



US006239932B1

(12) **United States Patent**
Hoogendoorn

(10) **Patent No.:** **US 6,239,932 B1**
(45) **Date of Patent:** **May 29, 2001**

(54) **METHOD OF AND ARRANGEMENT FOR
FORMATTING A MAGNETIZABLE MEDIUM**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/175,245**

(22) Filed: **Oct. 20, 1998**

(30) **Foreign Application Priority Data**

Oct. 30, 1997 (EP) 97203363

(51) **Int. Cl.⁷** **G11B 15/14; G11B 5/596**

(52) **U.S. Cl.** **360/64; 360/77.02**

(58) **Field of Search** 360/46, 63, 66,
360/64, 77.02, 77.08, 48

(56) **References Cited**

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Primary Examiner—W. Chris Kim

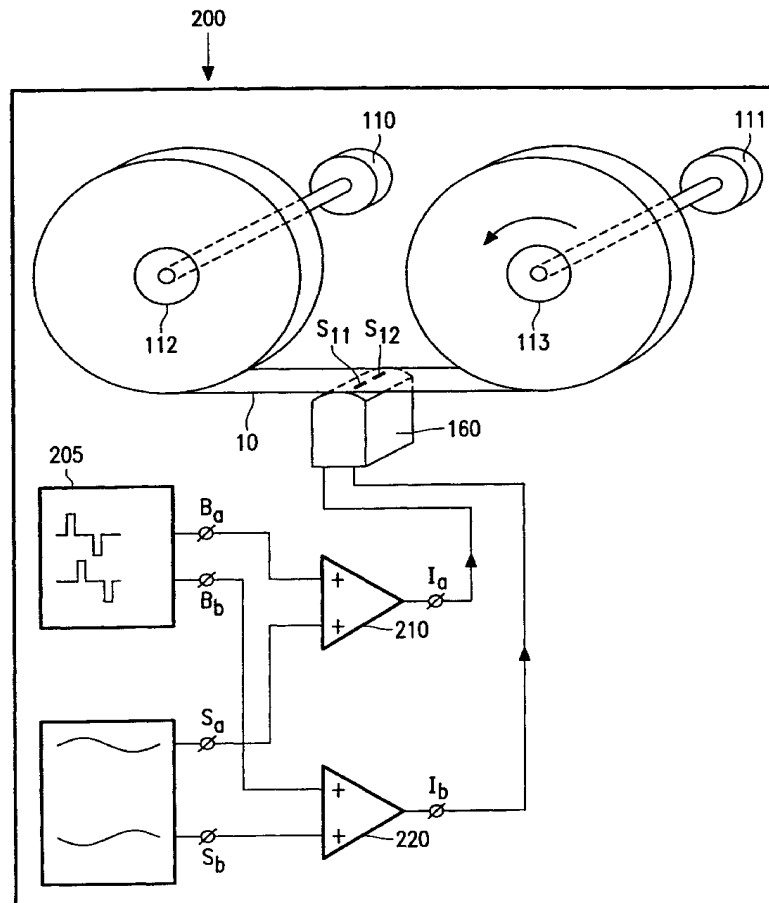
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(57) **ABSTRACT**

An arrangement for recording servo signals on a magnetic tape has first and second adjoining write heads respectively driven by first and second write signals. Each write signal includes a servo signal and a bias signal, the bias signals being phase displaced periodic signals which result in the magnetic tape being magnetized alternately by the first and second write heads. This provides a sharp transition in the servo signals produced from adjoining servo tracks during read-out.

8 Claims, 4 Drawing Sheets



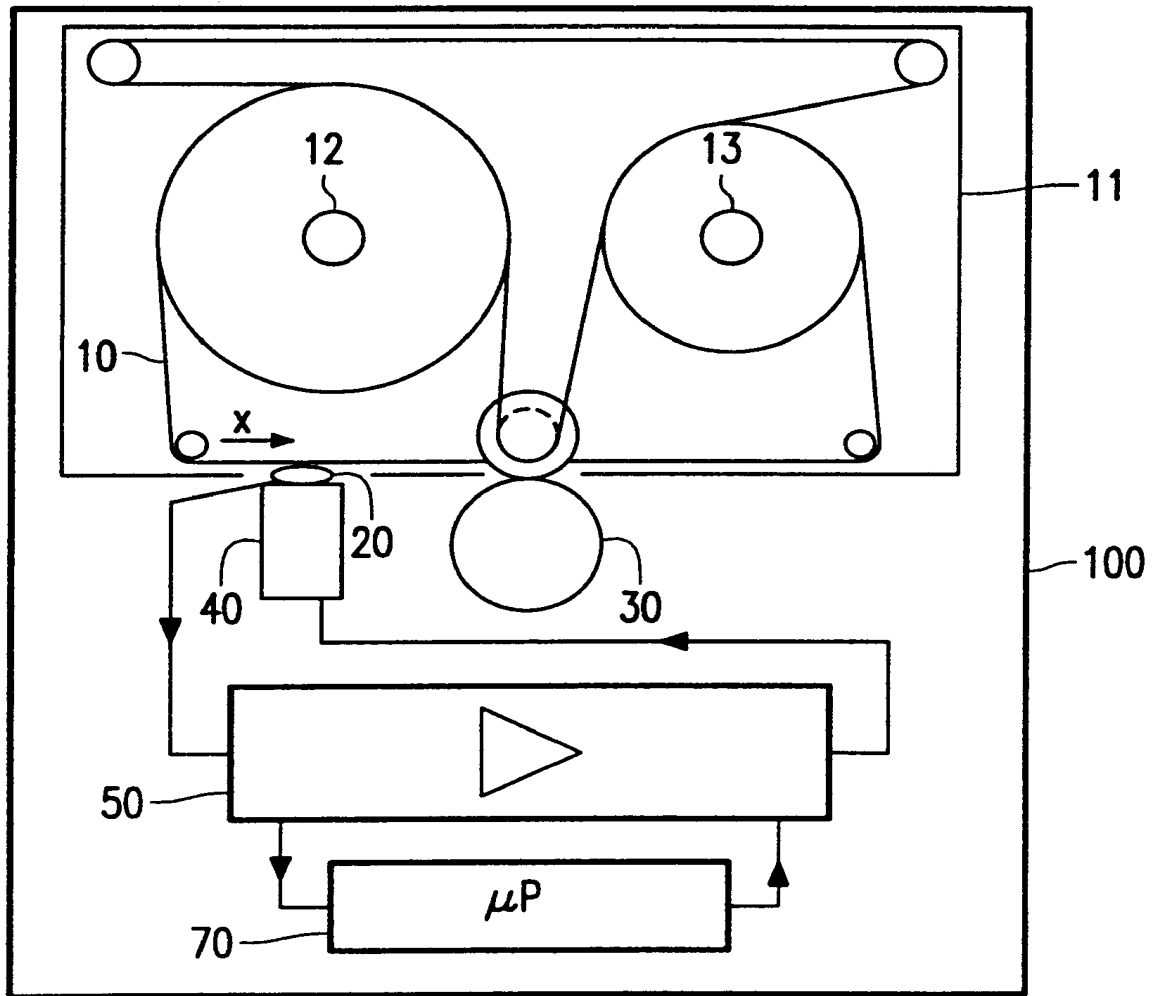


FIG. 1

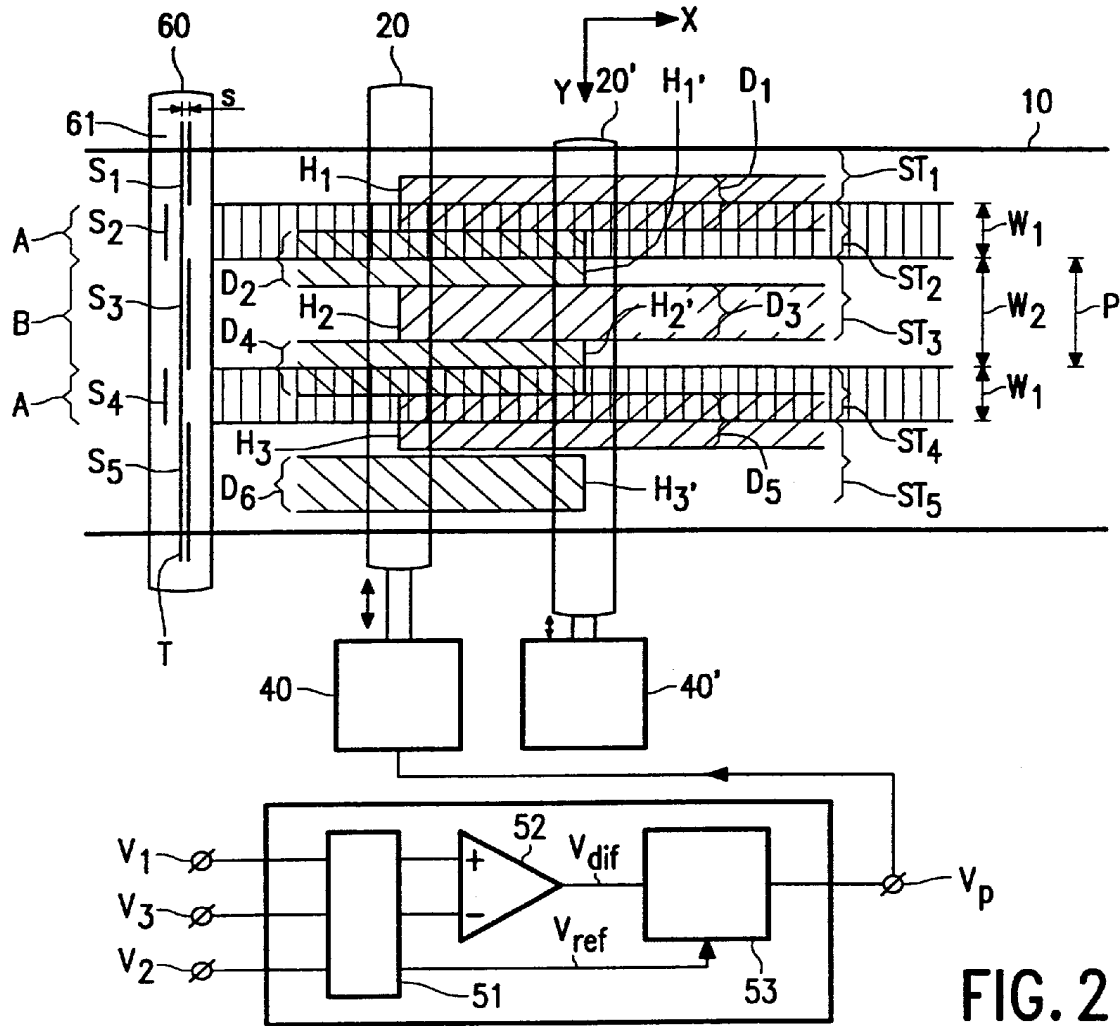


FIG. 2

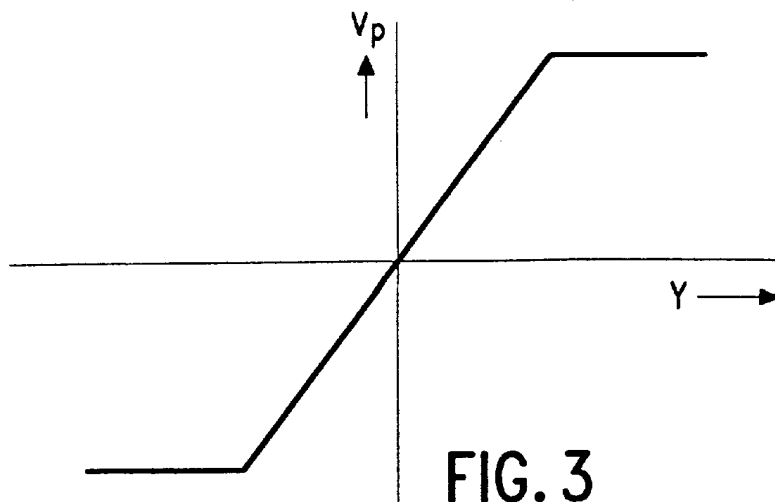


FIG. 3

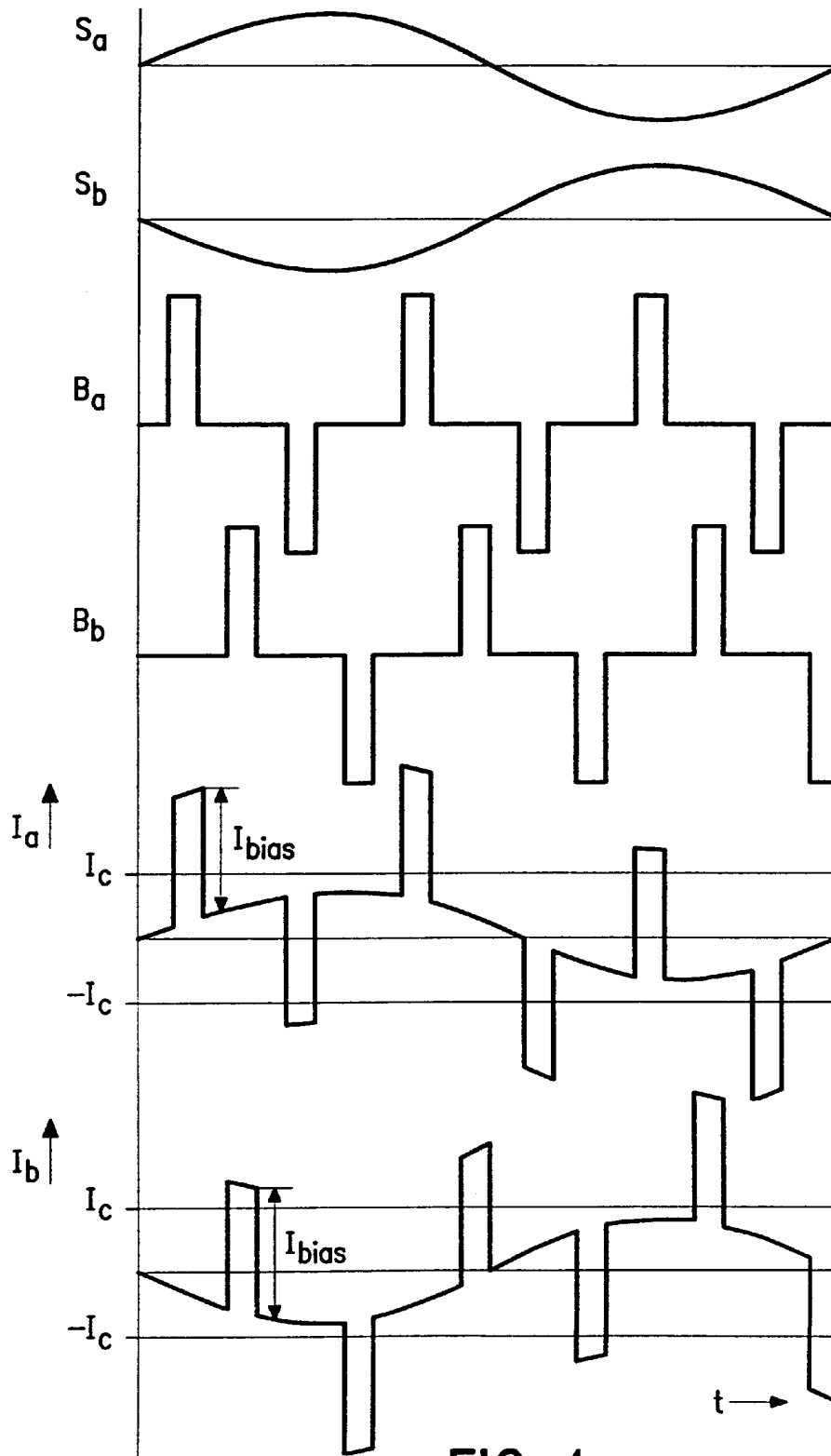


FIG. 4

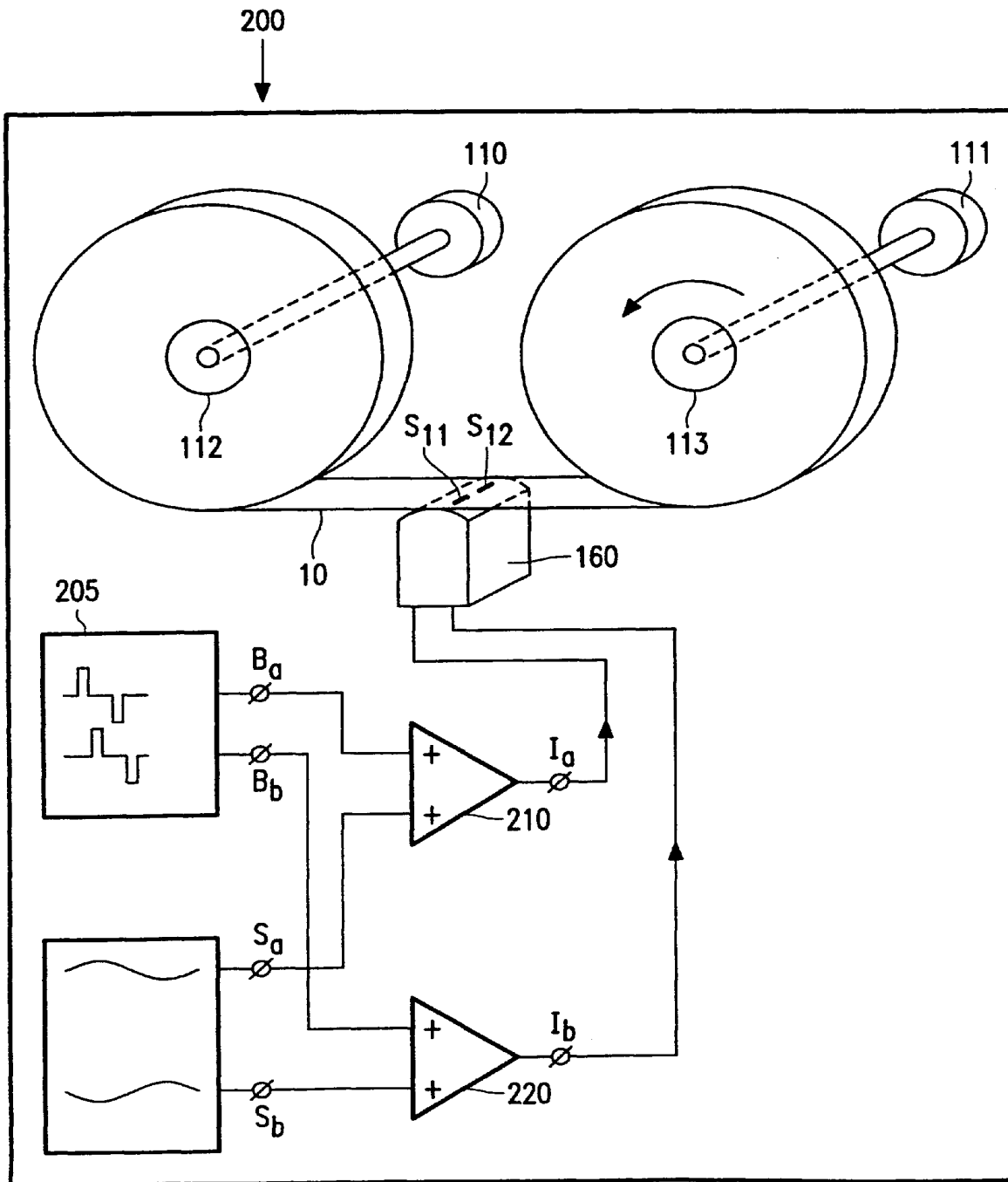


FIG. 5

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METHOD OF AND ARRANGEMENT FOR FORMATTING A MAGNETIZABLE MEDIUM

BACKGROUND OF THE INVENTION

The invention relates to a method of formatting a magnetizable medium, comprising the recording in one pass of at least a first servo signal in a first servo track by means of a first write head and a second servo signal in a second servo track, adjacent the first servo track, by means of a second write head.

The invention also relates to a magnetizable medium provided with at least a first servo track containing a first servo signal and a second servo track adjacent the first servo track and containing a second servo signal.

Furthermore, the invention relates to a cartridge comprising at least one reel hub on which a magnetic tape has been wound, which magnetic tape has been provided with at least a first servo track containing a first servo signal and a second servo track adjacent the first servo track and containing a second servo signal.

The invention also relates to an arrangement for formatting a magnetizable medium, comprising

- a write head unit comprising at least a first write head and a second write head disposed near the first write head,
- a mechanism for moving the medium and the write head unit with respect to one another,
- a servo generator for driving the first write head with a first servo signal and for driving the second write head with a second servo signal.

DESCRIPTION OF THE RELATED ART

Such a method, such a medium, such a cartridge and such an arrangement are known from WO 96/30897-A2 (PHN 15250). In the known method a large number of servo tracks are written simultaneously on a magnetic tape by means of a write-head unit having a number of write heads which is the same as the number of tracks. The write-head unit then scans the magnetic tape in its longitudinal direction and the write heads adjoin one another in a direction transverse to said longitudinal direction. The write heads are then driven in such a manner that two adjacent servo tracks always contain a distinguishable servo signal. A magnetic tape thus provided with servo tracks is used in a multi-track linear data recording apparatus. The transitions between two adjacent servo tracks serve to position a recording/reproducing head in the data recording apparatus with respect to the medium. A disadvantage of the known method is that the transition between two adjacent servo tracks is not sharp. As a result of this, the data recording apparatus is not capable of accurately positioning the recording/reproducing head with respect to the medium.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method of the type defined in the opening paragraph which yields a sharper transition between two adjacent servo tracks than the known method.

The method in accordance with the invention is characterized in that during the pass the medium is magnetized alternately by the first write head and the second write head. The invention is based on the recognition of the fact that the magnetic fields of the first write head and the second write head can interfere with one another as a result of which, amplified by non-linear characteristics of the magnetizable

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medium, a reduced magnetization of the medium is obtained near the transition between two adjacent servo tracks. Owing to the measures in accordance with the invention it is achieved that the magnetic fields of the first write head and the second write head alternate with one another as a function of time during use. As a result of this, the magnetic fields of the first write head and the second write head influence one another to a relatively small degree and a better magnetization of the medium is obtained near the transition between the first and the second servo track. In the transitional area between the first and the second write head the magnetic field at a given instant is determined almost entirely by the first write head or by the second write head. As a result of this, the transitional area between two adjacent servo tracks is magnetized alternately in accordance with the first servo signal and the second servo signal and a sharp transition between the first servo track and the second servo track is obtained.

A variant of the method in accordance with the invention is characterized in that use is made of a frequency of alternation which is higher than, or substantially equal to, the highest frequency in the first servo signal and the second servo signal. Owing to this measure, the first and the second servo signal, also referred to as tracking signal, can subsequently be recovered more easily from the first and the second servo track by filtering.

A variant of the method in accordance with the invention is characterized in that use is made of a frequency of alternation which is higher than, or substantially equal to, the Nyquist frequency of the medium. Owing to this measure it is achieved that the alternation frequency is recorded on the medium in a strongly attenuated form so that it is no longer necessary to filter out the alternation frequency during the reconstruction of the first and the second servo signal. Moreover, this results in substantially the entire bandwidth of the medium being available for the first and the second servo signal.

A variant of the method in accordance with the invention employs phase displaced periodic bias signals for the respective write heads.

That achieves that the distortion of the first and the second servo signal caused by non-linearity of the magnetization curve of the medium is reduced and at the same time a satisfactory magnetization is obtained near the transition between the first and the second servo track.

The bias signals may include a periodic trivalent signal. That yields the advantage that the first and the second write head are operated efficiently.

By configuring the first and the second servo signals to have phase opposed sinusoidal components, the transition between the first and the second servo track can readily be tracked by means of a servo system. For recording such signals the method in accordance with the invention has a great many advantages because, when this is method is not used, the magnetic fields caused by the first sinusoidal component and the second sinusoidal component counteract one another to a maximal extent because they are in phase opposition.

The two write heads may have a common pole. That has the advantage that the first and the second servo track can be written very close to one another so that the medium can store a large amount of information. When such write heads are used the method in accordance with the invention has a great many advantages because saturation of the common pole is precluded by the alternate write method.

The two servo signals may be recorded alternately in odd and even numbered servo tracks. That has the advantage that

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the medium can be provided with all the required servo tracks in one pass, as is described in WO 96/30897-A2 (PHN 15250), which is herewith incorporated by reference, and that only two different servo signals and two different bias signals have to be generated.

The medium in accordance with the invention is characterized in that

the first servo track contains a first bias signal and the second servo track contains a second bias signal, and the first bias signal and the second bias signal alternately assume their respective maximum value.

An advantage of the medium in accordance with the invention is that the transition between the first and the second servo track is sharp, so that the data recording apparatus is capable of accurately positioning the recording/reproducing head with respect to the medium. As a result of this accurate positioning the data can be written and read with a greater reliability. In addition, this accurate positioning enables the density of the data tracks to be higher than with the known system.

The cartridge in accordance with the invention is characterized in that

the first servo track contains a first bias signal and the second servo track contains a second bias signal, and the first bias signal and the second bias signal alternately assume their respective maximum value.

The arrangement in accordance with the invention is characterized in that the arrangement comprises means for alternately magnetizing the medium with the first write head and the second write head during the movement of the medium and the write head with respect to one another. The arrangement is suitable for using the method in accordance with the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of example, with reference to the drawings, in which

FIG. 1 is a diagrammatic representation of a system using the cartridge 11 and the medium 10 in accordance with the invention,

FIG. 2 diagrammatically represents how the medium 10 is formatted and a magnetic-head unit 20 is positioned with respect to the medium,

FIG. 3 shows a position signal V_p as a function of the position y of the magnetic-head unit 20 shown in FIG. 2,

FIG. 4 shows a first servo signal S_a , a second servo signal S_b , a first bias signal B_a , a second bias signal B_b , a first write signal I_a and a second write signal I_b , and

FIG. 5 diagrammatically shows an arrangement 200 for recording signals S_a and S_b on a magnetizable medium 10.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a diagrammatic representation of a system in which the cartridge and the medium in accordance with the invention can be used. The system comprises an apparatus 100 and a magnetizable medium, in the present case a magnetic tape 10 wound on two reel hubs 12 and 13 in a housing of a cartridge 11. The magnetic tape 10 has been provided with a pattern of servo tracks ST_1 – ST_5 which contain servo signals in the form of a magnetization pattern recorded at a deep level (see FIG. 2). These deep servo tracks are referred to as buried servo tracks. The apparatus 100 comprises a magnetic-head unit 20 and means, in the

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present case a motor 30, for realizing a relative movement of the magnetic tape 10 with respect to the magnetic-head unit 20 in a longitudinal direction x past the servo tracks (see FIG. 2). The apparatus 100 further comprises an actuator 40 for moving the magnetic-head unit 20 transversely to the servo tracks and a servo circuit 50 arranged between the magnetic-head unit 20 and the actuator 40. The apparatus 100 comprises control means, in the present case a micro-computer 70, for controlling the actuator 40 and the magnetic-head unit 20.

FIG. 2 diagrammatically shows the magnetizable medium in the form of the magnetic tape 10, a write head 60, the magnetic-head unit 20 and the actuator 40. The magnetic tape 10 has been provided with a pattern of servo tracks ST_1 – ST_5 which extend in a longitudinal direction x and which adjoin one another in a transverse direction y which extends perpendicularly to the longitudinal direction x . The servo tracks ST_1 , ST_3 and ST_5 are of a first type containing a first servo signal S_a and the servo tracks ST_2 and ST_4 are of a second type containing a second servo signal S_b . The servo signals S_a and S_b comprise a fundamental of the same frequency but are in phase opposition to one another (see FIG. 4). The servo signals S_a and S_b have been recorded by means of the write-head unit 60. The write-head unit 60 comprises a head face 61 with adjacent write heads S_1 – S_5 having a common pole T . The write heads S_1 – S_5 have a comparatively large gap length s , as a result of which the servo signals are written deep into the magnetic tape 10. Two write heads S_2 and S_4 of a group of write heads of a first type A are separated as if were by a write head S_3 of a second type B . The write heads S_2 and S_4 of the first type A have a first typical width W_1 and the write unit S_3 of the second type B has a typical width $W_2=2 \cdot W_1$. The write-head unit 60 writes the servo track pattern ST_1 – ST_5 onto the magnetic tape 10 in a single pass. This writing is effected preferably when the magnetic tape is manufactured or when the magnetic tape 10 is wound into the cartridge 11 (see FIG. 1).

The magnetic-head unit 20 forms part of the apparatus 100 as shown in FIG. 1 and comprises three magnetic heads H_1 , H_2 and H_3 which can read and write simultaneously. The apparatus 100 as shown in FIG. 1 is adapted to write information signals in information tracks D_1 – D_6 . For positioning the magnetic-head unit 20 during writing and/or reading of the information tracks D_1 – D_6 the apparatus 100 comprises an actuator 40 and a servo circuit 50. The servo circuit 50 is arranged between the magnetic-head unit 20 and the actuator 40 and is adapted to position the magnetic-head unit 20 with respect to servo track pattern ST_1 – ST_5 in response to the servo signals V_1 , V_2 and V_3 read from the servo tracks by the heads H_1 , H_2 and H_3 , respectively. The servo circuit 50 includes a selector 51 for selecting the signals from heads disposed at a transition line between two servo tracks and a comparator 52 for generating a difference signal V_{dif} from the selected signals. The selector 51 is controlled by the microcontroller 70 shown in FIG. 1. The servo circuit 40 further comprises a multiplier 53 for generating a position signal V_p as a function of the position y of the magnetic-head unit (see FIG. 3). The position signal V_p is generated by multiplying the difference signal V_{dif} by a reference signal V_{ref} obtained from the head which wholly situated on one of the servo tracks. The actuator 40 is driven until the position signal V_p is substantially equal to zero. The reference signal V_{ref} and the difference signal V_{dif} are formed as follows by the selector 51 depending on the pass:

pass	Vref	Vdif
1	V2	V1-V3
2	V3	V2-V1

The pitch p between the magnetic heads **H1**, **H2** and **H3** is equal to twice the typical width **W1** of the servo tracks **ST2** and **ST4**. As a result of this, two passes are needed to fill the magnetic tape **10** with information tracks **D1**–**D6**. In a first pass the magnetic-head unit **20** writes the information tracks **D1**, **D3** and **D5**, the magnetic tape **10** being moved in the x direction with respect to the magnetic-head unit **20**. In a second pass the same magnetic-head unit **20**, now referenced **20'**, writes the information tracks **D2**, **D4** and **D6** at another position in the transverse direction y , the magnetic tape **10** being moved in a direction opposite to the x direction with respect to the magnetic-head unit **20'**. After this second pass the magnetic tape **10** has returned to its initial position.

FIG. 4 shows the first servo signal **Sa**, the second servo signal **Sb**, a first bias signal **Ba**, a second bias signal **Bb**, a first write signal **Ia** and a second write signal **Ib**. When the servo tracks **ST1**–**ST5** are recorded the write heads **S1**, **S3** and **S5** are driven with the first write signal **Ia** and the write heads **S2** and **S4** are driven with the second write signal **Ib** (see FIG. 2). The first write signal **Ia** is generated by adding the first servo signal **Sa** and the first bias signal **Ba**, and the second write signal **Ib** is generated by adding the second servo signal **Sb** and the second bias signal **Bb**. The first servo signal **Sa** comprises a first sinusoidal component and the second servo signal **Sb** comprises a second sinusoidal component. The frequency of the first sinusoidal component is equal to the frequency of the second sinusoidal component and the first sinusoidal component and the second sinusoidal component are in phase opposition.

The first bias signal **Ba** and the second bias signal **Bb** consist of a periodic trivalent signal and the first bias signal **Ba** is approximately 90° shifted in phase with respect to the second bias signal **Bb**. As a result of this, the absolute value of the second bias signal **Bb** is comparatively small when the absolute value of the first bias signal **Ba** is comparatively large, and the absolute value of the first bias signal **Ba** is comparatively small when the absolute value of the second bias signal **Bb** is comparatively large. Consequently, the absolute value of the second write signal **Ib** is comparatively small when the absolute value of the first write signal **Ia** is comparatively large, and the absolute value of the first write signal **Ia** is comparatively small when the absolute value of the second write signal **Ib** is comparatively large. The frequency of the bias signals **Ba** and **Bb** is three times as high as the frequency of the servo signals **Sa** and **Sb** and slightly higher than the Nyquist frequency of the magnetic tape **10**. The amplitude of the bias signals **Ba** and **Bb** is at least three times and preferably ten times as high as the amplitude of the servo signals **Sa** and **Sb** (for practical reasons this ratio is shown differently in FIG. 4). Since the magnetic tape **10** has a certain coercivity the magnetic tape is not inscribed until the current **Ia** or **Ib** exceeds a given limit value **IC** or **-Ic**. Preferably, the amplitude **Tbias** of the pulses in the write currents **Ia** and **Ib** as a result of the bias signals is at least three times as high as said limit value **Ic**. In the case of a smaller current than **IC** the field strength of the magnetic field produced by a magnetic head is smaller than the coercivity of the magnetic tape **10**, as a result of which the

magnetic tape **10** is not magnetized. By means of the write currents **Ia** and **Ib** as shown in FIG. 4 the magnetic tape **10** is alternately magnetized by the write heads **S1**, **S3**, **S5** and the write heads **S2**, **S4**. Owing to the measures in accordance with the invention it is achieved that the signal **Vp** shown in FIG. 3 has a substantial slope, as a result of which the magnetic-head unit **20** is positioned accurately with respect to the magnetic tape.

FIG. 5 diagrammatically shows an arrangement **200** for recording signals **Sa** and **Sb** on a magnetizable medium **10**. The arrangement **200** comprises a write head unit **160** having at least a first write head **S11** and a second write head **S12** situated near the first write head **S11**. The arrangement **200** further has a mechanism comprising two electric motors **110**, **111** and two reel hubs **112**, **113** on which the medium **10** is wound. By means of this mechanism the medium **10** can be moved past the write head unit **160**. The arrangement **200** comprises a bias generator **205** for generating bias signals **Ba** and **Bb** as shown in FIG. 3 and adding means **210** and **220** for forming write signals **Ia** and **Ib** by adding the bias signals **Ba** and **Bb** to the signals **Sa** and **Sb** to be written onto the medium **10**. The write heads **S11** and **S12** are driven with the write signals **Ia** and **Ib**, respectively. Owing to the relationship between the bias signals **Ba** and **Bb** as described with reference to FIG. 3 the medium **10** is alternately magnetized by the first write head **S11** and the second write head **S12**.

It is to be noted that the invention is not limited to the examples shown herein. Several other variants are possible without departing from the scope of the invention. For example, instead of a magnetic tape a magnetic disc can be used. Moreover, the servo signals **Sa** and **Sb** can be signals of a different frequency, the servo circuit generating a position signal for controlling the actuator on the basis of the amplitude of the servo signals **Sa** and **Sb** as read by a number of heads. The signals **Sa** and **Sb** may also contain data instead of or in addition to said sinusoidal component. Furthermore, instead of a rectangular pulse shape the bias signals may have another, for example triangular, pulse shape, as a result of which the bias signal has more than three values.

What is claimed is:

1. A method of formatting a magnetizable medium, comprising the recording in one pass of at least a first servo signal in a first servo track by means of a first write head and a second servo signal in a second servo track, adjacent the first servo track, by means of a second write head, each of said first and second servo signals having a frequency, wherein during the pass the medium is magnetized alternately by the first write head and the second write head with a frequency of alternation which is higher than, or substantially equal to, the highest frequency in the first servo signal and the second servo signal.
2. A method as claimed in claim 1, characterized in that use is made of a frequency of alternation which is higher than, or substantially equal to, the Nyquist frequency of the medium.
3. A method as claimed in claim 1, characterized in that the first write head is driven with a first write signal comprising the first servo signal and a first bias signal, the second write head is driven with a second write signal comprising the second servo signal and a second bias signal, the absolute value of the second bias signal is comparatively small when the absolute value of the first bias signal is comparatively large, and the absolute value of the first bias signal being comparatively small

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when the absolute value of the second bias signal is comparatively large.

4. A method as claimed in claim 3, characterized in that the first bias signal and the second bias signal comprise a periodic trivalent signal, and

the phase of the first bias signal is shifted approximately 90 degrees with respect to the phase of the second bias signal.

5. A method as claimed in claim 1, characterized in that use is made of

a first servo signal comprising a first sinusoidal component and a second servo signal comprising a second sinusoidal component, the frequency of the first sinusoidal component being equal to the frequency of the second sinusoidal component, and the first sinusoidal component and the second sinusoidal component being in phase opposition.

6. A method as claimed in claim 1, characterized in that use is made of an arrangement in which the first write head and the second write head have a common pole.

7. A method as claimed in claim 1, characterized in that during the pass servo tracks ST1, ST2, . . . STn are recorded adjacent one another, the first servo signal being recorded in the odd-numbered servo tracks and the second servo signal being recorded in the even-numbered servo tracks.

8. An arrangement for formatting a magnetizable medium, comprising

a write head unit comprising at least a first write head and a second write head disposed near the first write head,

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a mechanism for moving the medium and the write head unit with respect to one another,

a servo generator for driving the first write head with a first servo signal and for driving the second write head with a second servo signal,

wherein

the arrangement comprises means for alternately magnetizing the medium with the first write head and the second write head during the movement of the medium and the write head with respect to one another, said means for alternately magnetizing the medium comprising a bias generator and adding means,

the bias generator being adapted to generate a first bias signal and a second bias signal, the absolute value of the second bias signal being comparatively small when the absolute value of the first bias signal is comparatively large, and the absolute value of the first bias signal being comparatively small when the absolute value of the second bias signal is comparatively large, and

the adding means being adapted to add the first bias signal to the first servo signal and to add the second bias signal to the second servo signal.

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