

Nov. 25, 1969

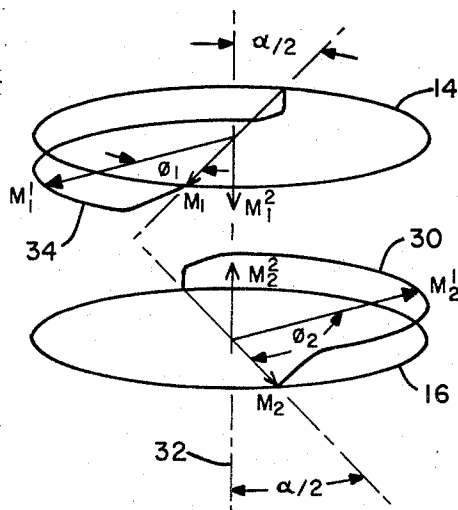
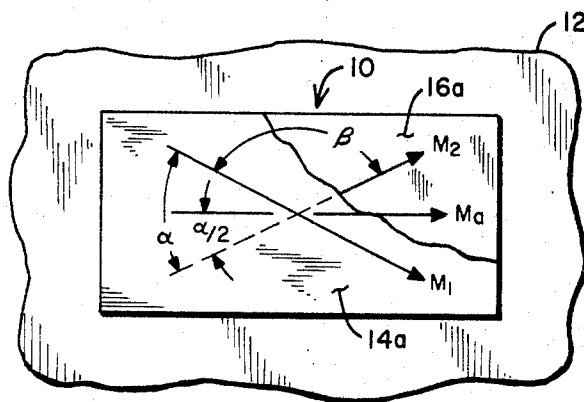
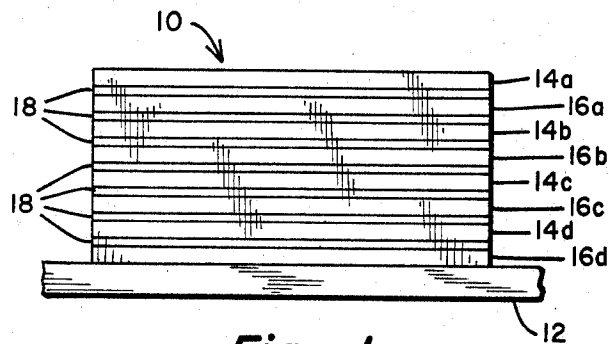
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3,480,926

SYNTHETIC BULK ELEMENT HAVING THIN-FERROMAGNETIC-FILM
SWITCHING CHARACTERISTICS

Filed June 16, 1967

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

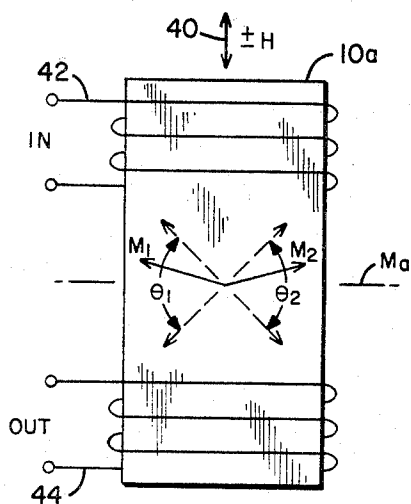


Fig. 4

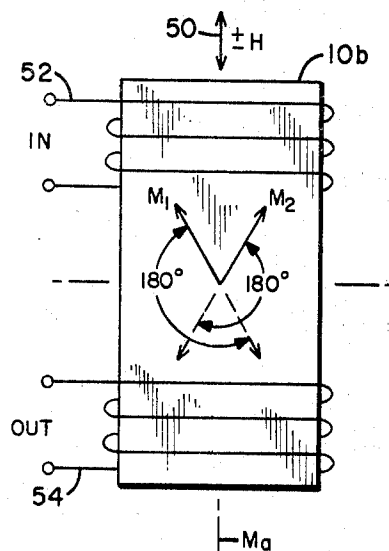


Fig. 5

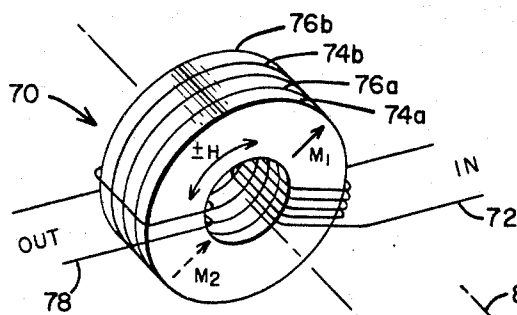


Fig. 7

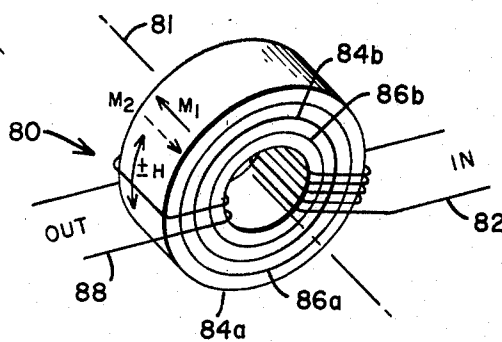


Fig. 8

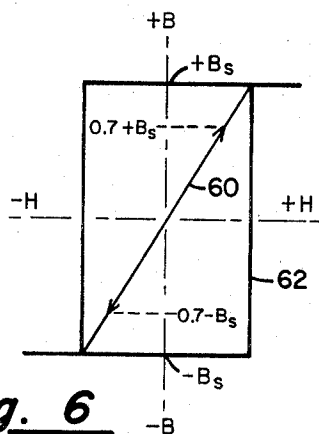


Fig. 6

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3,480,926
**SYNTHETIC BULK ELEMENT HAVING
THIN-FERROMAGNETIC-FILM SWITCH-
ING CHARACTERISTICS**

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Filed June 16, 1967, Ser. No. 646,639

Int. Cl. G11b 5/00

U.S. Cl. 340—174

9 Claims

ABSTRACT OF THE DISCLOSURE

An element that may be utilized as a transformer, or inductor, core or as a bistable memory core comprising a plurality of stacked, magnetizable layers of thin-ferromagnetic-films separated by interstitial layers of insulating material. The magnetizable layers possess the magnetic property of uniaxial anisotropy providing an easy axis thereby with adjacent magnetizable layers having their easy axes aligned along two respectively different axes forming a mean axis of magnetization M_a that is intermediate the two axes of the two sets, each set formed by the alternate magnetizable layers. Operation as a transformer, or inductor, core is achieved by the application and detection of an AC field along a magnetic axis that is orthogonal to the mean axis M_a ; operation as a memory core is achieved by the application of drive fields and detection of switching fields along a magnetic axis that is parallel to the mean axis M_a .

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a contract or subcontract thereunder with the Department of the Navy.

The present invention relates to magnetizable elements comprising a plurality of stacked, magnetizable layers of thin-ferromagnetic-films, each layer possessing single-domain properties and the magnetic characteristic of uniaxial anisotropy providing an easy axis along which the remanent magnetization thereof lies in a first or a second and opposite direction. The term "single-domain property" may be considered the magnetic characteristic of a three-dimensional element of magnetizable material having a thin dimension that is substantially less than the width and length thereof wherein no magnetic domain walls can exist parallel to the large surfaces of the element. The term "magnetizable" material shall designate a substance having a remanent magnetic flux density that is substantially high, i.e., approaches the flux-density at magnetic saturation. It is desirable that each of the several thin-ferromagnetic-film layers that make up the magnetizable element possess such single-domain property whereby single-domain rotational switching of the magnetization M of such magnetizable element shall be achieved in a manner such as described in the S. M. Rubens et al. Patent No. 3,030,612. Such magnetizable elements may be fabricated in a continuous vapor deposition process such as disclosed in the S. M. Rubens et al. Patent No. 2,900,282 and Patent No. 3,155,561. However, such magnetizable elements may be formed by any one of the plurality of well-known methods of fabricating magnetizable memory elements within an evacuable enclosure, e.g., cathodic sputtering.

As a thin-ferromagnetic-film layer possessing single-domain properties is limited in its maximum thickness to the order of 10,000 angstroms (A.) it is apparent that the net flux, which is a function of its cross-sectional area, is limited. Accordingly, it is desirable to have a magnetizable element that is capable of operating in a single-domain manner while providing substantially larger external mag-

netic fields that, upon the switching or rotation of the element's magnetization M , couple the lines associated therewith producing an output signal therein that is of a substantially larger magnitude than that achieved by a single thin-ferromagnetic-film layer. Prior art arrangements of magnetizable elements operating as a single element comprised a plurality of stacked, similar magnetizable layers of thin-ferromagnetic-films separated by interstitial layers of insulating material involved all such magnetizable elements wherein the easy axes of all of the thin-ferromagnetic-film layers thereof were aligned. However, in the preferred embodiment of the present invention alternate magnetizable layers have their easy axes aligned along two respectively different axes forming a mean axis of magnetization M_a that is intermediate the two axes of the two sets of alternate magnetizable layers.

Prior art arrangements of magnetizable elements operating as a single element comprised a plurality of stacked, similar magnetizable layers of thin-ferromagnetic-film separated by interstitial layers of insulating material that are fabricated with the easy axes of all magnetizable layers aligned. However, if it is desired that the magnetizable layers should rotate in a single-domain manner it is essential that the total thickness of the magnetizable element be limited to a substantially thin dimension. The reason for this is that when the magnetization M in the many magnetizable layers rotates such layers' magnetization M vectors rotate in the same direction. Thus, the components of M that are perpendicular to the major surfaces of the layers are all in the same aligned direction through the thickness thereof tending to be continuous in the magnetizable and insulating layers. In other words, internal pole pairs, i.e., pole pairs on opposite surfaces of each insulating layer, tend to cancel out each other leaving only the poles on the top and bottom layers uncanceled. This results in a small demagnetizing field, i.e., the field applied to the magnetizable layer that tends to demagnetize the layer's normal magnetization for the large thickness that is produced by the many magnetizable and insulating layers. This small demagnetizing field approaches that of bulk magnetizable material of the same thickness causing the magnetizable layers to switch in a manner similar to bulk material switching.

In contrast to this prior art arrangement, by utilizing the present invention the magnetization M in adjacent magnetizable layers rotate in opposite directions whereby the components of M that are perpendicular to the major surfaces of the layers are in opposite, but aligned, directions perpendicular to the thickness of the element. In this arrangement the internal pole pairs do not tend to cancel out each other. This results in a very large normal demagnetizing field on each magnetizable layer for the large thickness produced by the many magnetizable and insulating layers. This large demagnetizing field forces the magnetization M of the individual magnetizable layers to switch in a single-domain manner similar to that achieved by magnetizable elements of a single thin-ferromagnetic-film layer. When this large demagnetizing field is present the magnetization M vector remains essentially in the plane of the magnetizable layer during its rotation; this is a requirement and the reason for the high speed change in magnetization provided by single-domain films.

SUMMARY OF THE INVENTION

The present invention is an improvement of such above discussed prior art arrangements of magnetizable elements comprising a plurality of stacked, similar magnetizable layers of thin-ferromagnetic-films that are separated by interstitial layers of insulating material. All of the magnetizable layers are of substantially the same material and thickness and possess the magnetic characteristics of single-domain property and uniaxial anisotropy for pro-

viding an easy axis along which the remanent magnetization thereof shall lie in a first or a second and opposite direction. Alternate magnetizable layers forming a first set of layers are formed with their easy axes aligned along a first axis with the interstitial magnetizable layers forming a second set of layers with their easy axes aligned along a second axis that is different from the first axis. Thus, there are formed first and second sets, each of a plurality of magnetizable layers, with their easy axes at an angle forming a mean magnetization axis M_a that substantially bisects the acute angle formed by the easy axes of the two sets.

The magnetizable elements of the present invention have the ability to be operated as a transformer, or inductor, core or as a bistable memory core. Operation as an inductor core is achieved by the application and detection of an AC field along a magnetic axis that is orthogonal to the mean magnetization axis M_a . Operation as a bistable memory core is achieved by the application of a drive field and the detection of a switching field along a magnetic axis that is parallel to the mean magnetization axis M_a . Drive and sense lines, or windings, that are magnetically, or conductively, coupled to the magnetizable elements of the present invention may be of the well known printed circuit type as particularly adapted in bistable memory core operation or more conventional transformer winding techniques when operated as an inductor core. Additionally, readout may be by any of the well known methods, such as magnetoresistive or magnetooptic. Accordingly, it is a primary object of the present invention to provide a magnetizable element that may be utilized as an inductor core or as a bistable memory core that is comprised of a plurality of stacked, magnetizable layers of thin-ferromagnetic-films separated by interstitial layers of insulating material forming an element of substantial thickness while yet permitting the individual, and collective magnetizable layers to rotate, or switch, in a single-domain manner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a magnetizable element of a plurality of magnetizable layers separated by interstitial layers of insulating material as proposed by the present invention.

FIG. 2 is a plan view of the magnetizable element of FIG. 1 illustrating the orientation of the two easy axes of the respectively associated sets of magnetizable layers of the magnetizable element of FIG. 1.

FIG. 3 is a schematic illustration of the related vectors involved with the switching mechanism of adjacent magnetizable layers as proposed by the present invention.

FIG. 4 is a plan view of a magnetizable element of the present invention illustrating the orientation of the easy axes M_1 and M_2 of the respectively associated two sets of magnetizable layers of FIG. 1 when utilized as a transformer element.

FIG. 5 is a plan view of a magnetizable element illustrating the orientation of the two easy axes M_1 and M_2 of the respectively associated two sets of magnetizable layers of FIG. 1 when utilized as a memory element.

FIG. 6 is a composite illustration of the hysteresis loop characteristics of the magnetizable elements of FIG. 4 and FIG. 5.

FIG. 7 is an illustration of another embodiment of the present invention in which the magnetizable element is comprised a plurality of stacked, magnetizable layers having a washer-like configuration.

FIG. 8 is an illustration of another embodiment of the present invention in which the magnetizable element is comprised of a plurality of concentric, different-diameter toroidal-shaped magnetizable layers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With particular reference to FIG. 1 there is illustrated

a side view of a magnetizable element that incorporates the inventive concept of the present invention. Magnetizable element 10 is comprised of a substrate 12 and a plurality of magnetizable layers 14, 16 insulatively separated by a plurality of insulating layers 18. Magnetizable element 10 is particularly adaptable to be fabricated in successive deposition steps of alternate layers of magnetizable material and insulating material in an evacuable enclosure. Magnetizable layers 14, 16 are thin-ferromagnetic-film layers that possess the magnetic characteristics of single-domain properties and uniaxial anisotropy for providing an easy axis along which the remanent magnetization thereof shall lie in a first or a second and opposite direction. Each of the several thin-ferromagnetic-film layers 14, 16 that make up the magnetizable element 10 possess such single-domain property whereby single-domain rotational switching of the magnetization M of each of such layers may be achieved in the manner such as described in the S. M. Rubens Patent No. 3,030,612. Additionally, magnetizable element 10 is preferably fabricated in a continuous vapor deposition process such as disclosed in the S. M. Rubens et al. Patent No. 2,900,282 and 3,155,561 or the A. V. Pohm Patent No. 3,065,105. The multi-layer element 10 may be deposited upon a substrate 12 of many well known materials such as glass or metal.

With particular reference to FIG. 2 there is illustrated a plan view of the magnetizable element 10 of FIG. 1 for purposes of illustrating the orientation of the easy axes M_1 and M_2 each respectively associated with the two associated sets of layers; one set formed by the alternate layers 14a, 14b, 14c, and 14d, and the other set formed by the alternate layers 16a, 16b, 16c, and 16d as illustrated in FIG. 1. The two sets of different alternate magnetizable layers 14, 16 have the respectively associated easy axes M_1 , M_2 separated by an acute angle α . These easy axes M_1 , M_2 are separated by an acute angle α forming an effective, average, or mean easy axis M_a which preferably forms an angle $\alpha/2$ with each of the axes M_1 , M_2 . For purposes of the discussion in the present application the mean or average easy axis M_a shall be defined as the easy axis bisecting the acute angle formed by the two axes M_1 , M_2 that are associated with their respective sets of magnetizable layers 14, 16; it being recognized that the obtuse angle β established by the two easy axes M_1 , M_2 establishes a second mean easy axis that is orthogonal to the above defined mean easy axis M_a . Thus, in summary it may be stated that magnetizable element 10 is basically comprised of two sets of stacked, superposed, magnetizable layers (14, 16) in which adjacent magnetizable layers are separated by an insulating layer (18). All layers of each set have their easy axes (easy axes M_1 of the first set of magnetizable layers 14, and easy axis M_2 of the second set of magnetizable layers 16) aligned with the two respective easy axes of the two sets (easy axes M_1 and M_2 of sets one and two, respectively) oriented at an acute angle (α) forming an effective or mean easy axis (M_a) that bisects the so-formed acute angle. Note: for ease of discussion, the vector magnetization M , either aligned along, or rotated out of alignment with, the associated easy axis, and the associated easy axis M shall be identified by similar terms; i.e., magnetization M , of layer 14 having an easy axis M_1 .

With particular reference to FIG. 3 there is presented a diagrammatic illustration of the paths traced out by the magnetization vectors of magnetizable layers 14, 16. As discussed above, the present invention relates to a magnetizable element that comprises a plurality of stacked, superposed, magnetizable layers of thin-ferromagnetic-films separated by interstitial layers of insulating material. The magnetizable layers possess the magnetic property of uniaxial anisotropy providing an easy axis thereby with alternate magnetizable layers having their easy axes aligned along two respectively different axes M_1 and M_2 forming a mean axis of magnetization M_a .

that is intermediate the two axes of the two sets of alternate magnetizable layers. Each of the layers of magnetizable material, such as adjacent layers 14, 16, possess single-domain properties that are capable of having their magnetization switched, or rotated, in a single-domain manner such as disclosed in the above referenced S. M. Rubens et al. Patent No. 3,030,612.

If the magnetization M_2 , as in magnetizable layer 16, is effected by an applied drive field H along the mean axis M_a the magnetization M_2 is induced to rotate in the direction away from the applied drive field H toward a position M_2^1 through an angle ϕ_2 . When the magnetization begins to rotate out of alignment with its easy axis M_2 there is generated a component M_2^2 that is normal to the plane of the magnetizable layer. However, the demagnetizing field of the magnetizable layer 16 limits this normal component to extremely small values causing the magnetization M_2^1 to rotate through path 30 which path is substantially in the plane of layer 16. This mechanism is more fully discussed in the text "Amplifier And Memory Devices: With Films and Diodes" McGraw-Hill Book Company, 1965, Chapter 13.

With a plurality of magnetizable layers 16 arranged in a stacked, superposed arrangement similar to that of FIG. 1 with the easy axis of all such layers 16 aligned, an applied drive field H would cause the magnetization M_2 of all such layers 16 to rotate in the same direction. Thus, the components M_2^2 that are perpendicular to the major surfaces of layer 16 are all in the same aligned direction through the plurality of layers tending to be continuous therethrough. In other words, these adjacent layers 16 would form internal pole pairs with respect to adjacent layers 16, such as components M_2^2 , that tend to cancel each other leaving only the poles on the top and bottom layers 16 uncanceled. This results in a very small demagnetizing field M_2^2 for the relatively large thickness through the plurality of layers 16, this very small demagnetizing field approaches that of bulk magnetizable material of the same thickness causing the magnetization of the plurality of magnetizable layers 16 to switch in a manner similar to that of bulk material.

However, if instead of the above, wherein there was provided a plurality of stacked layers 16 having their easy axes aligned, assume that there are provided a like number of magnetizable layers 14 interstitial with the layers 16 forming adjacent pairs of layers 14 and 16 and further assume that the easy axes of such layers 14 are aligned but at an angle α with the aligned easy axes of the plurality of layers 16. These adjacent pairs of layers 14, 16 may then be assumed to generate an effective, or mean, magnetization axis 32 which bisects the angle α between the easy axes M_1 , M_2 associated with layers 14, 16 respectively. Now, if a drive field H is applied parallel to the planes of the layers 14, 16 and of an opposite polarization with respect to the average magnetization M_a along the mean axis 32 the magnetization M_1 and M_2 of layers 14 and 16, respectively, are forced to rotate in opposite directions. Thus, as in the example shown in FIG. 3, magnetization M_1 of layer 14 would rotate in a clockwise direction (as viewed from above) along a path 34 while magnetization M_2 in layers 16 would rotate in a counterclockwise direction along path 30. The vertical components M_1^2 and M_2^2 , generated by the rotation of magnetization M_1 and M_2 of layers 14 and 16, respectively, due to the opposite directions of rotation, would be of substantially equal magnitude but of opposite polarity. Thus, by utilizing the inventive concept of the present invention the magnetization in the adjacent magnetizable layers 14 and 16 rotate in opposite directions whereby the components of M that are perpendicular to the major surfaces of the layers are in opposite, but aligned, directions through the thickness of the magnetizable element provided by the plurality of pairs of layers 14, 16 and the associated insulating layers 18—see FIG. 1. In this arrangement the internal pole pairs, i.e., the M compo-

nents M_1^2 and M_2^2 that are perpendicular to the major surfaces of the layers 14 and 16, do not tend to cancel out each other. This results in a very large demagnetizing field for the large thickness produced by the many magnetizable layers 14, 16 and insulating layers 18. This large demagnetizing field forces the magnetization M of the individual magnetizable layers 14, 16 to switch in a single-domain manner similar to that achieved by magnetizable elements of a single thin-ferromagnetic-film layer. When this large demagnetizing field is present the magnetization M vector of each layer 14, 16 remains essentially in the plane of the associated magnetizable layer 14, 16; this is a requirement and the reason for high speed rotational change in magnetization.

With particular reference to FIG. 4 there is illustrated a plan view of a magnetizable element 10a illustrating the orientation of the easy axes M_1 , M_2 formed by the two sets of magnetizable layers 14, 16 respectively, when magnetizable element 10 is to be utilized as a transformer core. Although the illustrated embodiment is discussed as "magnetizable" it is to be understood that this is not essential thereto. A permeable layer having a permeability greater than that of air and with substantially no remanent magnetization could function as a transformer, or inductor, core. In this arrangement, utilizing magnetizable element 10a as a transformer, or inductor, core the easy axes of the two sets of magnetizable layers 14, 16 are established along the respective easy axes M_1 , M_2 generating a mean easy axis M_a that bisects the acute angle therebetween. Operation of magnetizable elements 10a as a transformer, or inductor, core is achieved by the application and detection of an AC field along a magnetic axis that is orthogonal to the mean axis M_a . The AC magnetizing field $\pm H$ applied along axis 40 by winding 42 causes the magnetization associated with axes M_1 , M_2 to oscillate about the mean axis M_a through the respective angles ϕ_1 , ϕ_2 . The flux variations of magnetizable element 10 due to the oscillation of the magnetization thereof about its mean axis M_a is detected by winding 44; as an inductor core only one winding 42 is required. In this arrangement windings 42 and 44 function as the primary and secondary windings, respectively, that are inductively coupled to the magnetizable element 10a. By winding 42 coupling a magnetizing force $\pm H$ of an intensity ($H > H_K$) just sufficient to cause the magnetizations M_1 , M_2 to oscillate $\pm 45^\circ$ about the mean axis M_a , i.e., ϕ_1 , ϕ_2 equal to 90° , the total flux change in magnetizable element 10a is equal to approximately 0.7 of the total switchable flux therein.

With particular reference to FIG. 6 there is presented the B-H loop 60 that is an approximate representation of the magnetic flux path traversed by the magnetic flux of magnetizable element 10a when operated in the transformer mode as described with particular reference to FIG. 4. Loop 60 represents the substantially lossless operation of magnetizable element 10a such as is usually associated with the operation of thin-ferromagnetic-film layers when driven in the "hard" direction. As will be further discussed with particular reference to FIG. 5, loop 62 represents the approximate path traversed by the magnetic flux of element 10b when operated as a memory element in accordance with the embodiment of FIG. 5. Loops 60 and 62 of FIG. 6 are typical B-H loops of thin-ferromagnetic-film elements having uniaxial anisotropy and being driven in the hard and easy directions, respectively. For a detailed discussion of the rotational loops of FIG. 6 reference may be had to the publication "Thin Ferromagnetic Films," A. C. Moore, IRE Transactions on Component Parts, March 1960, pages 3-14.

With particular reference to FIG. 5 there is illustrated a plan view of a magnetizable element 10b when utilized as a memory element. Operation as a memory element, or bistable core, is achieved by the application of a drive field $\pm H$, where $+H$ may be representative of the storing

of a "1" and $-H$ may be representative of the storing of a "0" in memory element 10b. This drive field H is coupled to memory element 10b by means of coil 52 providing a drive field that is oriented parallel to the mean axis M_a . In this embodiment the applied drive field H is of an intensity in the area of magnetizable element 10b, approximating H_k causing the magnetizations M_1 and M_2 to completely switch, i.e., be rotated a full 180° to assume a magnetization polarization along their respective easy axes M_1 and M_2 that is opposite to that of their original polarizations. The magnetic flux change in magnetizable element 10b due to the switching, or not switching of the magnetization M_1 , M_2 is detected by the output, or sense, coil 54 whose magnetic axis is oriented parallel to the mean axis M_a of magnetizable element 10b inducing a signal therein that is representative of the informational state of magnetizable element 10b when operated as a memory core. As an example, with the magnetization of the two sets of magnetizable layers 14, 16 of magnetizable element 10b established in their respective easy axis directions M_1 , M_2 , which directions may be representative of the storage of a "1" therein, the application of a $-H \approx H_k$ drive field by winding 52 would cause the magnetizations M_1 , M_2 thereof to switch 180° reversing their polarization and thus inducing a substantial signal in output winding 54. Conversely, with the magnetizations of magnetizable layers 14, 16 of magnetizable element 10b established along their easy axes M_1 , M_2 the application of a $+H$ drive field by winding 52 would induce an insubstantial signal in output winding 54 that may be representative of the storing of a "0" therein.

With particular reference to FIG. 6 there is illustrated the loop 62 that describes the magnetic flux path traversed by the magnetic flux of magnetizable element 10b when operated as a memory core in accordance with the embodiment of FIG. 5. It can be seen that loop 62 has a substantially rectangular form that approaches the ideal characteristic for a magnetizable memory element.

With particular reference to FIG. 7 there is presented another embodiment of the present invention that is particularly adapted to function as a transformer, or inductor, core such as previously discussed with particular reference to FIG. 4. Magnetizable element 70 is comprised of a plurality of stacked, superposed thin-ferromagnetic-film layers 74a, 76a, 74b, 76b similar to the layers 14, 16 of FIG. 1. Adjacent magnetizable layers are separated by suitable insulating layers as in FIG. 1, but are not illustrated for purposes of clarity. However, in this embodiment each of the magnetizable layers is in the form of a washer providing a closed flux path around the central aperture for the magnetizing field $\pm H$ that is applied to magnetizable element 70 by input winding 72. Layers 74, 76 are fabricated so as to have radial easy axes that are orthogonal to the $\pm H$ closed flux path. Adjacent cores, such as cores 74a and 76a provide substantially closed flux paths in a radial direction therebetween whereby there are provided two substantially orthogonally closed flux paths by each of two adjacent cores. Application of the AC drive field by means of winding 72 forces the magnetization M_1 , M_2 of layers 74, 76, respectively, to oscillate about their radially aligned easy axes in the nature as discussed with respect to FIG. 4 whereby there is produced by layers 74, 76 a magnetic flux change which is in turn coupled to output winding 78. As with respect to the embodiment discussed with respect to FIG. 4 windings 72 and 78 function as the primary and secondary windings, respectively, of transformer core 70; as an inductor core only winding 72 is required. The magnetic flux change in core 70 traverses a B-H loop similar to that of loop 60 as discussed with particular reference to FIG. 6.

With particular reference to FIG. 8 there is presented another embodiment of the present invention that is

particularly adapted to operate as a memory core in the nature as discussed with particular reference to FIG. 5. Magnetizable element 80 is comprised of a plurality of concentric rings of thin-ferromagnetic-films with adjacent layers separated by suitable insulating layers as in FIG. 1, but not illustrated herein for purposes of clarity. In this embodiment the magnetization of rings 84, 86 are aligned in opposite directions that are substantially parallel to the major axis 81. The concentric rings 84, 86 provide closed flux paths for the $\pm H$ drive field coupled thereto by input winding 82. Additionally, the magnetization M_1 , M_2 of adjacent layers 84, 86 are provided substantially closed flux paths through such adjacent rings. As is discussed with particular reference to the embodiment of FIG. 5, application of the $\pm H$ drive field to magnetizable element 80 by input winding 82 causes the magnetization M_1 , M_2 of layers 84, 86, respectively, to rotate out of alignment with their easy axes and to become aligned in a first or second and opposite direction along a line substantially parallel to the major axes 81.

Thus it is apparent there has been described and illustrated herein a preferred embodiment of the present invention that provides an improved magnetizable element comprising a plurality of stacked, magnetizable layers of thin-ferromagnetic-films that operate in a single-domain manner. It is understood that suitable modifications may be made in the structure as disclosed provided that such modifications come within the spirit and scope of the appended claims. Having, now, fully illustrated and described my invention, what I claim to be new and desire to protect by Letters Patent is set forth in the appended claims.

What is claimed is:

1. A synthetic bulk element operated in a domain rotational mode, comprising:

a plurality of stacked, superposed layers of substantially similar physical dimensions, material composition and magnetic characteristics each layer having a permeability greater than one, adjacent ones of said layers being separated by an insulating material; each of said layers possessing the magnetic characteristic of single-domain property and having a preferred axis of magnetization along which the magnetization thereof may lie;

said layers arranged in first and second sets;

said first set formed by alternate ones of said layers having their preferred axes aligned along a first axis M_1 ;

said second set formed by alternate ones of said layers, interstitial those of said first set, having their preferred axes aligned along a second axis M_2 for forming an angle α with said first axis M_1 ;

a mean easy axis M_a formed by said first axis M_1 and said second axis M_2 and bisecting said angle α ;

input means inductively coupling a drive field to said layers along said axis M_a ;

said drive field causing the magnetization of said first and second sets to rotate in a domain rotational manner in opposite rotational directions;

equal but opposite polarity field components M_1^2 and M_2^2 normal to the planes of adjacent layers of said first and second sets formed by said rotating magnetization;

internal pole pairs formed by said field components M_1^2 and M_2^2 cancelling each other except at the top and bottom one of said layers for forming a relatively small demagnetizing field for the relatively large thickness of the stacked layers.

2. The element of claim 1 wherein said layers are magnetizable thin-ferromagnetic-films and said preferred axes are easy axes due to uniaxial anisotropy.

3. The element of claim 2 wherein the adjacent layers of the first and second sets form substantially closed flux paths for each other,

4. A bistable memory operable in a domain rotational mode, comprising:

a plurality of stacked, superposed magnetizable thin-ferromagnetic-film layers of substantially similar physical dimensions, material composition and magnetic characteristics separated by intersitial layers of insulating material;

each of said magnetizable layers possessing the magnetic characteristics of single-domain property and of uniaxial anisotropy providing an easy axis along which the remanent magnetization thereof may lie in a first or a second and opposite direction;

said magnetizable layers arranged in first and second sets;

said first set formed by alternate ones of said magnetizable layers having their easy axes aligned along a first axis M_1 ;

said second set formed by alternate ones of said magnetizable layers, other than those of said first set, having their easy axes aligned along a second axis M_2 ;

said first and second axes M_1 and M_2 forming an angle α therebetween for providing a mean axis M_a ;

input and output means inductively coupled to said magnetizable layers having a magnetic axis that is parallel to said mean axis M_a ;

said input means coupling a drive field H to said layers for causing the magnetization of said first and second sets to rotate in opposite directions about the mean axis M_a for providing a signal to said output means, and for establishing the magnetization of said first and second sets in a first or a second and opposite direction along their respective first and second axes M_1 and M_2 ;

equal but opposite polarity field components M_1^2 and M_2^2 normal to the planes of adjacent layers of said first and second sets formed by said rotating magnetization;

internal pole pairs formed by said field components M_1^2 and M_2^2 cancelling each other except at the top and bottom ones of said layers for forming a relatively small demagnetizing field for the relatively large thickness of the stacked layers.

5. The memory of claim 4 wherein said first and second axes M_1 and M_2 form an acute angle α therebetween for providing said mean axis M_a that bisects said acute angle.

6. The memory of claim 5 wherein said mean axis M_a bisects said acute angle α in equal portions $\alpha/2$.

7. The memory of claim 6 wherein said drive field H is of an intensity, in the area of said layers, $H > H_k$ of said layers.

8. The memory of claim 7 wherein said input and output means include separate associated windings.

9. The method of operating a synthetic bulk element in a domain rotational mode, comprising:

forming a plurality of stacked, superposed layers of substantially similar physical dimensions, material composition and magnetic characteristics, each of said layers having a permeability greater than one;

generating in each of said layers the magnetic characteristics of single domain property and uniaxial anisotropy providing an easy axis along which the remanent magnetization thereof may lie in a first or a second and opposite direction;

arranging said layers in first and second sets, alternate layers forming said first set and the layers that are intersitial the alternate layers of said first set forming said second set;

orienting the easy axes of the layers of the first set along a first easy axis M_1 ;

orienting the easy axes of the layers of the second set along a second easy axis M_2 ;

forming an angle α between said axes M_1 and M_2 ;

forming a mean easy axis M_a between said axes M_1 and M_2 and bisecting said angle α ;

coupling a drive field to said layers along said axis M_a ;

rotating the magnetization of the layers of said first and second sets in a domain rotational mode in opposite rotational directions and substantially in the planes of the layers;

generating equal but opposite polarity field components M_1^2 and M_2^2 normal to the planes of adjacent layers of said first and second sets;

forming internal pole pairs with respect to field components M_1^2 and M_2^2 of adjacent layers;

cancelling all internal field components M_1^2 and M_2^2 ;

leaving uncanceled only those poles on the top and bottom layers.

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