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(54) IMPROVEMENTS IN OR RELATING TO MAGNETIC DEVICES

(71) We, WESTERN ELECTRIC COMPANY, INCORPORATED, of 195 Broadway, New York City, New York State, United States of America, a Corporation organized and existing under the laws of the State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to magnetic devices. A single wall domain is a magnetic domain characterized by a domain wall which closes upon itself in the plane of a layer of magnetic material in which it can be moved. Inasmuch as the wall closes on itself, the domain is self-defined and is free to move anywhere in the plane. Domains of this type are disclosed in GB Patent No. 1,187,623.

A layer of magnetic material in which single wall domains can be moved typically comprises an epitaxially grown single crystal film having a preferred direction of magnetization normal to the plane of the film. A domain in such a material may be visualized as a right circular cylinder magnetically positive at the top surface of the layer and negative at the bottom forming a magnetic dipole along an axis normal to the plane of movement. When exposed to polarized light, a single wall domain appears as a circular disk relatively dark or light, in contrast to the remainder of the layer, when viewed through an analyzer.

A single wall domain is stable in most suitable films over a (stability) range of diameters which varies from a maximum at which a domain "strips out" to a minimum at which the domain collapses, a range in which the maximum and minimum values differ by a factor of about three. A magnetic field of a polarity to reduce the diameter of a domain typically determines an operating diameter in the middle of a bias range which

corresponds to the stability range of diameters to ensure the widest possible operating margins in a practical single wall domain arrangement.

Hitherto, it has been prescribed by those skilled in the art that the bias field be maintained at a preselected constant value and that a layer of material suitable for the movement of single wall domains be characterized by properties which ensure a stability range which is ideally constant as a function of temperature over a practical temperature range. Inasmuch as the stability range of a layer of selected material varied the operating margins were reduced. The properties of magnetic materials and the relationship of those properties to the stability range are discussed in the *Bell System Technical Journal*, Vol. 50, No. 3, March 1971, at page 725 et seq., in an article by A. A. Thiele, entitled "Device Implications of the Theory of cylindrical Magnetic Domains."

For materials which, in addition, have a characteristic "material length" which is constant with varying temperature, a constant bias field ensured a constant domain diameter. But a temperature independent material length was hard to realise in materials which also exhibited temperature independent stability ranges. In the absence of constant domain diameters domain size either increases or decreases during operation. These variations lead to increased domain interaction or decreased coupling to the drive fields, either of which can lead to improper domain movement and, thus to decreased margins.

The reduction in margins is noticeable, for example, in operations of the type known as a "field-access" arrangement. A field-access, single wall domain arrangement includes a periodic pattern of magnetically soft elements, typically of permalloy, which is coupled to the layer in which domains are to be moved. A magnetic field reorienting in the plane of the layer generates in the ele-

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ments pole patterns which change as the orientation of the field changes. The changing pole patterns produce continuously offset field gradients for moving the domains. One form of a field-access arrangement employs a repetitive T and bar-shaped pattern of elements, with a period of about three domain diameters, which responds to a magnetic field rotating in the plane domain movement. GB Patent No. 1,241,235 discloses single wall domain arrangements of this type. Sufficiently large changes in the diameter of domains have been observed to result in improper movement of domains. Consequently, an important criteria for a suitable domain material has been a relatively constant stability range of domain diameters (or bias field) over a practical temperature range from which a relatively constant operating diameter could be maintained for materials with constant "material lengths".

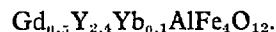
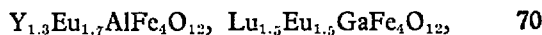
According to the present invention there is provided a magnetic device comprising a layer of material in which single wall domains can be moved, the material having the property that with a bias field varying insubstantially from a first value a said domain is stable only within a predetermined temperature range, the device further comprising means for providing a bias field substantially variable according to temperature, such that, in operation, the temperature range within which a said domain is stable substantially exceeds said predetermined range.

The range of bias field within which a domain is stable at a temperature within said predetermined temperature range may not overlap the range of bias field within which a domain is stable at a temperature outside the predetermined range but within the range which exceeds the predetermined range.

The means for providing the bias field may comprise magnetic material having the property that the magnetic field provided thereby varies according to temperature. The means for providing the bias field may comprise a plurality of members of said magnetic material linked by members of magnetically soft material and arranged for providing a region, for said layer, in which the bias field is substantially uniformly distributed. The magnetic material may be selected from the group comprising:— $\text{BaFe}_{12}\text{O}_{19}$, $\text{BaFe}_{11}\text{O}_{19}$, $\text{SrFe}_{14}\text{O}_{23}$, $\text{CeCuFe}_{10}\text{Co}_{3.5}$. The means for providing the bias field may comprise a film of said material exchange coupled to the layer.

The layer of material may comprise a garnet having a Curie temperature outside the said range within which a domain is stable when subject to said variable bias field, and the garnet may have no compensation point. The layer of material may comprise an epitaxially grown film on a non-magnetic substrate. The film and said substrate may have

respective crystal properties such that the film exhibits a strain induced anisotropy. The layer may comprise material selected from the group:—



In an embodiment of the present invention, a bias magnet is used which supplies a bias field which varies as a function of temperature, thus enlarging the class of materials which are potentially useful for single wall domain arrangements so long as those materials exhibit a stability range which also varies as a like function of temperature. In other words, materials with properties which vary as a function of temperature in a manner to provide a stability range which varies in a manner and corresponds to variations in a bias field provided by an associated magnet as temperature varies appear particularly useful in this context.

Materials found to have such properties include, for example, $\text{Y}_{1.3}\text{Eu}_{1.7}\text{AlFe}_4\text{O}_{12}$ and $\text{Ca}_{1.8}\text{Bi}_{1.2}\text{V}_{0.9}\text{Fe}_{4.1}\text{O}_{12}$ which are particularly well suited for this purpose. Materials of this type are characterized by a magnetization which varies as a simple function of temperature which closely approximates the variation of a permanent magnet of, for example, $\text{BaFe}_{12}\text{O}_{19}$. Moreover, these materials as well as a number of related garnets are also characterized by an anisotropy which varies approximately as the fourth power of the moment and thereby produces an essentially invariant "material length" or domain diameter over the temperature range of interest. Consequently, a magnetic domain arrangement is realized where a layer in which single wall domains can be moved and a biasing arrangement for determining an operating diameter for domains in the layer are chosen so that each varies as similar functions of temperature within acceptable limits over a relatively large range of temperatures. For a layer of $\text{Y}_{1.2}\text{Yb}_{1.7}\text{Eu}_{1.7}\text{AlFe}_4\text{O}_{12}$ and a permanent magnet of $\text{BaFe}_{12}\text{O}_{19}$, the arrangement can operate over a temperature range of 200—400° Kelvin.

The invention will now be described with reference to the accompanying drawings in which:—

Fig. 1 is a line diagram of a magnetic single wall domain arrangement embodying the invention;

Figs. 2, 3, and 4 are graphs showing the properties of permanent magnet and domain layer materials as functions of temperature;

Fig. 5 is a schematic representation of a permanent magnet structure exhibiting a vary-

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ing magnetic field as a function of temperature;

Fig. 6 is a cross-sectional view of the structure of Fig. 5 showing a layer of material in which single wall domains can be moved;

and Fig. 7 is a graph of bias field versus in-plane field for various frequencies of in-plane field.

Fig. 1 shows a single wall domain arrangement 10 comprising a layer 11 of material in which single wall domains can be moved. Channels along which domains move in layer 11 are defined by a representative pattern of T and bar-shaped elements 12 in a familiar manner.

A representative input for domains is shown at 13 in Fig. 1 to comprise a magnetically soft rectangular element 14 and an associated conductor 15. Conductor 15 is connected to an input pulse source represented by block 16 in the figure.

A representative detector arrangement is shown at 20. The detector arrangement comprises a magnetoresistance element 21 operative to enlarge a domain moved along a channel into the position of element 21. The element is connected to a utilization circuit 22 to which it applies a signal representative of the presence of a domain. In operation, a current is applied to element 21 (pulsed or d.c.) to effect an output signal. Arrangements of this type are described in GB Patent Specification 1,387,853.

Domains selectively introduced at input 13 are moved along the propagation channel to detector 20 in response to a magnetic field rotating in the plane of layer 11. A source of such a field is represented by block 25 of Fig. 1.

In practice, a domain in the arrangement of Fig. 1 is maintained at a nominal operating size by a bias field supplied by a source represented by block 26 of Fig. 1. Any one of a variety of suitable sources may be used for biasing purposes. For example, a permanent magnet, or an exchange coupled film are suitable to this end. Alternatively, a current driven coil may be adapted for providing the bias field.

In accordance with prior art teaching, a material for layer 11 is selected to provide domains which are stable over a known (stability) range of bias field values and a particular bias field value is selected to maintain a domain at a nominal operating diameter in that range. The propagation arrangement is designed to have a period about three times the domain operating diameter. Any variation in, for example, domain size leads to operating margin reduction as mentioned hereinbefore.

Criteria for material selection for layer 11 and for a biasing field source in accordance with prior art teachings are discussed in con-

nection with Figs. 2 and 3. Fig. 2 shows a graph of bias field H_B as a function of temperature T over an arbitrary temperature range from 0° to 100° Centigrade, a range which is acceptable for device application where, for example, air conditioning is not contemplated. The top curve 30, as viewed in the figure, represents the bias field values at which domains collapse at various temperatures. The bottom curve 31 represents the domain strip out values. Both curves can be seen to slope downward for increasingly higher temperatures as is characteristic of suitable materials for layer 11.

In accordance with prior art thinking, practical operation of a single wall domain arrangement is achieved only, for a selected range of temperatures, between the lowest point of curve 30 and the highest point of curve 31. Horizontal lines 32 and 33 in Fig. 2 delineate the operational area for the range of temperature contemplated. An acceptable change in bias field ΔH_B is specified in this manner, the maximum temperature range being defined for $\Delta H_B \rightarrow 0$. An acceptable bias field range, of course, may be appreciated to be restricted to a small percentage of the range of bias field at a given temperature as a practical matter. For typical operating bias field values of about 100 oersteds, ± 20 oersteds define the collapse and strip out points, respectively. The change ΔH_B in this instance typically may be less than about a few oersteds and possibly less than a small fraction of an oersted depending on familiar design trade-off considerations.

Fig. 3 shows a graph of magnetic field H_M versus temperature for a permanent bias magnet for a temperature range of 0° to 100° Centigrade. The curve 34 is shown in a worst case configuration (to emphasize a point) to rise for increasingly higher temperatures. The change in bias field ΔH_M is defined by the highest and lowest points on the curve intersected by horizontal lines 35 and 36, respectively, in the figure. The change in bias field ΔH_M may be appreciated to be restricted to a range consistent with the permissible change ΔH_B of Fig. 2 typically a few oersteds or less variation with temperature, the usable margins being $\Delta H_B - \Delta H_M$.

The prescription for suitable materials for layer 11 and for a suitable biasing magnet in this prior art context is clear. A magnetic material must be selected with properties (such as magnetization M , wall energy, anisotropy, etc.) so that the range of bias field values between collapse and strip out varies only negligibly with temperature T over an acceptable range of temperature values. The prescription for suitable biasing magnets is that the field produced by magnet be essentially constant over the accepted temperature range.

Within these constraints, the search for suitable materials both for the magnet and for layer 11 is limited. Typical suitable materials for layer 11 under these constraints are shown in Table I.

TABLE I

Material	$\Delta H_B = \frac{1}{M} \left(\frac{dM}{dT} \right)$
$\text{Eu}_2\text{ErGa}_7\text{Fe}_{4.3}\text{O}_{12}$	5%
$\text{GdY}_2\text{Al}_{1.8}\text{Fe}_{4.2}\text{O}_{12}$	3%

10 Suitable bias magnet materials are shown in Table II.

TABLE II

Material	$\Delta H_M = \frac{1}{M} \left(\frac{dM}{dT} \right)$
Quench hardened steel	.015%/°C
15 Vicalloy (38 Fe, 52 Co, 10V)	.01 %/°C
Alnico 5 (8Al, 14Ni, 24Co, 3Cu, 51Fe)	.06 %/°C

20 Such materials typically can be operated over a range of about 50° Centigrade.

The foregoing prior art prescriptions were for ideal materials only approximated in practice. Of course, any selected magnet material exhibits some change in H_M as a function of temperature. By the same token, any selected material for layer 11 also exhibits some change as a function of temperature. On occasion, when examined retrospectively the changes have now been found not to have been inconsistent with one another and to have resulted in a marginally better than might have been expected operational range. Nevertheless, the prescription for the materials suitable for layer 11 imposed a severe constraint on those charged with the responsibility to produce suitable domain materials. The most attractive materials used with an

ideally "constant" bias field have been useful over a range of temperatures of about 70°C from 0° to 75°C.

In devices embodying the present invention the constraints on the classes of materials suitable for layer 11 or for the biasing magnet are considerably relieved. Specifically, the materials for the biasing magnet and for layer 11 are chosen such that H_M and H_B respectively vary as like functions of temperature. Thus, materials for layer 11 may be selected from a class where none of the members of the class is characterized by a positive ΔH_B as shown in Fig. 2. In other words, even for an assumed ideal bias field source which provides a constant bias field independent of temperature, none of the members of the class would be useful over any significant temperature range.

A typical material from this class is represented in Fig. 4 by curves representing relatively sharply decreasing values of H_B with increasing temperature leading to a negative (viz: nonexisting) ΔH_B as indicated by the horizontal lines 32a and 33a corresponding to lines 32 and 33 of Fig. 2. For such materials a positive range $\Delta H_B - \Delta H_M$ exists over only a negligibly small temperature range as is clear from the figure. Typical materials which lie within the present class, but which are unsuitable for single wall domain arrangements in accordance with the prior art prescription, comprise rare earth iron oxides which have no compensation points and have Curie temperatures above the highest contemplated operating temperature often as high as about 500° or 600° Centigrade, and materials which have stress (or strain) induced uniaxial anisotropy out of the plane of the layer.

Table III shows some suitable materials, where

$$\frac{1}{M} \left(\frac{dM}{dT} \right)$$

is the percent change of magnetization with temperature.

TABLE III

	Material	Substrate	f(t)
85	Growth Induced		
	$\text{Y}_{1.3}\text{Eu}_{1.7}\text{AlFe}_4\text{O}_{12}$	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	0.2 %/°C
	$\text{Lu}_{1.3}\text{Eu}_{1.5}\text{GaFe}_4\text{O}_{12}$	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	0.2 %/°C
	$\text{Lu}_2\text{Eu}_4\text{AlFe}_4\text{O}_{12}$	$\text{Y}_3\text{Ga}_5\text{O}_{12}$	0.2 %/°C
	Stress Induced		
90	$\text{Ca}_{1.8}\text{Bi}_{1.2}\text{V}_{0.8}\text{Fe}_{4.1}\text{O}_{12}$	$\text{Gd}_3\text{Sc}_{1.7}\text{Ga}_{3.3}\text{Fe}_4\text{O}_{22}$	0.12%/°C
	$\text{Gd}_{.5}\text{Y}_{2.4}\text{Yb}_{.1}\text{AlFe}_4\text{O}_{12}$	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	0.15%/°C

Strain induced anisotropy arises from a choice of materials with lattice constants different from that of the substrate on which they are grown. Epitaxial growth of the film occurs at elevated temperature leading to a layer 11 under tension or compression when

the temperature is later reduced to room temperature in accordance with well-understood considerations.

5 A biasing magnet cooperating with a layer 11 of a material from the class prescribed is designed to exhibit a bias field which varies substantially with temperature, as does the material of layer 11, a function of temperature ideally as represented by line 40 of Fig. 4. Line 40 is intermediate lines 30a and 31a of Fig. 4 respectively. In practice, the ideal curve is approximated by a characteristic represented by line 45 or 46 in Fig. 4 leading to a ΔH_M corresponding to that shown in Fig. 3. The allowable change in bias field is about ± 5 percent.

A suitable bias field source is represented by a block designated 26 in Fig. 1 as has been stated hereinbefore. A type of magnet known as a Watson magnet particularly well suited (as source 26) for providing a uniform bias field is shown in detail in Figs. 5 and 6. The magnet comprises high permeability (typically of permalloy) end plates 51 and 52 as shown in Fig. 5 with plugs 53 and 54 of a selected material to provide an H_M which tracks the material selected for layer 11 in any specific arrangement. The separation between the plates is controlled by a screw adjustment as indicated in the figure.

Fig. 6 represents a cross section of the magnet of Fig. 5. The arrows in the figure represent the flux lines and can be seen to represent a uniform field within the area bounded by plugs 53 and 54. The intensity of the field is adjusted (via the screw adjustment) by changing the air gaps 56 and 57 in Fig. 6. Layers 11a to 11i, formed on suitable substrates, typically are mounted on a ceramic fixture 58 for insertion into the area between plugs 53 and 54 as shown in Fig. 6.

The shape of curve 40 in Fig. 4 produced by such a magnet is determined by the materials used in the plugs 53 and 54. The position of the curve is determined by the adjustment of air gaps 56 and 57 as is consistent with prior art thinking. Materials which are particularly well suited in this respect are shown in Table IV.

TABLE IV

Material	1 dM
	M dT
BaFe ₁₂ O ₁₉	0.2%/°C
BaAlFe ₁₁ O ₁₉	0.2%/°C
55 SrFe ₁₄ O ₂₂	0.2%/°C
CeCuFe ₁₃ Co _{3.5} (cast)	0.1%/°C

In a first example, an epitaxially grown garnet film of Ca_{1.8}Bi_{1.2}V_{0.9}Fe_{4.1}O₁₂ exhibiting stress induced anisotropy was selected for layer 11 and ceramic BaFe₁₂O₁₉ was

selected as the material for plugs 53 and 54. The plugs (as well as layer 11) exhibited a decrease of 0.2 percent per degree in field strength as temperature varied from 0°—100° Centigrade with the gaps adjusted to give a strength of 100 oersteds at 50° Centigrade. Layer 11 exhibited essentially the same percentage decrease in desirable bias as shown in Fig. 4. In accordance with the prior art, a layer 11 comprising a film of Ca_{1.8}Bi_{1.2}V_{0.9}Fe_{4.1}O₁₂ would have only a small useful range of operation. The arrangement exhibited about a $\pm 15\%$ change in domain diameter and operated over a temperature range greater than from -50° to +150°C.

In a second example an epitaxially grown film of Y_{1.3}Eu_{1.7}AlFe₄O₁₂ exhibiting growth induced anisotropy was selected for layer 11 and ceramic BaAlFe₁₁O₁₉ was employed as the material for plugs 53 and 54 to provide an average 0.2%/°C drop in field. Domain diameter in such arrangements varied about $\pm 10\%$ over a temperature range of from 0°C to 100°C.

Fig. 7 shows a family of curves representing bias field H_B as a function of the rotating field strength at different rotating field frequencies, a d.c. value represented by curve 60, a relatively low frequency represented by curve 61 and a relatively high frequency represented by curve 62. The area defined by each curve represents the associated operating margins. Curve 62 corresponds to the frequency at which domain movement becomes limited by the mobility of the material of layer 11. Vertical broken lines 63 and 64 represent rotating field values below which the coercivity of the overlay (viz: T-bar shaped) pattern of permalloy has sufficient coercivity to resist switching and above which the rotating field values saturate the pattern, respectively.

If it is recalled that increasingly higher values of bias field H_B correspond to increasingly smaller diameter domains, it becomes clear from Fig. 7 that margins are reduced for increasingly smaller domains as rotating field frequency increases. The reason for this is that for a fixed field gradient, the force on a domain is a function of domain radius as is well known. Consequently, the smaller the radius the slower the domain moves.

In this context, an optimum bias field source varies as a function of temperature in a manner to maintain domain size constant. This implies that the "material length" l

$$l = \frac{\sigma_w}{4\pi M_s^2}$$

where σ_w is the wall energy) be relatively constant versus temperatures over as wide a temperature range as can be achieved. For optimum film thicknesses (with the materials

5 $Y_{1.3}Eu_{1.7}AlFe_4O_{12}$ and $Ca_{1.8}Bi_{1.2}V_{0.9}Fe_{4.1}O_{12}$ listed in Table III) equal to about four times the characteristic "material length," a permissible ΔH_M (see Fig. 4) for curve 40 is $\pm 5\%$ which maintains domain diameters to within an acceptable $\pm 25\%$ of the nominal values.

10 Sources 16 and 25 and circuit 22 are connected to a control circuit 60 shown in Fig. 1 for synchronization and actuation. The various sources and circuits may be any elements capable of performing the above described operations.

15 What has been described is merely illustrative and various modifications thereof can be derived. For example, exchange coupled films are known to provide bias fields for constructing domains in a contiguous film. It is contemplated, that a domain layer and an exchange coupled film be chosen of materials to exhibit like variations in their pertinent characteristics as represented in Fig. 4.

WHAT WE CLAIM IS:—

25 1. A magnetic device comprising a layer of material in which single wall domains can be moved, the material having the property that with a bias field varying in substantially from a first value a said domain is stable only within a predetermined temperature range, the device further comprising means for providing a bias field substantially variable according to temperature, such that, in operation, the temperature range within which a said domain is stable substantially exceeds said predetermined range.

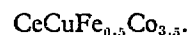
30 2. A magnetic device according to claim 1, wherein the range of bias field within which a domain is stable at a temperature within said predetermined temperature range does not overlap the range of bias field within which a domain is stable at a temperature outside the predetermined range but within the range which exceeds the predetermined range.

45 3. A magnetic device according to claim 1 or 2, wherein the means for providing the bias field comprises magnetic material having the property that the magnetic field provided thereby varies according to temperature.

50 4. A magnetic device according to claim 3, wherein the means for providing the bias field comprises a plurality of members of said magnetic material linked by members of mag-

netically soft material and arranged for providing a region, for said layer, in which the bias field is substantially uniformly distributed.

5. A magnetic device according to claim 3 or 4, wherein said magnetic material is selected from the group comprising:—



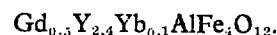
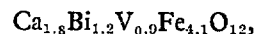
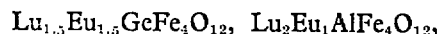
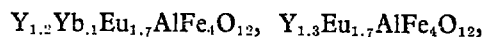
6. A magnetic device according to claim 3, wherein the means for providing the bias field comprises a film of said magnetic material exchange coupled to the layer.

7. A magnetic device according to any preceding claim, wherein the layer of material comprises a garnet having a Curie temperature outside the said range within which a domain is stable when subject to said variable bias field, and the garnet having no compensation point.

8. A magnetic device according to any preceding claim, wherein the layer of material comprises an epitaxially grown film on a non-magnetic substrate.

9. A magnetic device according to claim 8, wherein, said film and said substrate have respective crystal properties such that the film exhibits a strain induced uniaxial anisotropy out of the plane of the layer.

10. A magnetic device according to claim 7, wherein said layer comprises material selected from the group:—



11. A magnetic device substantially as herein described with reference to the accompanying drawings.

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$Y_{1.3}Eu_{1.7}AlFe_4O_{12}$ and $Ca_{1.8}Bi_{1.2}V_{0.9}Fe_{4.1}O_{12}$ listed in Table III) equal to about four times the characteristic "material length," a permissible ΔH_M (see Fig. 4) for curve 40 is $\pm 5\%$ which maintains domain diameters to within an acceptable $\pm 25\%$ of the nominal values.

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WHAT WE CLAIM IS:—

1. A magnetic device comprising a layer of material in which single wall domains can be moved, the material having the property that with a bias field varying in substantially from a first value a said domain is stable only within a predetermined temperature range, the device further comprising means for providing a bias field substantially variable according to temperature, such that, in operation, the temperature range within which a said domain is stable substantially exceeds said predetermined range.

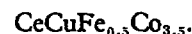
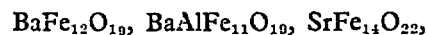
2. A magnetic device according to claim 1, wherein the range of bias field within which a domain is stable at a temperature within said predetermined temperature range does not overlap the range of bias field within which a domain is stable at a temperature outside the predetermined range but within the range which exceeds the predetermined range.

3. A magnetic device according to claim 1 or 2, wherein the means for providing the bias field comprises magnetic material having the property that the magnetic field provided thereby varies according to temperature.

4. A magnetic device according to claim 3, wherein the means for providing the bias field comprises a plurality of members of said magnetic material linked by members of mag-

netically soft material and arranged for providing a region, for said layer, in which the bias field is substantially uniformly distributed.

5. A magnetic device according to claim 3 or 4, wherein said magnetic material is selected from the group comprising:—



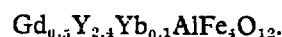
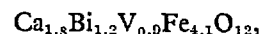
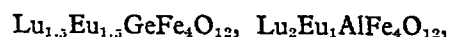
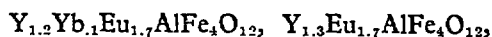
6. A magnetic device according to claim 3, wherein the means for providing the bias field comprises a film of said magnetic material exchange coupled to the layer.

7. A magnetic device according to any preceding claim, wherein the layer of material comprises a garnet having a Curie temperature outside the said range within which a domain is stable when subject to said variable bias field, and the garnet having no compensation point.

8. A magnetic device according to any preceding claim, wherein the layer of material comprises an epitaxially grown film on a non-magnetic substrate.

9. A magnetic device according to claim 8, wherein, said film and said substrate have respective crystal properties such that the film exhibits a strain induced uniaxial anisotropy out of the plane of the layer.

10. A magnetic device according to claim 7, wherein said layer comprises material selected from the group:—



11. A magnetic device substantially as herein described with reference to the accompanying drawings.

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