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(54) **Detection method of semi-soft security features**

(57) A method for detecting the presence of a semi-soft magnetic or soft magnetic security feature in a substrate of a security article wherein this soft magnetic security feature has a magnetic saturation field ranging from 100 A/m to 1000 A/m, comprises following steps :

(a) emitting an electromagnetic drive signal of one or more particular frequencies to an article so that any present semi-soft magnetic security features in the article go into saturation for both positive and negative magnetic fields;

(b) detecting an electromagnetic detection signal (20) emanating from the article;
(c) measuring the height (C) of the peaks of the detection signal ;
(d) measuring the time or relative phase delays (B) between a reference point of the drive signal and a point at which the peaks occur;
(e) comparing the measured heights and measured time or relative phase delays with values which are typical for semi-soft magnetic features.

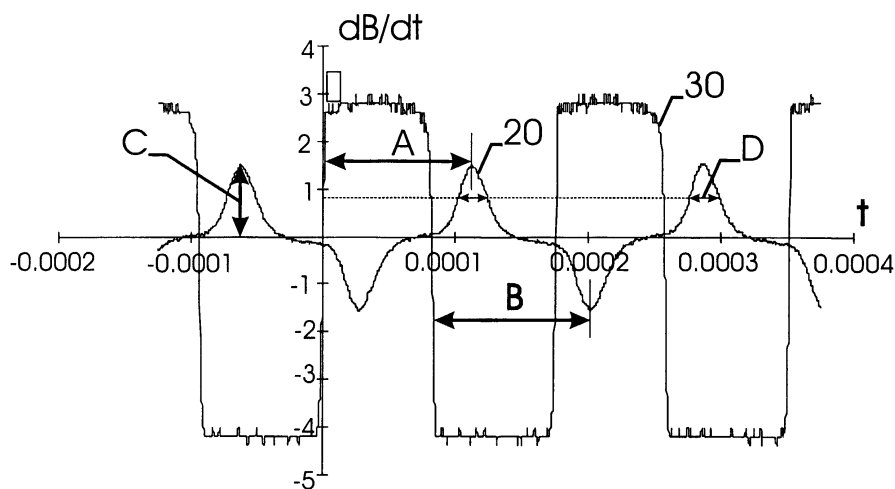


FIG. 2

Description

Field of the invention.

[0001] The present invention relates to a method for detecting the presence of a semi-soft magnetic security feature in a substrate of a security article.

Background of the invention.

[0002] Soft magnetic security features are well known in the art of electronic article surveillance systems (EAS) and are often called anti-pilferage tags. The EAS systems make use of the non-linear magnetic properties of the B-H loop of the soft magnetic material. Small activating fields typically drive the soft magnetic material into saturation. Sensitivity to small fields is required here because it is difficult to generate a large magnetic field at a distance from a source, and typical EAS systems need to interrogate as large a volume as possible, e.g. the public access routes in and out of shops. The security features used here are therefore commonly based upon very soft magnetic materials such as the amorphous Metglas® or Vitrovac® or thin films such as made of a $\text{Co}_a\text{Fe}_b\text{Ni}_c\text{Mo}_d\text{Si}_e\text{B}_f$ alloy, where a to f are atomic percentages and a ranges between 35 % and 70 %, b between 0 % and 8 %, c between 0 % and 40 %, d between 0 % and 4 %, e between 0 % and 30 %, f between 0 % and 30 %, with at least one element of each of the groups (b, c, d) and (e, f) being non zero. Such a $\text{Co}_a\text{Fe}_b\text{Ni}_c\text{Mo}_d\text{Si}_e\text{B}_f$ composition is hereinafter referred to as a CoFeNiMoSiB composition. CoFeNiMoSiB films are marketed under the name of Atalante®.

The term "thin" here refers to a film having a thickness, which is smaller than 10 micrometer. These materials have a very low coercivity and a high magnetic permeability.

Generally, the term "soft magnetic" typically refers to materials having a low coercive force, e.g. a coercive force ranging between 3 A/m and 100 A/m (measured at 1 kHz).

[0003] Using non-linear magnetic properties for the authentication of objects could also be an attractive approach because of simplicity and sensitivity. However, the approach would be of little use if the security elements set-off the alarms of the gates commonly used for EAS. The approach would also be of little use unless the security elements were difficult to obtain or copy.

[0004] Patent applications WO-A-98/26378 and WO-A-98/26377 disclose how to solve the above problem. The security element used comprises small, elongated magnetic particles which require a magnetic field greater than 100 A/m, and preferably greater than 300 A/m, to saturate. This property is chosen to ensure that the magnetic hardness of the particles is sufficiently high that they will not be driven into saturation at the field strengths commonly used in EAS gates. The security feature used here will therefore not set-off the alarm of

the EAS gates.

[0005] In addition it is desirable to keep the magnetic field required for saturation well below that at which more commonly available Ferro-magnetic materials will saturate and to keep it at a sufficiently low level that the particles can be saturated, and therefore detected, at short ranges from a compact reading apparatus. In general this implies magnetic fields of less than about 3000 A/m.

[0006] The term "semi-soft magnetic material" refers to magnetic materials typically having a magnetic saturation field ranging from 100 A/m to 3000 A/m, e.g. from 200 A/m to 3000 A/m, preferably from 300 A/m to 3000 A/m (measured at 1 kHz).

[0007] Although the generation of high harmonics at low magnetic field strengths is particular to the soft magnetic materials in the case of EAS and to the semi-soft magnetic materials in the case of authentication, the inventors have discovered, however, that there is no clear difference between these types of materials. This is particularly true if the orientation of the security element is varied relative to the magnetic field.

[0008] Another problem with soft magnetic materials and semi-soft magnetic materials is that soft magnetic materials may be looked as semi-soft magnetic materials at a great distance between the drive coil and the material.

Moreover the drive field at which the security element will saturate, will vary with the orientation of the security element in the field.

These problems can be solved by making the authentication method a contact one or by ensuring that the spatial orientation of the drive coil and material are fixed. However, for hand-held applications it is most convenient to validate the security element with a non-contact reading where the spatial orientation between drive coil and material is not fixed.

[0009] Still another problem is that there may be a magnetic field, external to the field generated by the drive coil, which could bias the total field.

Summary of the invention.

[0010] It is an object of the present invention to avoid the problems of the prior art.

It is a further object of the present invention to provide an authentication system, which can discriminate between various types of soft magnetic and semi-soft magnetic materials.

It is a further object of the present invention to provide a non-contact and a hand-held method for authentication.

It is also an object of the present invention to provide a compact low cost reading apparatus, which can be used to detect the special markers at distances up to a few centimeters.

According to the invention there is provided a method for detecting the presence of a semi-soft magnetic or

soft magnetic security feature in a substrate of a security article. The magnetic security feature is preferably a semi-soft magnetic security feature with a magnetic saturation field ranging from 100 A/m to 1000 A/m.

The method comprises following steps :

- (a) emitting an electromagnetic drive signal of one or more particular frequencies to an article so that any present semi-soft magnetic security features in the article go into saturation for both positive and negative magnetic fields;
- (b) detecting an electromagnetic detection signal emanating from the article;
- (c) measuring the height of the peaks of the detection signal;
- (d) measuring the time or relative phase delays between a reference point of the drive signal and a point at which the peaks occur;
- (e) Comparing the measured heights and measured time or relative phase delays with values, which are typical for semi-soft magnetic features.

The height of the peaks of the detection signal gives an indication about the distance or the orientation of the article.

[0011] The time or relative phase delay between a reference point of the drive signal and a point at which the peaks occur give, together with the height of the peaks, an indication of the magnetic softness of the article.

[0012] Due to the fact that an indication is given about the distance or orientation of the material, the detection method can be a non-contact method, and more particularly a hand-held method.

[0013] In a preferable embodiment the electromagnetic detection signal is proportional to the rate of change of magnetic flux in the article ($dB(t)/dt$).

[0014] In another example the electromagnetic detection signal is proportional to an integral of the rate of change of magnetic flux in the article ($B(t)$).

[0015] In a more elaborated example, the detection method further comprises a step of measuring the width of the peaks of the detection signal at one or more levels in order to discriminate semi-soft magnetic security features from Ferro-magnetic materials such as iron.

[0016] The semi-soft magnetic security feature can take many forms.

[0017] In a typical example the semi-soft magnetic security feature comprises a number of fibres such as disclosed in the above-mentioned patent applications WO-A-98/26378 and WO-A-98/26377.

[0018] In another example the semi-soft magnetic security feature comprises a thin semi-soft magnetic film.

[0019] In both examples the demagnetisation factor N of the fibres or the thin films is very low. Preferably, the demagnetisation factor N ranges from 10^{-5} to 10^{-4} . Such a low demagnetisation factor N means that the dynamic magnetic permeability μ_r' is not reduced very much in comparison with the bulk permeability μ_r and

remains very high.

[0020] In a preferable embodiment of the invention, the semi-soft magnetic security feature comprises two or more types of magnetic material with different magnetic coercivity values, e.g. two or more different thin semi-soft magnetic films.

In comparison with security features which only comprise a single semi-soft magnetic material with only one coercivity value, such a security feature with two or more different values of coercivity has the following advantages:

- (a) it is easier to detect and to distinguish from other soft magnetic and semi-soft magnetic materials;
- (b) it is more difficult to copy as security feature ;
- (c) The detection algorithm is more difficult to copy.

Brief description of the drawings.

[0021] The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1 compares a dB/dt signal coming from a soft magnetic material with a dB/dt signal coming from a semi-soft magnetic material.
- FIGURE 2 illustrates what values can be measured on a dB/dt curve in a detection method according to the invention.

Description of the preferred embodiments of the invention.

[0022] In a detector apparatus one or more coils, the drive coils, are driven with an alternating current to drive the security elements into saturation for both positive and negative magnetic fields. One or more coils, the detection coils, are used to detect the returned signal which is proportional to the rate of change of flux with time ($dB(t)/dt$). Signal processing electronics is then used to process and analyse the signals and to provide an indicator signal which may be visual or auditive, when materials having the correct magnetic properties are situated in the drive field.

[0023] FIGURE 1 shows time plots 10 and 20 of typical $dB(t)/dt$ signals received from two magnetic materials with different magnetic properties. It can be seen that the two materials have both different shapes and that they occur at different distances along the time axis, which is referenced to the drive current in the drive coils. In this plot the peaks of the signal correspond with the maximum slope of the B-H loop. The material corresponding to plot 10 is a soft magnetic material; the material corresponding to plot 20 is a semi-soft magnetic material.

[0024] FIGURE 2 shows a time plot 20 of a typical $dB(t)/dt$ signal received from a semi-soft magnetic material and of a square wave 30. Square wave 30 is derived

from the sinusoidal drive current to the drive coils. This square wave 30 is used to provide a reference to start measuring the A-value and the B-value.

Both the A-value and the B-value are time or relative phase delays between reference points of the drive signal and a point at which the peaks in the $dB(t)/dt$ occur. In terms of signal processing it has been found practical to sum the A-value and the B-value to obtain an indication on the magnetic hardness of the material under detection. The height C of the peaks of the $dB(t)/dt$ signal is also measured. Only measurements of C within a certain range of amplitude are further processed since measurements of C lying outside that range indicate that the article under detection is too remote or is too close. The height C provides information the distance or the orientation of the magnetic material. Due to the fact that an indication is given about the distance or orientation of the material, the detection method can be a hand-held method. Alternatively, if increased precision of measurement is needed, it may be used in a configuration in which the distance and orientation of the material from the signal drive and detection means is known. The measurement of the magnetic hardness can then reliably based on the sum of the above-mentioned A- and B-values. Using this approach it has been found to be possible to minimise the effect of external fields and to give reliable discrimination between materials of different hardness. This reliability can be explained as follows. The A-value is the time interval between a reference and a positive peak and the B-value is the time interval between a reference and a negative peak. Any extraneous magnetic fields are compensated in this way.

[0025] It has also been found that adding into the recognition algorithm a parameter based on the shape of the positive and / or negative pulses of the $dB(t)/dt$ signal can give a further improvement in the ability to discriminate materials. One example of this parameter is the width D of the peak at one or more levels of the $dB(t)/dt$ signal. Measurement of D is a good way to determine if the returned signal is from a large object of common Ferromagnetic materials such as iron. Magnetically hard materials such as iron will not be saturated by the detector field but they will return a large sinusoidal signal. The shape of $dB(t)/dt$ signals returned from iron is much more rounded than the signals from soft magnetic and semi-soft magnetic materials as shown in Figures 1 and 2. To improve the consistency of the width measurement for different magnitudes of the returned signal it is beneficial to use a circuit which tracks the peak value and then measures the width at one or more fixed fractions of the peak value.

[0026] If the security feature is constructed from several materials with different magnetic properties, and particularly if this property is the magnetic field required to drive them into saturation, then the returned signal will show changes in shape as each material goes into saturation. In fact, a double or a triple superimposed B-

H hysteresis curve is obtained, because of the different magnetic properties. Ferromagnetic coupling between the various magnetic materials also effects this curve, which means that the coercivity values of the various materials taken in isolation, will be changed due to the combination of the materials. In the case of thin films, this ferromagnetic coupling is largely dependent upon the thickness of the layers so that a wide variety of security features can be obtained.

The relative positions of the shape changes of the B-H curve can be used in the same way as for the single materials to determine parameters proportional to the hardness of the materials.

An example of such a security element is a combination of a thin CoFeNiMoSiB film with a thin film of an amorphous $Co_xZr_yNb_z$ alloy.

[0027] As is well known, the magnetic properties of the materials can be strongly affected by the shape factor (the ratio of length to cross-section area). For example, if the security feature is in the form of magnetic fibres of high permeability material, then the field at which they will saturate can be controlled by altering the length to diameter ratio.

However, altering the orientation of the fibres relative to the magnetic field will also change the field at which they will saturate and so this needs to be taken into account in interpreting the signals from the reading apparatus. One example, if the fibres are randomly distributed in the substrate, is to extract the minimum saturation field to determine the type of material present. An alternative would be to orient the fibres so that they can be aligned with the interrogating magnetic field.

[0028] If the security feature is made up from a combination of materials showing a significant anisotropy between the saturation field in the hard and soft directions, and these materials are arranged with their soft axes at a range of discrete angles, then the signal from a relative rotation between the detector and material will show peaks as the drive field aligns with each soft axis direction. This approach can be used to provide a coded signal. The reference point for the coded signal could be one layer with a greater thickness or permeability, which would always give a greater signal than the other layers, or it could be via an optical security feature and associated sensor system. An alternative would be to use the shape anisotropy of magnetic fibres, which could then be aligned at a series of discrete angles in the substrate to give the same effect as, described above.

Claims

1. A method for detecting the presence of a semi-soft magnetic or soft magnetic security feature in a substrate of a security article, said method comprising following steps :

- (a) emitting an electromagnetic drive signal of one or more particular frequencies to an article so that any present semi-soft magnetic or soft magnetic security features in said article go into saturation for both positive and negative magnetic fields ;
 (b) detecting an electromagnetic detection signal (20) emanating from said article ;
 (c) measuring the height (C) of the peaks of said detection signal;
 (d) measuring the time or relative phase delays (B) between a reference point of the drive signal and a point at which said peaks occur;
 (e) comparing the measured heights and measured time or relative phase delays with values which are typical for semi-soft magnetic or soft magnetic features.
2. A method according to claim 1 wherein said security feature is a semi-soft magnetic feature having a magnetic saturation field ranging from 100 A/m to 1000 A/m.
3. A method according to claim 1 wherein said method is a non-contact method.
4. A method according to claim 1 or claim 2 wherein said method is a hand-held method.
5. A method according to any one of the preceding claims wherein said electromagnetic detection signal is proportional to the rate of change of magnetic flux in the article ($dB(t)/dt$).
6. A method according to claim 1 wherein said electromagnetic detection signal is proportional to an integral of the rate of change of magnetic flux in the article ($B(t)$).
7. A method according to any one of the preceding claims, said method further comprising a step of measuring the width of the peaks of said detection signal at one or more levels in order to discriminate semi-soft magnetic and soft magnetic security features from Ferro-magnetic materials such as iron.
8. A method according to any one of the preceding claims wherein said semi-soft magnetic or soft magnetic security feature comprises a number of magnetic fibres.
9. A method according to any one of claims 1 to 6 wherein said semi-soft magnetic or soft magnetic security feature comprises a thin semi-soft magnetic film.
10. A method according to claim 7 or claim 8 wherein the demagnetisation factor N of the magnetic fibres or of the thin film varies between 10^{-5} and 10^{-4} .
11. A method according to any one of the preceding claims wherein said semi-soft magnetic or soft magnetic security feature comprises two or more types of magnetic material with different magnetic coercivity values.
12. A method according to claim 10 wherein said semi-soft magnetic or soft magnetic security feature comprises two or more different thin soft magnetic films.
13. A method of providing semi-soft magnetic or soft magnetic material which is suitable to function as a security feature in a detection method according to any one of the preceding claims, said method comprising as step combining two or more types of magnetic material with different magnetic coercivity values.

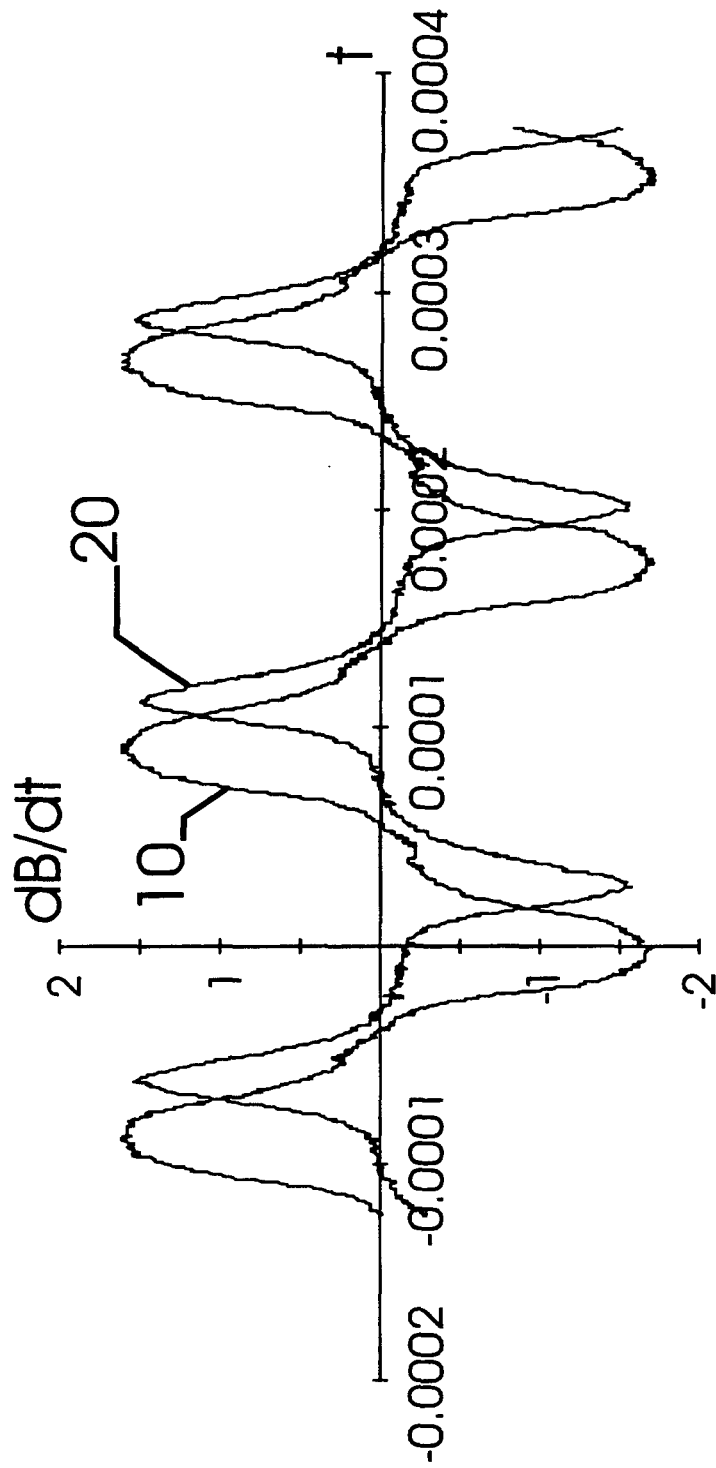


FIG. 1

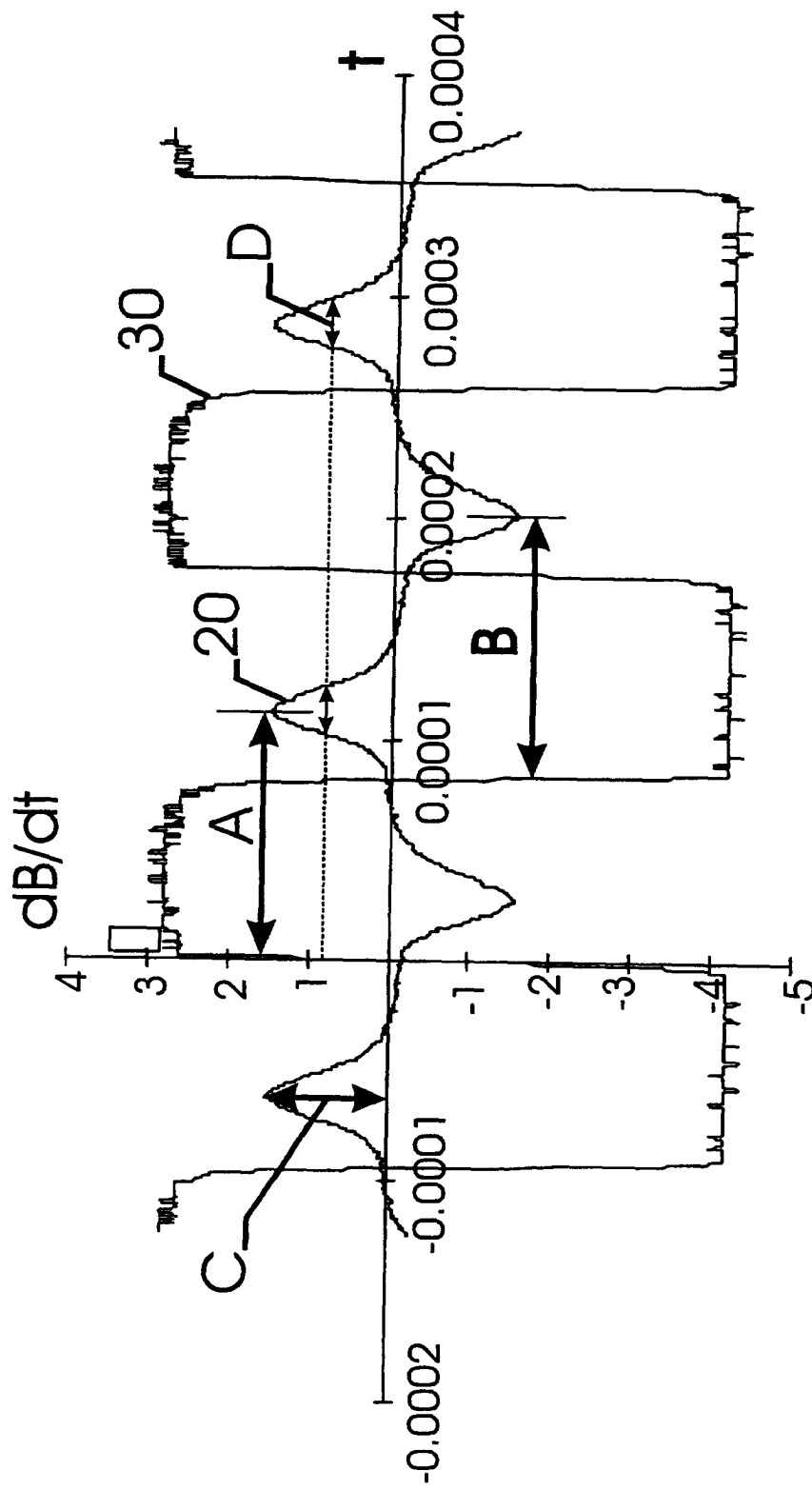


FIG. 2



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 3618

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 April 2000	Examiner De la Cruz Valera, D
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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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