(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 961 301 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
01.12.1999 Bulletin 1999/48

(21) Application number: **98953009.2**

(22) Date of filing: **11.11.1998**

(51) Int. Cl.[6]: **H01F 1/12**, H01F 10/00

(86) International application number:
PCT/JP98/05069

(87) International publication number:
WO 99/26257 (27.05.1999 Gazette 1999/21)

(84) Designated Contracting States:
DE ES FR IT

(30) Priority: **17.11.1997 JP 31498397**

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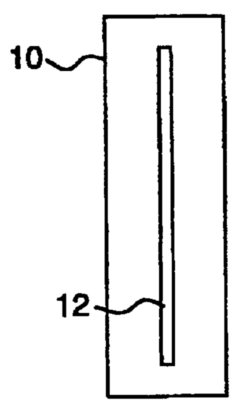
(54) A MAGNETIC MARKER

(57) A small-sized magnetic marker is provided which can be used with good sensitivity in both a so-called large Barkhausen type system and a so-called high permeability type system. The magnetic marker includes a soft magnetic material with its length not longer than 70 mm. When an external alternating field having magnetic field strength of not higher than 0.2 Oe is applied, the soft magnetic material generates abrupt magnetization reversal with a magnetic flux change of not less than 8.0×10^{-9} Wb. It is preferable that a fluctuation in the magnetic field strength, where soft magnetic material generates the abrupt magnetization reversal, is not higher than 0.1 Oe.

Fig.1A



Printed by Xerox (UK) Business Services
2.16.7/3.6

Description

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0001] The present invention relates to a magnetic marker to be used in an electronic apparatus for monitoring articles.

BACKGROUND ART

[0002] In order to prevent a theft of articles, many electronic article monitors have been used recently. A special marker is attached to a target article, and such a monitor discriminates the existence of the article according to a signal generated due to the marker. There are some types of systems, and they are mainly classified into a system for utilizing magnetizing process of a special soft magnetic material, a system for utilizing an abrupt change in impedance of an LC resonance circuit at a specified frequency, and a system for radiating a special electric wave from an oscillation circuit.

[0003] In the above systems, the magnetic system has been used recently widely because a marker can be supplied at a low price. The magnetic system is roughly classified into a type utilizing magnetostrictive vibrations and a type utilizing hysteresis characteristic.

[0004] Details of the magnetic marker and the system utilizing hysteresis characteristic are disclosed, for example, in Japanese Patent Publication No. 3-27958 (1991). According to this publication, a material including an Febased amorphous metallic wire is used as a magnetic marker. A detection system is installed in an area where articles are monitored, and an ac magnetic field of 73 Hz, for example, is generated as an inquiry signal from an exciting coil. As a result, when magnetization of the metallic wire included in the magnetic marker is reversed, a voltage is induced in a detection coil, and it is discriminated as a detection signal. The above-mentioned material of the metallic wire is characterized in that its magnetization is very stable in a longitudinal direction, and the magnetization is reversed simultaneously just as the magnetic field reaches a critical value and the flux reversal is completed in a moment. This characteristic is bistable and is often called as large Barkhausen reversal. Since when such a material is excited by a great amplitude, a discontinuous and extremely abrupt step of the magnetization is observed in a hysteresis loop, and it can be discriminated. When the magnetization is abruptly reversed in the marker, a very high pulse voltage is induced in the detection coil. Since the induced voltage waveform is extremely unique, in comparison with other general magnetic materials, such as an iron plate used for a shopping basket, it can be discriminated easily. In the above system, frequency analysis of the induced voltage waveform is performed, and according to amplitudes and generating timing of higher harmonics it is decided whether or not the marker exists and it is also decided whether or not generation of a warning is necessary.

[0005] Another magnetic marker and system utilizing the hysteresis characteristic is disclosed in Japanese Patent Publication No. 3-55873 (1991). In this system, a magnetic marker including a Co-based amorphous metallic ribbon and the like is used. They are known as so-called high permeability materials, and since their magnetostriction and magnetocrystalline anisotropy are small and a coercive force is low, they are magnetized very easily. When these materials are magnetized by magnetic field of a great amplitude, a hysteresis loop is observed to have a very narrow width and to change continuously. When a length of these materials included in the magnetic marker is long enough, rising of the magnetization of the hysteresis loop becomes abrupt. This means that a flux change occurs abruptly in the monitor system. Similarly to Japanese Patent Publication No. 3-27958 (1991), in this system, an AC magnetic field is generated by an exciting coil in a monitor area, and a voltage induced to a detection coil is captured as a signal. The AC magnetic field applied at this system has a combination of a plurality of frequencies of, for example, 25 Hz, 1.5 kHz and 2.5 kHz. When the high permeability material included in the magnetic marker is magnetized, a pulse voltage, which includes a frequency component of the sum of or the difference between 1.5 kHz and 2.5 kHz is induced in the detection coil. Therefore, if the magnitude of a voltage signal having a frequency of 4 kHz obtained by adding 1.5 and 2.5 kHz is not less than a predetermined value, for example, it is judged that the magnetic marker exists. Further, in this system, a low-frequency magnetic field of 25 Hz is superposed. Since this magnetic field magnetically saturates the marker at 25 Hz, the above mixed frequency signal of the sum or difference is generated only at a zero-crossing point in the magnetic field of 25 Hz. Therefore, sensitivity of the system can be guaranteed by checking the generation of the mixed frequency signal and a phase of the magnetic field of 25 Hz.

[0006] In the above-mentioned magnetic electronic article monitor system, magnetic markers exclusive for respective types have been used. Namely, in a system represented by the system disclosed in Japanese Patent Publication No. 3-27958 (1991), an Fe-based amorphous metallic wire showing the large Barkhausen reversal was used, and a Co-based amorphous metallic thin ribbon which is a high permeability material was used in such a system as disclosed in Japanese Patent Publication No. 3-55873 (1991).

[0007] However, the utilization of the exclusive markers in the respective systems narrows the scope of application the systems. Recently, it is demanded that markers for monitoring articles are stuck to products at the stage of manufacturing thereof. This is called as a factory sticking or source tagging. Since products which already have markers for monitoring are distributed, it is not necessary to stick the markers to products in shops, and thus the management cost can be reduced. However, as mentioned above, respective magnetic markers exist in a plurality of types of magnetic systems, and the different type markers cannot be detected respectively by the systems. This prevents it becomes popular to stick magnetic markers to products in factory.

[0008] Therefore, if the magnetic markers are utilized in different magnetic type electronic article monitor systems, and their sensitivities are good enough in the respective system. Thus, the factory sticking for the magnetic system can be developed greatly. It is desirable that a magnetic marker can be sensitively used particularly both in a so-called large Barkhausen type system as disclosed in Japanese Patent Publication No. 3-27958 (1991) and in a so-called high permeability type system as disclosed in Japanese Patent Publication No. 3-55873 (1991).

[0009] An object of the present invention is to provide a small-size magnetic marker which can be sensitively used particularly both in a so-called large Barkhausen type system and in a so-called high permeability type system.

DISCLOSURE OF INVENTION

[0010] The inventors of the present invention find that the above problem can be solved by using a magnetic marker made of a soft magnetic material whose magnetic characteristic is limited carefully, to attain to the present invention.

[0011] A magnetic marker of the present invention comprises a soft magnetic material capable of generating abrupt magnetisation reversal, and its length is not longer than 70 mm. When an external alternating magnetic field of amplitude not larger than 0.2 Oe is applied, the soft magnetic material generates abrupt magnetisation reversal with a magnetic flux change of not less than 8.0×10^{-9} Wb.

[0012] Preferably, the soft magnetic material generates the abrupt magnetization reversal when the magnetic field amplitude is fluctuated by an amount equal to or lower than 0.1 Oe.

[0013] Preferably, in the magnetic marker, an amount of magnetic flux radiated around the soft magnetic material accompanying the abrupt magnetization reversal is not less than 8.0×10^{-9} Wb.

[0014] Preferably, in the magnetic marker, the soft magnetic material has a difference between signal amplitudes at 1.5 kHz and at 3.5 kHz is smaller than -3 dBm when the sinusoidal magnetic field of amplitude of 1.5 Oe is applied at frequency of 73 Hz.

[0015] In the magnetic marker, the soft magnetic material is, for example, a wire.

[0016] In the magnetic marker, the soft magnetic material is, for example, a ribbon.

[0017] In the magnetic marker, the soft magnetic material is for example, a thin film.

[0018] In the magnetic marker, for example, two kinds of the soft magnetic material are arranged close to each other.

[0019] In the magnetic marker, for example, the soft magnetic material of wire or thin film is arranged on the soft magnetic material of thin film

[0020] In the magnetic marker, for example, a hard magnetic material having coercive force larger than the soft magnetic material is arranged near the soft magnetic material.

[0021] The invention is explained further here. The magnetic marker of the present invention is a small-sized magnetic marker whose length is not longer than 70 mm. The magnetic marker includes the soft magnetic material, and the soft magnetic material has a characteristic such that when an external alternating magnetic field is applied and its magnetic field amplitude exceeds a certain critical value, the abrupt magnetization reversal occurs. Preferably, the magnetic field amplitude where the magnetization of the soft magnetic material is reversed is not higher than 0.2 Oe, and the fluctuation in the critical magnetic field is not higher than 0.1 Oe, and a change of the magnetic flux radiated externally according to the abrupt magnetization reversal is not less than 8.0×10^{-9} Wb. The magnetic marker of the present invention, which is composed of the soft magnetic material whose magnetic characteristic is limited carefully, can be used sensitively in both a so-called large Barkhausen type system represented by the system disclosed in Japanese Patent Publication No. 3-27958 (1991) and a so-called high permeability type system represented by the system disclosed in Japanese Patent Publication No. 3-55873 (1991).

[0022] Since the magnetic marker of the present invention includes the soft magnetic material which can show abrupt magnetization reversal by applying a weak magnetic field, the magnetic marker can be utilized suitably in a plurality of electronic anti-theft systems such as a system utilizing a large Barkhausen effect element and a system utilizing a high permeability element.

BRIEF DESCRIPTION OF DRAWINGS

[0023] These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, and in which:

Figs. 1A to 1F are schematic plan views of various magnetic sensors;

Fig. 2 is a perspective view of a space of a monitor gate; and

FIG. 3 is a perspective view of three types of space positions of a magnetic sensor.

BEST MODES FOR CARRYING OUT THE INVENTION

[0024] Embodiments of the invention will be explained below with reference to the drawings appended herewith.

[0025] First, the limitation is described on a magnetic characteristic and the like of a soft magnetic material as a component of a magnetic marker. A magnetic marker of the present invention is small, namely, its length is not longer than 70 mm so that it is applicable to factory sticking. The length is preferably not longer than 50 mm, and more preferably not longer than 25 mm. Its lower limit is not particularly restricted, but since a demagnetizing field of a magnetic material becomes strong, it is not actually preferable that the length is not longer than 10 mm.

[0026] The magnetic marker of the invention includes the soft magnetic material which can reverse the magnetization abruptly when the amplitude of an ac magnetic field applied to the magnetic marker exceeds a critical value. The abrupt magnetization reversal means that the direction of the magnetization of the soft magnetic material is changed in a very short time or in a very small change in magnetic field. In such a magnetic material, when the magnetic hysteresis curve is observed, a step-like change region is observed. Such step-like magnetization reversal has a feature that it is affected by the largest amplitude of the magnetic field applied to the material. For examples, materials which are called as large Barkhausen reversal materials generally cause abrupt magnetization reversal at a particular critical magnetic field, and the hysteresis curve shows a step-like change. However, the magnetization is not reversed at a magnetic field smaller than the critical one, and no hysteresis is observed. In another example, a material shows magnetization reversal at a relatively small magnetic field but the change is smooth and the hysteresis curve is continuous. However, when a magnetic field equal to or larger than the critical value, abrupt magnetization reversal appears, and the hysteresis curve has a step-like change. A material of both cases can be used as the magnetic marker of the invention because abrupt magnetization change appears at a magnetic field equal to or larger than the critical value.

[0027] The abruptness can be evaluated, for example, by frequency analysis of the magnetic pulses radiated to the surrounding accompanied by the abrupt magnetization reversal. When the magnetization of a magnetic material is reversed, the magnetic field is radiated secondarily to the surrounding. When the magnetization reversal is abrupt, the radiating magnetic field is changed instantaneously. When a coil is put near the magnetic material, an electric voltage pulse is induced in the coil. The frequency analysis of the electric voltage pulse signal is performed, and signal amplitude at various frequencies and ratios thereof are compared in order to evaluate the abruptness of the magnetization reversal. That is, the magnetization reversal is evaluated to be more abrupt as the amplitude at a higher frequency is stronger. The amplitude is evaluated in a generalized way by normalization with use of a ratio of signal amplitudes at various frequencies relative to the that at the same frequency as that of the magnetic field to be applied, where influence of the specifications of the measurement apparatus, the size of the magnetic materials and the like are decreased. An approach which uses a ratio of signal amplitudes at two frequencies sufficiently higher than the exciting basic frequency is a simply evaluation method. For example, when a sinusoidal magnetic field of amplitude of 1.5 Oe at frequency of 73Hz is applied to a magnetic material, the abruptness of magnetization reversal can be evaluated with a difference between signal amplitudes at 1.5 kHz and at 3.5 kHz. For example, if the difference is smaller than -3 dBm, it is decided that very abrupt magnetization reversal happens, and the material is suitable for the invention. As the difference becomes smaller, the magnetic material is more suitable, and it is more preferable that the difference is equal to or smaller than -2 dBm.

[0028] The magnetic marker of the present invention includes a soft magnetic material in which abrupt magnetization reversal is observed when an external alternating field is applied to the magnetic marker and the magnetic field amplitude exceeds a certain critical value. The magnetic marker has sufficiently high sensitivity in a so-called large Barkhausen type system and in a so-called high permeability type system. When an alternating field of 73 Hz is applied to the soft magnetic material, the magnetization of the soft magnetic material is reversed abruptly by a magnetic field strength of not larger than 0.2 Oe, and its magnetic field strength is preferably not larger than 0.15 Oe and more preferably not larger than 0.1 Oe. Its lower limit is not restricted particularly, and as its value decreases, the sensitivity becomes high, but when the value decreases below about 0.03 Oe, the sensitivity is rarely changed. Meanwhile, in a soft magnetic material whose magnetization reversal field is large, i.e. exceeds 0.2 Oe, the sensitivity is lowered particularly in the so-called high permeability type system, so it is not preferable for the present invention. In the case where the magnetic marker is excited by a sufficiently strong magnetic field, this magnetic field strength has a physical meaning to correspond to a coercive force of the soft magnetic material. The coercive force generally has a tendency to depend on amplitude of an exciting field, and the above-mentioned value approximately corresponds to the coercive force when the magnetic marker is excited by the amplitude of 1 Oe. In order to obtain a magnetic marker whose detection sensitivity is high in the systems, it is preferable that the dependence of the coercive force on the exciting field strength is small. For example, a difference in coercive force when the marker is excited by 1 Oe and by 5 Oe falls within

50 % of the coercive force when the magnetic marker is excited by 5 Oe. Moreover, it is generally known that the coercive force depends on an exciting frequency, and it is preferable that a difference in the coercive forces when the marker is excited, for example, by 73 Hz and by 1 kHz falls within 50 % of the coercive force when excited by 1 kHz. Here, a critical magnetic field necessary for the magnetization reversal exists in the soft magnetic material to be used for the magnetic marker of the present invention, and discontinuous magnetization reversal behavior is shown around the critical magnetic field. For example, in a state that a magnetic field which is weaker than the critical magnetic field is applied, the magnetization of the soft magnetic material is not reversed at all, but just as the value reaches the critical magnetic field, the magnetization is reversed abruptly. In the present invention, the critical magnetic field amplitude is preferably not larger than 0.15 Oe, and more preferably not larger than 0.1 Oe.

[0029] Next, the inventors find that even if the magnetization reversal field falls within the above condition range, the detection sensitivity in the systems is not sufficient when a magnetic flux change due to the magnetization reversal does not exceed a certain range. Namely, a change in the magnetic flux radiated by the soft magnetic material included in the marker due to the abrupt magnetization reversal should be not less than 8.0×10^{-9} Wb. The magnetic flux change is preferable not smaller than 9.0×10^{-9} Wb, and more preferably not smaller than 10.0×10^{-9} Wb. The magnetic flux change is measured in the following manner. An ac MH loop is measured with the ac magnetic field of a frequency in correspondence to the system (for example, 73 Hz in a system disclosed in Japanese Patent Publication No. 3-27958 (1991)), and a magnetization change in the abrupt magnetization reversal observed in the hysteresis loop is taken as the magnetic flux change. In the case where the magnetic flux change is less than 8.0×10^{-9} Wb, intensity of a signal generated from the magnetic marker is weak, and this situation is not desirable because the detection sensitivity becomes low in the so-called large Barknausen type system disclosed in Japanese Patent Publication No. 3-27958 (1991).

[0030] Next, a change with time in the magnetic field where magnetization is reversed is examined in detail. As a result, it is found that particularly in the so-called large Barkhausen type system disclosed in Japanese Patent Publication No. 3-27958 (1991), the fluctuation in the magnetic field which causes magnetization reversal greatly influences the detection sensitivity of the marker, and the excellent sensitivity cannot be obtained when the magnetic field does not fall within a certain range. Namely, it is desirable that when the magnetisation of the soft magnetic material included in the marker of the present invention is reversed, the magnetic field strength falls within a variation range of 0.1 Oe. The variation range is preferably not larger than 0.07 Oe, and more preferably not larger than 0.05 Oe. The change in the reversal magnetic field in this case means that when an alternating field with uniform amplitude is applied to the same magnetic marker repeatedly, the magnetic field strength for the magnetization reversal of the soft magnetic material in the magnetic marker changes in each cycle. Its value is evaluated in the following manner in the present invention. The magnetization reversal field strength is measured continuously in 20 cycles, and an average of the magnetization reversal field strength in positive and negative cycles is calculated. Next, absolute values of differences between average magnetization reversal field strength in positive and negative cycles and the actual magnetization reversal field strength are calculated, and a sum of the results is divided by 40. The obtained value is defined as the fluctuation in the reversal magnetic field. When the fluctuation in the reversal magnetic field exceeds 0.1 Oe, the detection sensitivity is lowered extremely in the so-called large Barknausen type system disclosed in Japanese Patent Publication No. 3-27958 (1991), so this is not preferable.

[0031] The magnetic marker of the present invention composed of the soft magnetic material having the above magnetic characteristic can be realized by various structures, so it is not particularly limited in the present invention. Concrete examples of the soft magnetic materials suitable for the magnetic marker of the present invention are as follows. For example, an amorphous metallic wire is prepared by an in-rotating-liquid melt spinning method disclosed in Japanese Patent laid open Publication No. 56-165016 (1981), or an amorphous metallic ribbon is prepared by a single roll apparatus disclosed in Japanese Patent Publication No. 3-27958 (1991), and the wire or ribbon is used suitably as the soft magnetic material of the magnetic marker of the present invention. When it is subjected to heat treatment under tension, torsion, magnetic field, electric current flow or the like, the critical magnetic field of the magnetization reversal and its magnetic flux change can be adjusted arbitrarily. When the wire or ribbon is subject to a wire drawing process, rolling process, slit process or the like before the heat treatment, is can be formed into a desired form, and thus such processes are effective because a demagnetizing field can be adjusted. Besides the wire and ribbon, a thin film of magnetic material can be used suitably as the soft magnetic material of the present invention. Such a magnetic thin film material is disclosed, for example, in Japanese Patent Laid-Open Publication No. 4-218905 (1992). According to such a document, a soft magnetic thin film having an abrupt magnetization reversal behavior with a critical value can be provided, so it is suitable for the object of the present invention.

[0032] Figs. 1A to 1F show various magnetic markers schematically. Fig. 1A shows a magnetic marker comprising a soft magnetic wire 12 adhered to a polyethylene terephthalate (PET) film 10, Fig. 1B shows a magnetic marker comprising a soft magnetic thin ribbon 14 adhered to a PET film 10, and Fig. 1C shows a magnetic marker comprising a soft magnetic thin film 18 adhered to a PET film 10.

[0033] Further, the magnetic marker of the invention can be constructed by combining two kinds of magnetic materials, and this can be expected to improve the performance. For example, as shown in Fig. 1D, two pieces of soft magnetic material 16 is arranged at two ends of a linear soft magnetic material 12 in contact with each other. Then, the marker has a higher sensitivity for an anti-theft system than a marker comprising only the single long magnetic material, and a more compact magnetic marker can be provided. It is considered that the two pieces of soft magnetic material 16 function as a magnetic yoke which concentrates the adjacent magnetic field to guide to the linear magnetic material. A similar advantage is also observed when a linear magnetic material 12 is combined with a magnetic thin film 18 on a PET film 10, as shown in Fig. 1E. In this case, it is preferable that the linear magnetic material is put on a sheet of magnetic thin film. Especially, the advantage is remarkable when the magnetic thin film has magnetic anisotropy wherein the longitudinal direction of the linear magnetic material is along to the magnetically hard axis of the thin film, and good performance can be obtained on the marker.

[0034] A length of the above soft magnetic material is not particularly limited. However, it is desirable that because the above magnetic material cannot become longer than the magnetic marker, its length is desired at least not longer than 70 mm, preferably 10 to 70 mm, and more preferably 20 to 60 mm.

[0035] Since a demagnetising field influences the soft magnetic material, a relationship between a cross section and a length thereof is important. In the case of a wire material, for example, a material whose diameter is 30 μm and length is 10 mm can be utilized suitably. On the other hand, when the diameter is 100 μm, if the length is not longer, the characteristic of the material has a tendency to be deteriorated. In this case the length is preferably equal to or longer than 20 mm, for example. A ribbon and a thin film have the same tendency in this case. On this point, the intensity of a signal generated from the magnetic marker has a tendency to depend strongly on a volume, particularly, on a cross section of the soft magnetic material. Namely, it is desired that the size of the soft magnetic material is determined by taking a level of required signal intensity into consideration.

[0036] Deactivation function can be added to the magnetic marker of the present invention by using another magnetic material with different characteristic besides the above soft magnetic material. That is, as shown in Fig. 1F, a hard magnetic material 20, whose coercive force is stronger than that of a soft magnetic material 12, is arranged in the vicinity of the soft magnetic material (at three positions in this example). A bias magnetic field can be applied to the soft magnetic material by remanent magnetization of the hard magnetic material. The deactivation function can be provided by the magnetic marker having such a structure. In the marker, when the hard magnetic material is neutralized, the soft magnetic material shows the inherent abrupt magnetization reversal, and the marker reacts in a monitor area. However, when the hard magnetic material is magnetized, the magnetization reversal of the soft magnetic material is prevented. Thus, the marker does not react or it is deactivated. Since the marker can be deactivated or activated by a simple device, a user can apply the electronic article monitor system to various uses widely. For the hard magnetic material to be used for such an object, a metallic ribbon such as available from <u>Arnochrome</u> (Arnold) or <u>Semivac</u> (<u>Vacuum Schmelze</u>) are suitably used. Further, a paint including magnetic powders, a hard magnetic foil such as Ni and the like can also be utilized.

[0037] The magnetic marker of the present invention is used normally in forms of a label, a tag and the like with an adhesive layer, but the present invention is not limited to these forms. For the understanding of the invention, a magnetic marker of a label will be described as an example. In the marker, the soft magnetic material which will generate a signal in the monitor area is contained between two sheets of paper or plastic film. An adhesive layer is applied to an inner surface of the paper or film so that the soft magnetic material is held thereto. In the case where the hard magnetic material for the deactivating function is included further, it is arranged so as to closely contact with the soft magnetic material, and it is arranged between the two sheets of paper or plastic film. Another adhesive layer is applied to an outer surface of one of the two sheets of paper or plastic film, and the marker is stuck by this adhesive layer to an article required to be monitored. Such markers are stuck continuously onto a reel of a paper, and the paper is wound and provided to a user. Then, the maker is removed for use from the paper by a hand labeler, an automatic sticking apparatus or a hand. Here, printing or the like according to an object is given to an outer surface of the other sheet of paper or film where the adhesive layer is not formed.

[0038] The following will describe an example of the magnetic marker.

(Preparation of soft magnetic material)

[0039] Preparation of samples in Examples 1 through 3 and Comparative examples 1 and 2 will be first described. Metallic wires having characteristics shown in Table 1 are prepared with an in-rotating-liquid melt spinning method. Preparation conditions are as follows. A mother alloy of about 200 g is inserted into a quartz nozzle, and is melted with a high frequency induction in argon atmosphere. An argon gas pressure is increased to about 4.5 kg/cm^2, and liquid metal is ejected from a nozzle hole with a diameter of about 130 μm. The liquid metal is ejected onto a cooling water layer formed on an inner wall of a cylinder drum with a diameter of 600 mm rotating at about 300 rpm, and it is rapidly cooled to become solid. Then, it is wound around the drum inner wall. The wire obtained in such a manner is subjected to a wire drawing process with a die so as to have a predetermined wire diameter. Then, it is subjected to heat treatment at 340°C for ten minutes under tension of 135 kg/mm^2. The metallic wire obtained in such a manner is cut to 65 mm length, and it is inserted between two sheets of PET film of thickness of 25 μm to which an adhesive material of 23 μm have been applied for fixing. The obtained magnetic marker is Comparative example 1. In Examples 1 through 3, wires which have been subject to the heat treatment under tension as mentioned above are further subjected to heat treatment at 400°C for 10 minutes under no tension, and the wires obtained above are processed similarly to fabricate magnetic markers as Examples 1 through 3. Here, Comparative example 2 is subjected to the wire drawing so as to become thinner by 50 % than Examples 1 and 2.

[0040] The following will describe preparation of Examples 4 and 5 and Comparative example 3. Metallic ribbons having characteristics shown in Table 1 are prepared by using a single roll apparatus. The preparation conditions of the single roll method are as follows. A mother alloy of about 200 g is inserted into the quartz nozzle, and it is melted with a high frequency in argon atmosphere. The argon gas pressure is increased to about 2 kg/cm^2, and liquid metal ejected from the nozzle hole of a diameter of about 300 μm. The liquid metal ejected onto an outer peripheral surface of a copper roll of a diameter of 200 mm rotating at about 1200 rpm so as to be rapidly cooled to become solid, and it is wound around a reel by a winding mechanism. The metallic ribbons obtained in such a manner are twisted 10 or 5 times per 1 m and simultaneously are subjected to the heat treatment at 320°C for ten minutes. Then, they are processed to fabricate magnetic markers in the same method as in Example 1. The obtained samples are Examples 4 and 5. As for Comparative example 3, a ribbon obtained by the single roll apparatus is not subject to the heat treatment, and it is used as Comparative example 3 of magnetic marker.

Table 1

Characteristics of various samples					
	Example 1	Example 2	Example 3	Comp Ex. 1	Comp Ex. 2
Existence/non-existence of abrupt magnetization reversal	Exist	Exist	Exist	Exist	Exist
Critical magnetic field (Oe)	0.09	0.09	0.17	0.21	0.1
Coercive force (Oe)	0.14	0.13	0.23	0.27	0.15
Magnetic flux change ($\times 10^{-9}$ Wb)	18.06	17.94	17.7	19.84	7.0
Change in reversal magnetic field (Oe)	0.07	0.1	0.15	0.04	0.05
1.5 kHz signal amplitude (dBm)	-43.5	-44.0	-44.1	-43.7	-49.2
3.5 kHz signal amplitude (dBm)	-44.2	-44.8	-45.4	-44.2	-50.0
3.5 kHz - 1.5 kHz (dBm)	-0.7	-0.8	-1.3	-0.5	-0.8
Detection sensitivity (A) (%)	70	70	63	78	46
Detection sensitivity (B) (%)	35	34	34	12	25
	Example 4	Example 5	Comp Ex. 3		
Existence/non-existence of abrupt magnetization reversal	Exist	Exist	Not exist		
Critical magnetic field (Oe)	0.1	0.06	-		
Coercive force (Oe)	0.19	0.14	0.06		
Magnetic flux change ($\times 10^{-9}$ Wb)	20.44	13.98	15.6		
Change in reversal magnetic field (Oe)	0.03	0.06	0.02		
1.5 kHz signal amplitude (dBm)	-43.4	-44.5	-44.6		
3.5 kHz signal amplitude (dBm)	-44.4	-45.5	-49.6		
3.5 kHz to 1.5 kHz (dBm)	-1.1	-1.0	-5.0		
Detection sensitivity (A) (%)	82	70	38		
Detection sensitivity (B) (%)	42	52	63		

Measurements of crystalline structure and shape of the samples:

[0041] Structures of the above samples are measured by X-ray diffraction, and only a halo pattern is observed on all the samples. Then, the structures are identified as an amorphous phase. Moreover, as for the sample shape, cross sections in ten points of the samples are observed by an OPTIPHOT optical microscope of Nikon, and an average value of the cross sections is measured. A magnetic hysteresis characteristic of each sample is measured by an AC magnetic hysteresis measurement apparatus ACBH-100K of Riken Electron Co. Ltd. A pick-up coil of 100-turn with a compensating coil, where diameter is 30 mm and length is 20 mm, is arranged in an excitation solenoid coil having a diameter of 60 mm, length of 198 mm and 189 turns. Each of the samples of Examples 1 through 5 and Comparative examples 1 through 3 is inserted into the pick-up coil so that the position of the pick-up coil come to the center of the sample. An ac magnetic field of 73 Hz is generated by an excitation solenoid, and a change in the magnetization of the samples is detected by the pick-up coil. It is checked according to the hysteresis loop obtained in such a manner whether or not the magnetization of the respective samples is changed discontinuously and abruptly. Further, a magnetic field strength and a magnetic flux change when the magnetization is reversed are measured. In order to investigate abruptness of magnetization reversal, frequency analysis is performed on the magnetic signals generated by a sample. A function generator 3341A of Hewlett Packard and a high speed power amplifier 4025 of NF Electronics Instrument are connected to a Helmholtz coil of 400 mm of diameter to generate a sinusoidal magnetic field of 73 Hz of frequency and 1.5 Oe of amplitude at the center position. A detection coil of 200 turns is put in the center positions, and a sample is inserted into the detection coil. An output of the detection coil is subjected to frequency analysis with a dynamic signal analyzer 35665A of Hewlett Packard. The signal amplitude at each frequency is represented with dBm using a basis of 1 mV. Especially, a difference of harmonics signal amplitudes at 1.5 and 3.5 kHz is evaluated as an indicator of the abruptness of magnetization reversal.

Measurement of marker sensitivity:

[0042] A system of Sensormatic is selected as the large Barkhausen type system disclosed in Japanese Patent Publication No. 3-27958 (1991), and a system 2200SA of Esselte Meto is selected as the high permeability type system disclosed in Japanese Patent Publication No. 3-55873 (1991), and the detection sensitivity of the magnetic markers of Examples 1 through 5 and Comparative examples 1 through 3 is measured. As shown in Fig. 1, a space of a monitor gate is divided from a bottom towards a gate inlet at heights from its bottom of 39, 65, 93, 120 and 135 cm, and from the gate center in a width-wise direction at intervals of 10 cm. Then, each of the magnetic markers is allowed to pass the gate path in the space so that it is examined whether or not the system senses the magnetic marker. At this time, a magnetic marker 1 including a soft magnetic material 3 (metallic wire, ribbon and the like) is arranged and measured in longitudinal, transverse and vertical directions with respect to the gate (the respective directions are shown in Fig. 2), as shown at left, middle and right sides in Fig. 2. The measurements are made twice when the material enters and goes out the gate. The detection sensitivity of the magnetic marker 1 is evaluated by a ratio (%) obtained by dividing a number of times the system senses the magnetic marker 1 by a total number of times the maker passes through the gate. The results obtained by the system of Sensormatic are shown in row (A), and the results obtained by the system of Esselte Meto are shown in row (B) in a table.

[0043] As shown in Table 1, in Comparative example 3 which does not show discontinuous and abrupt magnetization reversal, the sensitivity measured by the system of Sensormatic is low. Comparative example 1 where discontinuous and abrupt magnetization reversal is observed and the magnetization reversal field exceeds 0.2 Oe, the sensitivity measured by the system of Esselte Meto is obviously low. As for Comparative example 2, even if the magnetization reversal field is smaller than 0.2 Oe, the change in magnetic flux radiated at the time of the magnetization reversal is smaller than 8.0×10^{-9} Wb, and it does not have sufficient sensitivity in both systems of Sensormatic and of Esselte Meto. On the contrary, Examples 1 through 5 as the magnetic markers of the present invention, where discontinuous and abrupt magnetization reversal occurs in a magnetic field smaller than 0.2 Oe and the magnetic flux changes at the reversal is larger than 8.0×10^{-9} Wb, shows sufficient sensitivity both systems of Sensormatic and of Esselte Meto. Here, as for Example 3 where the magnetization reversal field changes larger than 0.1 Oe, its sensitivity is lower in the system of Sensormatic than the other examples.

[0044] The invention can be embodied in various ways without departing from the gist thereof. Although the invention has been fully described in connection with the above embodiments thereof, it is explained only on examples, and the invention is not limited thereto. The scope of the present invention is defined by the appended claims and various modifications within the claims are to be understood as included.

Claims

1. A magnetic marker comprising a soft magnetic material, the magnetic marker having a length equal to or shorter than 70 mm, wherein said soft magnetic material generates abrupt magnetization reversal with a magnetic flux change of not less than 8.0×10^{-9} Wb when an external alternating field with magnetic field strength equal to or smaller than 0.2 Oe is applied.

2. The magnetic marker according to claim 1, wherein said soft magnetic material generates the abrupt magnetization reversal when the magnetic field strength is fluctuated by an amount equal to or lower than 0.1 Oe.

3. The magnetic marker according to claim 1, wherein an amount of magnetic flux radiated around said soft magnetic material accompanying the abrupt magnetization reversal is not less than 8.0×10^{-9} Wb.

4. The magnetic marker according to claim 1, wherein said soft magnetic material has a difference between signal amplitudes at 1.5 kHz and at 3.5 kHz which is smaller than -3 dBm when the sinusoidal magnetic field of amplitude of 1.5 Oe is applied at frequency of 73 Hz.

5. The magnetic marker according to claim 1, wherein said soft magnetic material is a wire.

6. The magnetic marker according to claim 1, wherein said soft magnetic material is a ribbon.

7. The magnetic marker according to claim 1, wherein said soft magnetic material is a thin film.

8. The magnetic marker according to claim 1, wherein two kinds of said soft magnetic material are arranged close to each other.

9. The magnetic marker according to claim 1, wherein said soft magnetic material of wire or thin film is arranged on said soft magnetic material of thin film

10. The magnetic marker according to claim 1, further comprising a hard magnetic material having coercive force larger than said soft magnetic material, wherein said hard magnetic material is arranged near said soft magnetic material.

Fig.1A

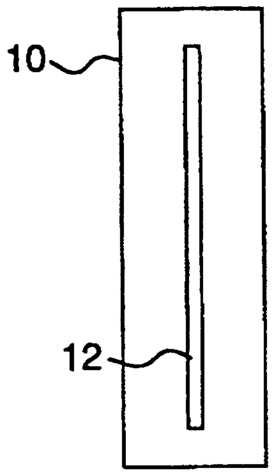


Fig.1B

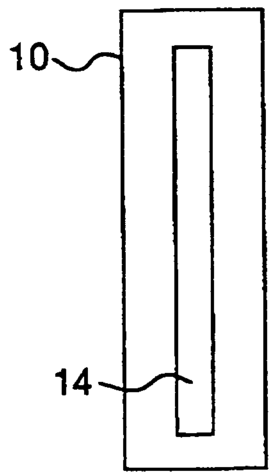


Fig.1C

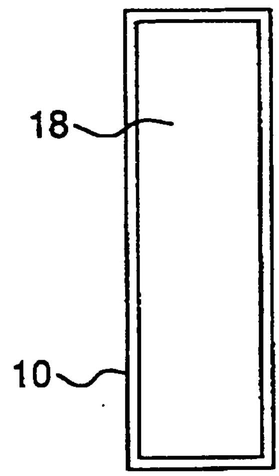


Fig.1D

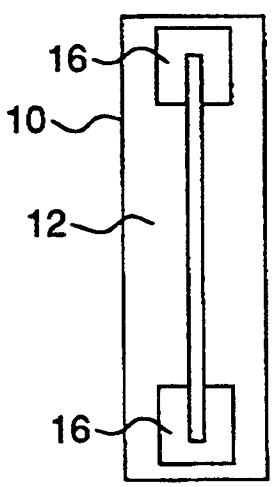


Fig.1E

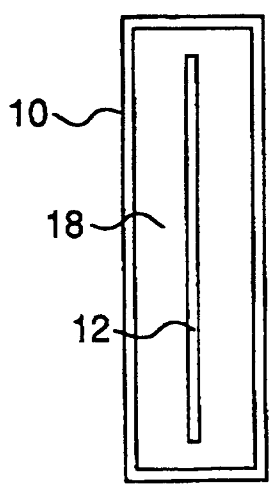


Fig.1F

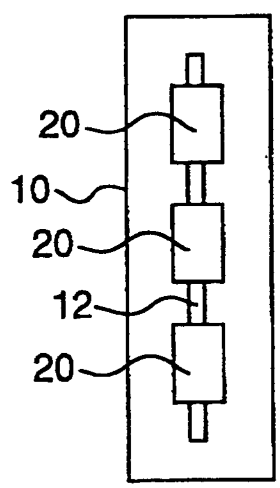


Fig.2

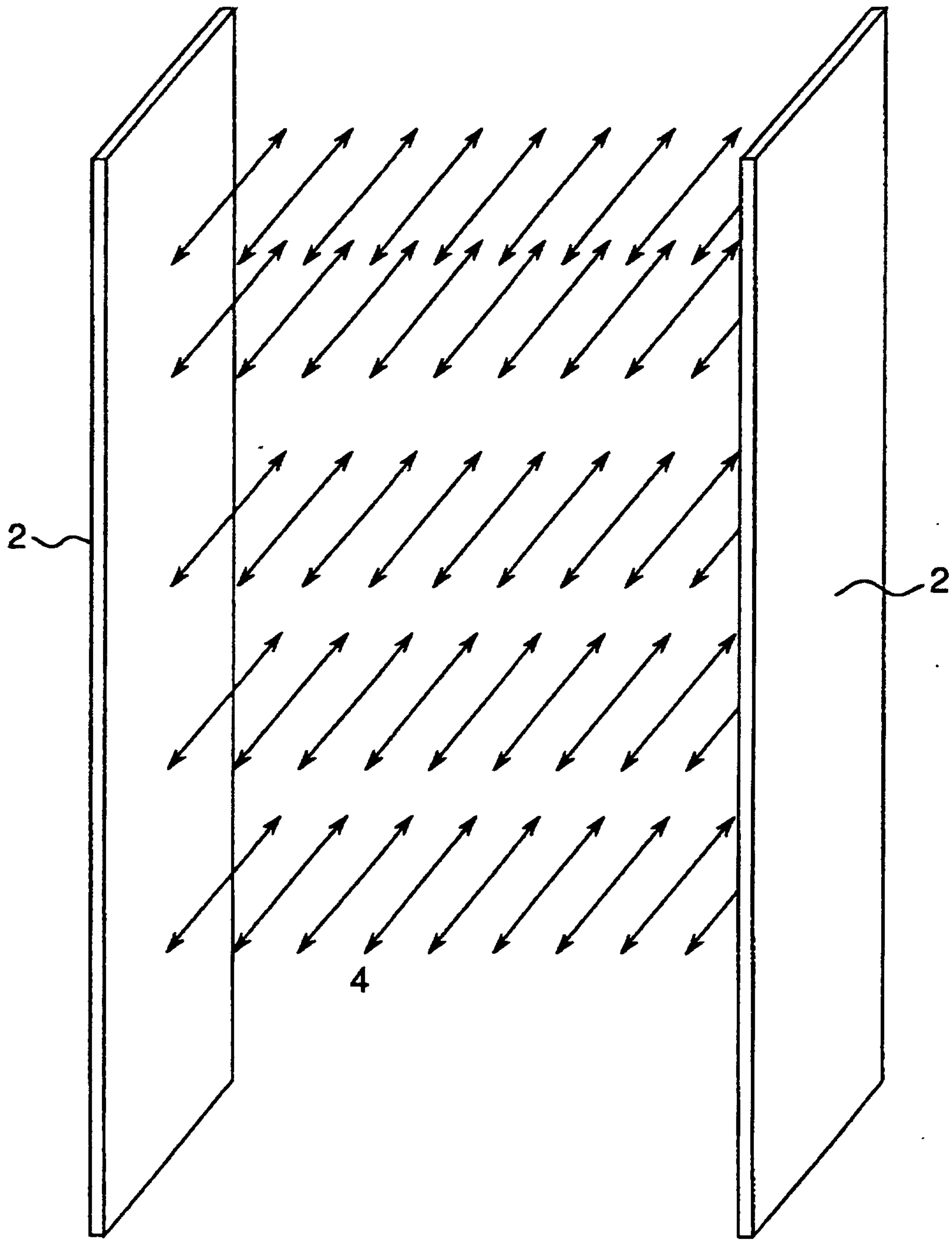
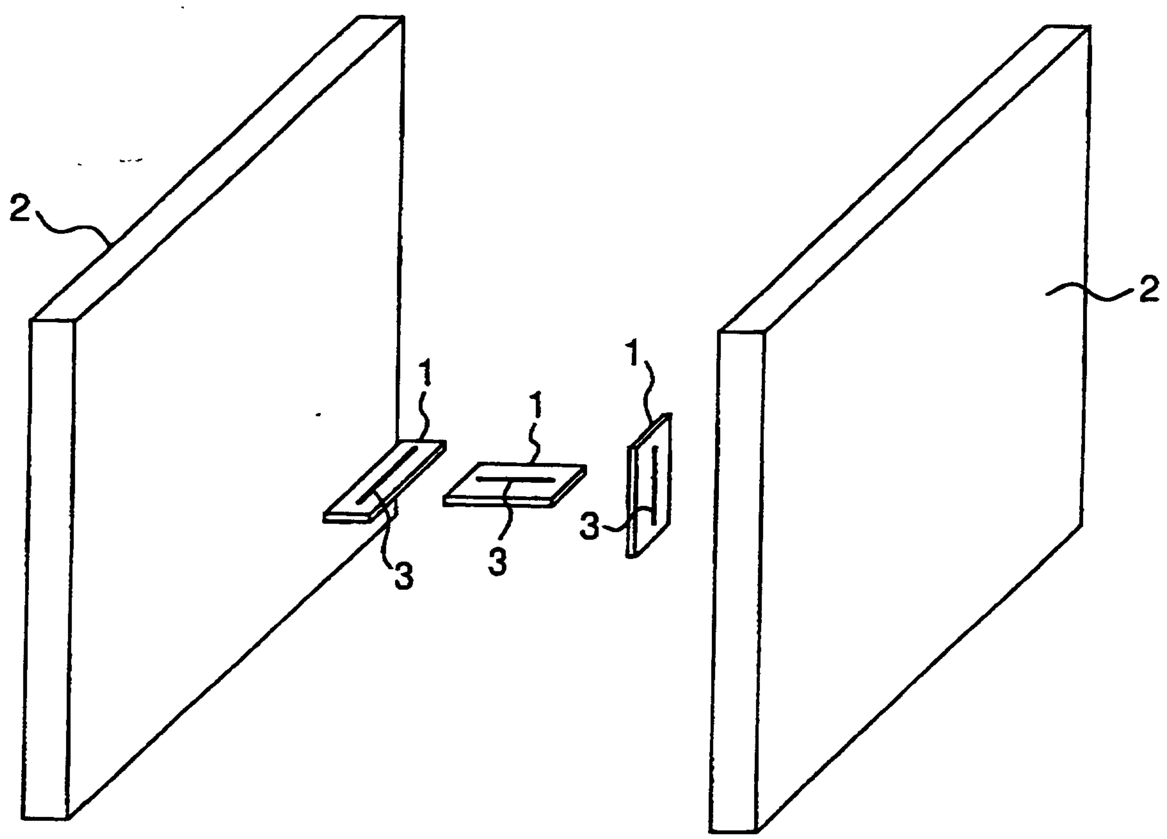


Fig.3



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP98/05069

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl[6] H01F1/12, 10/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl[6] H01F1/12, 10/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-1999
Kokai Jitsuyo Shinan Koho	1971-1999	Jitsuyo Shinan Toroku Koho	1996-1999

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 5-256953, A (Knogo Corp.), 8 October, 1993 (08. 10. 93) & EP, 545422, A1 & US, 5304983, A	1-10
A	JP, 9-134817, A (Unitika Ltd.), 20 May, 1997 (20. 05. 97) & EP, 773523, A1	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"E" earlier document but published on or after the international filing date

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January, 1999 (29. 01. 99)	9 February, 1999 (09. 02. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)