the drive field in the detection coil whilst providing a region above the overlapping coils in which the
 25 magnetic field is effective in coupling into the magnetic particles. An equivalent nulling effect could also be provided electronically by a negative feed back of a fundamental frequency.

FIGURE 4, FIGURE 5 and FIGURE 6 all show embodiments of arrangement of drive coil and detection coil to be used in reproduction apparatus such as high-resolution colour photocopying apparatus. The arrangement is such that a bank note with a width of only 7 cm can be detected on a scanning area of 21 cm x 29.7 cm (if it comprises magnetic
 30 particles).

According to FIGURE 4, four pairs of a drive coil 18 with a detection coil 20 are arranged on a suitable carrier 34 at regular distances along the width of the scanning area so that the presence of any genuine bank note will be detected irrespective of its position on the scanning area.

In the embodiment of FIGURE 5 a plurality of drive coils 18 and a plurality of detection coils 20 form a daisy chain
 35 wherein a drive coil 18 is alternated with a detection coil 20 and vice versa.

In the embodiment of FIGURE 6 the drive coil 18 takes the form of an elongated eight with the height of the eight equal to the width of the scanning area. The detection coil takes the form of an elongated ellipse with the length of the longitudinal axis equal to the width of the scanning area. Drive coil 18 and detection coil 20 are arranged one above the other so that here also the part of the magnetic flux which goes in one direction through detection coil 20 is almost equal
 40 to the part of the flux which goes in the other direction in order to null-out the drive field in the detection coil. FIGURE 6 shows for didactical reasons a drive coil 18 and a detection coil 20 at a distance apart from each other, but they are to be arranged next to one another.

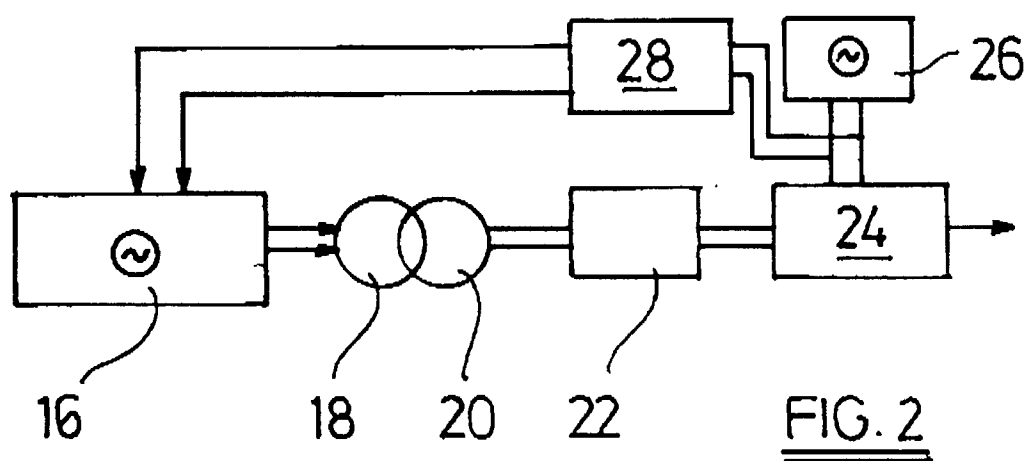
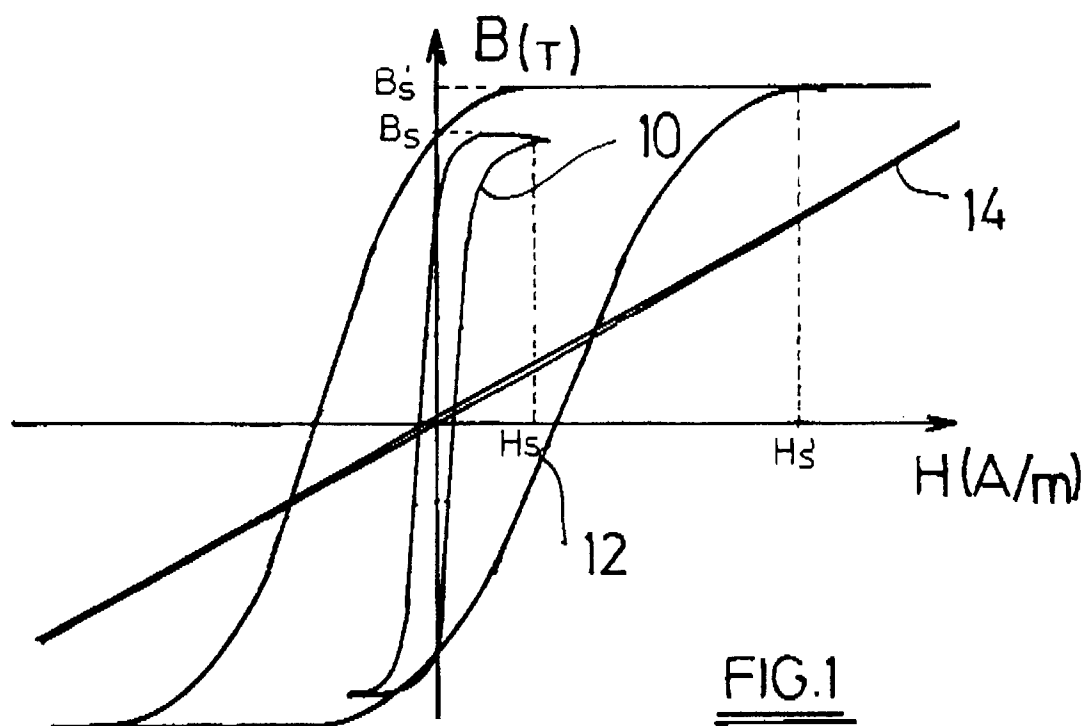
FIGURE 7 shows schematically an embodiment with only one drive coil 18 and four detection coils 20 so arranged that the drive magnetic field balances out in detection coils 20.

Claims

1. A substrate comprising a base material and elongated particles inside said base material, the magnetic properties of said particles differing from the corresponding magnetic properties of said base material, the particles having
 50 such a long and thin form that their demagnetisation factor N is smaller than $1/250$, preferably smaller than $1/1000$, their diameter being smaller than 30 micrometer and their magnetic saturation field ranging from 100 to 1000 A/m.
2. A substrate according to claim 1 wherein said elongated particles have a magnetic saturation flux ranging from 0.1 to 1 Tesla.
3. A substrate according to claim 1 or 2 wherein said elongated particles have a magnetic dynamic permeability μ_r'
 55 ranging from 100 to 10000.

4. A substrate according to anyone of claims 1 to 3 wherein said base material is made of paper or plastic.
5. A substrate according to anyone of claims 1 to 4 wherein the combination of shape, composition and structure of the magnetic particles is such that they have :
 - i) a saturation field ranging from 100 to 1000 A/m ;
 - ii) a saturation flux density ranging from 0.1 to 1 Tesla ;
 - iii) a dynamic relative permeability ranging from 100 to 10000.
6. A substrate according to anyone of claims 1 to 5 wherein said particle has a D.C. magnetic remanence which is smaller than 0.3 Tesla.
7. A substrate according to anyone of claims 1 to 6 wherein said elongated magnetic particles are made of a magnetic material, or a non-magnetic material being coated or encapsulated with a magnetic material.
8. A substrate according to anyone of claims 1 to 7 wherein the magnetic elongated particles have a mean cross-sectional diameter ranging from 1 to 30 micrometer and a length ranging from 1 to 20 mm.
9. A substrate according to anyone of claims 1 to 8 wherein the quantity of magnetic elongated particles in said substrate ranges from 0.1 to 5 per cent by weight relative to the weight of said substrate.
10. A substrate according to claim 1 to 9 wherein said particles are hard drawn or work hardened metal fibres.
11. A substrate according to anyone of claims 1 to 9 wherein said particles are amorphous metal fibres.
12. A substrate according to anyone of claims 1 to 11 wherein said magnetic articles are made of an alloy comprising components chosen among Fe, Cr, Co, Ni, Cu, Mo, Mn, Nb, Si, V, B, and P.
13. A substrate according to claim 12 wherein the said alloy comprises components chosen among Ni, Fe, Cu, Mo and Mn.
14. A security document comprising a substrate as claimed in claims 1 to 13.
15. An antiphotocopy security document according to claim 14 comprising said magnetic elongated particles uniformly dispersed inside said substrate, said substrate comprising a paper or plastic sheet.
16. A security document comprising a substrate as claimed in claims 1 to 15 wherein the magnetic elongated particles are made of metallic fibres, the quantity of magnetic fibres in said substrate ranging from 0,2 to 2 %, the substrate being a paper sheet.
17. A method for detecting the presence of magnetic elongated particles in a substrate according to anyone of claims 1 to 16, said method comprising following steps :
 - (a) emitting an electromagnetic source signal of one or more particular base frequencies to said substrate so that any present magnetic elongated particles go into a non-linear part of their B-H curve for at least part of a cycle of the source signal ;
 - (b) detecting an electromagnetic detection signal emanating from said substrate ;
 - (c) testing the detection signal for the presence of particular higher harmonics of said base frequencies or of any linear combination of said base frequencies as well as the harmonics, said particular higher harmonics being indicative of the presence of said magnetic particles.
18. A method according to claim 17 wherein said source signal has only one base frequency.
19. A method according to claim 18 wherein said base frequency is higher than kHz.
20. A method according to anyone of claims 17 to 19 wherein said particular higher harmonics have a frequency higher than 10 kHz.

21. A method according to claim 20 wherein said particular higher harmonics are of the order of ten or higher.
22. A method according to claim 20 or 21 wherein said particular higher harmonics is of the order of 19 and has a frequency of 380 kHz.
23. A method according to anyone of claims 17 to 22 wherein, in addition to said electromagnetic source signal, micro-waves are emitted to said substrate to detect the presence of any present magnetic elongated particles.
24. A method according to anyone of the preceding claims wherein said method comprises the following additional step :
 - d) generating a signal which prevents from taking a true copy in case said particular harmonics are present.
25. A magnetic elongated particle for being incorporated in a base material of a substrate with magnetic properties differing substantially from the corresponding magnetic properties of said particle, said particle having such a long and thin form that its demagnetisation factor N is smaller than 1/250, preferably smaller than 1/1000, a diameter being smaller than 30 micrometer and a magnetic saturation field ranging from 100 to 1000 A/m.
26. A magnetic particle according to claim 25 wherein said particle has a magnetic saturation flux ranging from 0.1 to 1 Tesla.
27. A magnetic particle according to claims 25 to 26 wherein said particle has a magnetic dynamic permeability μ_r' ranging from 100 to 10000.
28. A magnetic particle according to anyone of claims 25 to 27 wherein the combination of shape, composition and structure of the magnetic particle is such that they have :
 - i) a saturation field ranging from 100 to 1000 A/m ;
 - ii) a saturation flux density ranging from 0.1 to 1 Tesla ;
 - iii) a dynamic relative permeability ranging from 100 to 10000.
29. A magnetic particle according to anyone of claims 25 to 27 wherein said magnetic particle is made of a magnetic material or a non-magnetic material coated or encapsulated with a magnetic material.
30. A magnetic particle according to anyone of claims 25 to 28 wherein said magnetic particle has a mean cross-sectional diameter ranging from 1 to 30 micrometer and a length ranging from 1 to 20 mm.
31. A magnetic particle according to anyone of claims 25 to 30 wherein said magnetic material is made of an alloy comprising components chosen among Fe, Co, Cr, Ni, Cu, Mo, Mn, Nb, Si, V, B, and P.
32. A magnetic particle according to anyone of claims 25 to 31 wherein said particle has a D.C. magnetic remanence smaller than 0.3 Tesla.



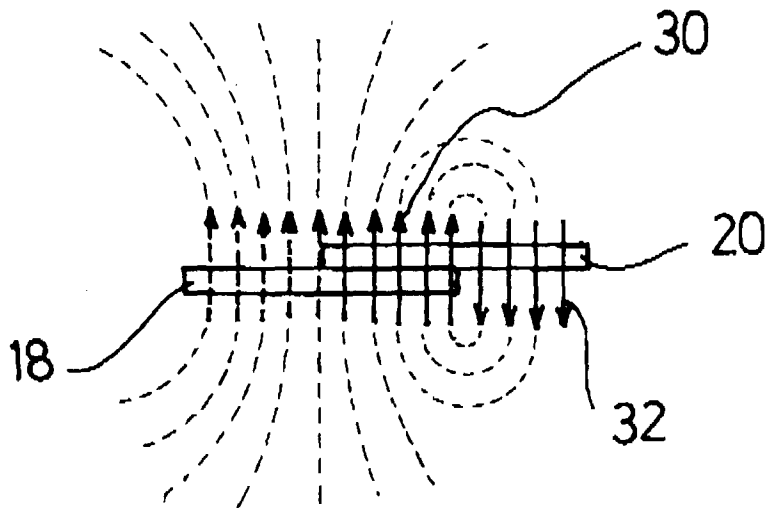


FIG. 3

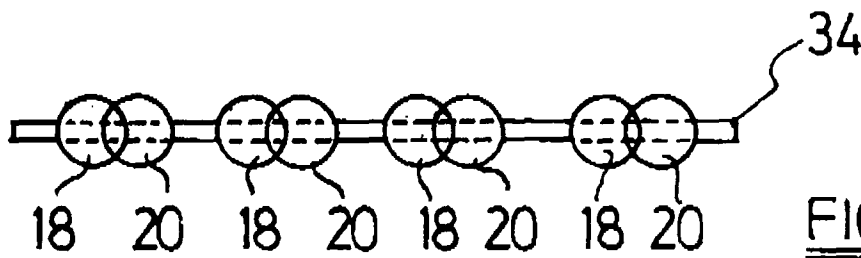


FIG. 4

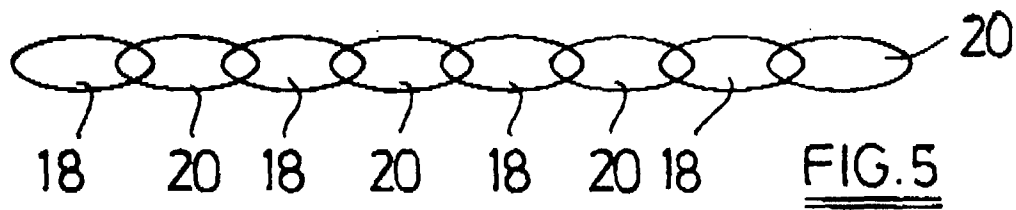


FIG. 5

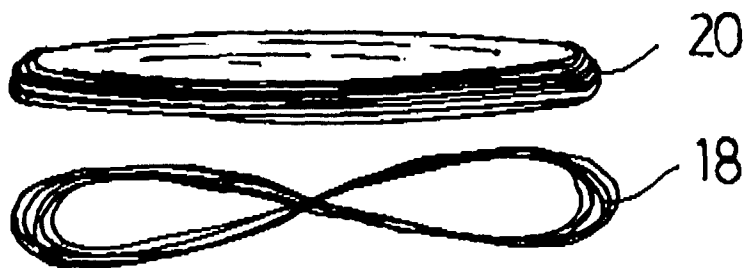


FIG. 6

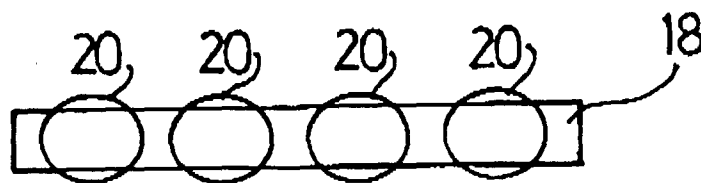


FIG. 7



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 96 40 2721

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	DE 26 35 795 A (DASY INT SA) 17 March 1977 * claim 1; figure 1 * ---	1-32	G07D7/00 G07F7/08
A,D	US 4 114 032 A (BROSOW JORGEN ET AL) 12 September 1978 * claim 1; figure 1 * ---	1-32	
A,D	EP 0 656 607 A (NHK SPRING CO LTD) 7 June 1995 * claim 1; figure 1 * ---	1-32	
A,D	EP 0 632 398 A (NHK SPRING CO LTD) 4 January 1995 * claim 1; figure 1 * ---	1-32	
A,D	EP 0 625 766 A (NHK SPRING CO LTD) 23 November 1994 * claim 1; figure 2 * ---	1-32	
A,D	WO 95 24000 A (BEKAERT SA NV) 8 September 1995 * claim 1; figure 1 * -----	1-32	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6) G07D G07F
Place of search THE HAGUE		Date of completion of the search 14 May 1997	Examiner Kirsten, K
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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