

METHOD FOR OBTAINING HEAD POSITIONS IN MAGNETIC DATA WRITING APPARATUS

Field of the Invention

5 The present invention relates to a magnetic data writing apparatus called a “disk servo writer”, for writing servo patterns for detecting magnetic head positions, ID patterns for identifying disks, and programs into magnetic disks, in which any data has not been written so far, to produce magnetic disk products including the data written therein at the requests of
10 the clients. Hereinafter, the magnetic data writing apparatus will be referred to as the “disk servo writer”.

Specifically, the present invention relates to a disk servo writer for stacking a plurality of magnetic disks (hereinafter referred to as “copy
15 disks”), to which magnetic data is to be transferred, and a magnetic disk (hereinafter referred to as an “original disk”) storing the magnetic data to be transferred to the copy disks and/or the magnetic data referred to in writing data to the copy disks, for rotating the copy disks and the original disk concentrically (around a common axis), and for simultaneously writing the
20 magnetic data, determined on the basis of the data read out from the original disk via a magnetic head used solely for reading out data (hereinafter referred to as a “read-only head”), to the recording surfaces of the respective copy disks via multiple sets of magnetic heads (hereinafter referred to as “servo heads”), each set including a plurality of servo heads
25 arranged on the recording surface of each of the copy disks.

More specifically, the invention relates to a method of obtaining the head positions in a magnetic data writing apparatus (disk servo writer) for easily obtaining the relative position address relations between the
30 read-only head and the servo heads in advance to make the servo heads on

the recording surface of a copy disk write data correctly into the respective track ranges, to which the servo heads are assigned.

In the accompanied drawing, the same reference numerals are used to
5 designate the same or corresponding constituent elements.

Prior Art

Recently, the recording densities of the hard disk drives become higher and higher to realize small magnetic storages, the storage capacities thereof
10 are high. To realize a higher recording density, the tracking servo technique for the magnetic heads for writing and reading data plays important roles.

According to the conventional tracking servo technique, tracking servo signals, address signals (track addresses, sector addresses), clock signals
15 and such data signals are formatted and recorded in the form of servo patterns in the magnetic recording media (magnetic disks). The magnetic head reads out these data signals, checks the position thereof based on the data signals read out, and corrects the position thereof to scans the tracks accurately.

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One of the means for recording the servo patterns in the magnetic disks is a disk servo writer, which stacks a plurality of magnetic disks, employs one of the magnetic disks as an original disk, stores the servo data in the original disk in advance, and copies the servo patterns formed from
25 the servo data in the original disk to the other magnetic disks via magnetic heads.

Now a conventional disk servo writer will be described below with reference to FIGs. 9 through 11. FIG. 11 is a top plan view of a magnetic
30 disk 4 schematically showing regions PS2 (hereinafter referred to as

“servo pattern regions”), in which servo patterns are stored, and regions DTA (hereinafter referred to as “data regions”), in which data is stored. Servo pattern regions PS2 are arranged radially at every certain degrees of angle, that is at a sector interval. Servo pattern regions PS2 and data regions DTA are on both major surfaces of magnetic disk 4. In the following, the reference symbol PS2 is used also to designate servo patterns and the reference symbol DATA also to designate data.

Data regions DTA are the regions, in which the foregoing ID patterns and programs are written by a disk servo writer at the requests of the client, or the regions, in which data is written by the user of magnetic disk 4.

FIG. 9 is a block diagram schematically showing a conventional disk servo writer. A disk servo writer of the similar kind is disclosed in Japanese Unexamined Laid Open Patent Application 2001-216750.

Referring now to FIG. 9, a disk servo writer 101 mounts a disk stack unit 5 stacking multiple sheets (9 sheets in the figure) of magnetic disks (copy disks) 4, in which data is to be written, and a clock pattern disk 3K below disk stack unit 5 on the shaft of a spindle motor so that disk stack unit 5 and clock pattern disk 3K may be rotated simultaneously at a high rotating speed.

Clock pattern disk 3k is obtained by writing clock patterns PCO in the outermost circumference section of a magnetic disk as shown in FIG. 10 with disk servo writer 101 in advance to writing servo patterns PS2 to the other copy disks 4. Then, servo patterns PS2 are written into copy disks 4 synchronizing with the clocks obtained by reading out clock patterns PCO.

In FIG. 9, a clock head 10K for writing and reading clock patterns PCO

directly to and from clock pattern disk 3K, a clock head positioner 2K for supporting clock head 10K and for positioning clock head 10K in the outermost circumference section of clock pattern disk 3K, and a clock pattern generator 9K for generating the signals of clock pattern PCO to be written into clock pattern disk 3K are shown.

In FIG. 9, servo heads 10, which are magnetic heads arranged in one to one correspondence to the respective surfaces of M sheets of copy disks 4, for writing servo patterns PS2 directly to the respective surfaces of copy disks 4, and a rotary positioner 2 for stacking servo heads 10 and for rotating servo heads 10 around an axis 2s to move servo heads 10 to the desired radial positions on the respective copy disks 4, an encoder 20 arranged in a coaxial manner with rotary positioner 2 for detecting the rotating position of rotary positioner 2, and a position detector 21 for obtaining the position (analog value) of servo head 10 in the radial direction of the magnetic disk from the rotating position detected by encoder 20 are also shown.

A servo compensator 12 and a power amplifier 13 constitute together with encoder 20 and position detector 21 a feedback loop for controlling via rotary encoder 2 the positioning of servo heads 10 in the radial direction of the respective disks, that is the positioning of servo head 10 on the radial position in the center of the desired track.

The difference between the reference position ρ_s of servo head 10 (the analog value corresponding to the radius of the center of the target track) and the detected head position ρ , which is the actual radial position outputted from position detector 21, is inputted to servo compensator 12. Servo compensator 12 amplifies the inputted difference and calculates a servo compensation value that minimizes the difference. Power amplifier

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13 outputs a current for driving rotary positioner 2 based on the servo compensation value to move servo head 10.

In FIG. 9, a servo pattern generator 9, to which the clock is inputted from clock head 10K and the detected head position ρ from position detector 21, generates servo patterns PS2 and makes servo heads 10 stacked on rotary positioner 2 write servo patterns PS to the respective copy disks 4.

Now the entire functions of the conventional disk servo writer shown in FIG. 9 will be described. First, clock head 10K stores clock patterns PCO generated from clock pattern generator 9K in an arbitrary radial position (the outermost circumference section in FIG. 10) on clock pattern disk 3K.

Then, actual radial position ρ of servo head 10 is detected by rotary encoder 20 arranged in a coaxial manner with rotary positioner 2 and position detector 21. The error (difference) between the detected head position ρ and the reference head position ρ_s is fed back through servo compensator 12 and power amplifier 13, and servo head 10 is made to track the reference head position ρ_s via rotary positioner 2.

In the tracking state, servo heads 10 simultaneously write servo patterns PS2, which servo pattern generator 9 generates, to the surfaces of the respective copy disks 4 synchronizing with the clock read out from clock pattern disk 3K via clock head 10K.

Servo pattern generator 9 provided with means (not shown) outputs data such as ID data and programs to servo heads 10 synchronizing with the clock from clock pattern disk 3K and makes servo heads 10 write the data

and the programs to data regions DTA on copy disks 4.

Japanese Unexamined Laid Open Patent Application H10 (1998)- 172254
and Japanese Unexamined Laid Open Patent Application H03 (1991)-
5 214474 disclose the methods for writing servo data to magnetic disks
including the step of selecting a master surface from the recording surfaces
of magnetic disks, the step of writing a master servo pattern onto the
master surface in a hard disk drive, and the step of writing servo patterns
onto the recording surfaces other than the master surface while positioning
10 the magnetic heads based on the master servo pattern. Japanese
Unexamined Laid Open Patent Application H06 (1994)- 44711 discloses the
method for simultaneously writing servo patterns on the recording surface
of a magnetic disk with a plurality of magnetic heads in a disk servo writer.

15 Japanese Unexamined Laid Open Patent Application H06 (1994)-
28793 discloses the method for simultaneously writing servo data to a
plurality of magnetic disks in a hard disk drive based on the signals from an
external servo writer. Japanese Unexamined Laid Open Patent Application
H06 (1994)- 28793 discloses the method for compensating off-track in a hard
20 disk drive.

Problems to be solved by the Invention

Since the conventional disk servo writers write the servo patterns
generated by a servo pattern generator simultaneously to stacked magnetic
25 disks synchronizing with the clock patterns recorded in advance in a clock
pattern disk, the time for writing the servo patterns to the entire surfaces
of all the disks in a disk stack unit is given by (the disk rotating time) $\times$
(the number of tracks, to which the servo patterns are written).

30 As the track density on a magnetic disk is improved, the time for servo

pattern writing becomes longer, causing lower throughput. Although it is possible to shorten the time for servo pattern writing by increasing the disk rotation speed, the mechanical vibrations become more vigorous in tradeoff for the faster disk rotation and it becomes harder to write the servo patterns accurately.

Although the throughput for one magnetic disk is improved by increasing the number of the magnetic disks stacked, the accuracy of the spindle motor rotation is impaired, since a heavier load is exerted to the spindle motor, and it becomes harder to mount the magnetic heads within the predetermined range of accuracy, since the number of the magnetic heads stacked increases.

A method for avoiding these problems and for shortening the servo pattern writing time has been proposed. The method stacks an original disk storing servo data as a base of servo patterns and a plurality of copy disks on the shaft of a spindle motor, arranges a plurality of servo heads on each surface of the copy disks, and makes the servo heads write the servo patterns formed based on the servo data read out by a read-only head from the original disk to the respective track ranges assigned to the respective servo heads.

However, since the displacements between the read-only head on the original disk and a plurality of the servo heads on the surface of each copy disk are different from a servo head to a servo head, the servo patterns written in may be displaced. For preventing the servo pattern displacement from causing, it is necessary to detect the accurate relative positional relations between the read-only head and the servo heads in advance and to correct the displacements prior to writing the servo patterns via the servo heads. However, it takes time to detect the positions of the magnetic heads.

Therefore, it is necessary to obviate this problem.

In view of the foregoing, it would be desirable to provide a method of obtaining the head positions in a disk servo writer, which stacks an original
5 disk and a plurality of copy disks and makes a plurality of servo heads arranged on each surface of the copy disks simultaneously write the servo patterns obtained based on the servo data read out by a read-only head from the original disk to each surface of the copy disks, for easily obtaining the relative positional relations between the read-only head on the original disk
10 and the servo heads on each surface of the copy disks.

Means for solving the Problems

According to a first aspect of the invention, there is provided a method for obtaining magnetic head positions in a magnetic data writing apparatus
15 (a disk servo writer) including a spindle motor having a shaft mounting thereon a plurality of first magnetic disks (copy disks), thereto magnetic data is to be transferred, and a second magnetic disk (an original disk) storing at least in one major surface thereof original disk data including the magnetic data to be transferred to the copy disks and/or the magnetic data
20 consulted in writing magnetic data to the copy disks, the spindle motor rotating the copy disks and the original disk as a unit; and a rotary positioner on the periphery of the copy and original disks, the rotary positioner stacking rotatably multiple sets of first magnetic heads (servo heads) and a second magnetic head (a read-only head) for reading the
25 original disk data from the original disk into a unit, each set of servo heads including a predetermined number of servo heads assigned to each surface of each of the copy disks for writing magnetic data to the each surface of the copy disk to make the servo heads simultaneously write the magnetic data determined based on the original disk data, which the read-only head reads
30 out from the original disk, to the respective track ranges assigned thereto on

the each surface of the copy disk, the method including:

mounting third magnetic disks (calibration disks) on the shaft of the spindle motor in substitution for the copy disks prior to writing magnetic data to the copy disks, the calibration disks storing calibration data, which facilitates making the servo heads accurately read therefrom first addresses indicating the addresses of the tracks and sectors, therein the servo heads are at present, on each surface of each calibration disk; and

reading out a second address from the original disk data, which the read-only head reads out from the original disk, the second address indicating the address of the track and sector on the original disk, therein the read-only head is at present, and reading out the first addresses from the calibration disks simultaneously with reading out the second address to obtain the relations between the position address of the read-only head and the position addresses of the servo heads.

According to a second aspect of the invention, there is provided a method for obtaining magnetic head positions in a disk servo writer including a spindle motor having a shaft mounting thereon a plurality of copy disks, thereto magnetic data is to be transferred, and an original disk storing at least in one major surface thereof original disk data including the magnetic data to be transferred to the copy disks and/or the magnetic data consulted in writing magnetic data to the copy disks, the spindle motor rotating the copy disks and the original disk as a unit; and a plurality of rotary positioners on the periphery of the copy and original disks, each of the rotary positioners stacking rotatably servo heads making access to the respective surfaces of the copy disks and a read-only head for reading the original disk data from the original disk into a unit, the servo heads on each surface of each of the copy disks being assigned to the respective track ranges on the each surface of the copy disk for writing magnetic data to the respective track ranges, the read-only heads being assigned to the respective

track ranges on one surface of the original disk corresponding to the track ranges of the corresponding servo heads to make the servo heads simultaneously write the magnetic data determined based on the original disk data, which the read-only heads read out from the original disk, to the
5 respective track ranges assigned thereto on the each surface of the copy disk, the method including:

 mounting calibration disks on the shaft of the spindle motor in substitution for the copy disks prior to writing magnetic data to the copy disks, the calibration disks storing calibration data, which facilitates
10 making the servo heads accurately read therefrom first addresses indicating the addresses of the tracks and sectors, therein the servo heads are at present, on the surface of the calibration disks; and

 reading out second addresses from the original disk data, which the read-only heads read out from the respective track ranges on the original
15 disk, the second addresses indicating the addresses of the tracks and sectors on the original disk, therein the read-only heads are at present, and reading out the first addresses from the calibration disks simultaneously with reading out the second addresses to obtain the relations between the position addresses of the read-only heads and the position addresses of the
20 servo heads.

 Advantageously, the method further includes: comparing the first address, which each of the servo heads reads out while scanning the calibration disk surface including at least a track range assigned to the each
25 of the servo heads, and the second address corresponding to the first address to prepare an address lookup table indicating the relations between the position addresses of the servo heads and the position address of the read-only head corresponding to the servo heads; and obtaining the first address of each of the servo heads with reference to the address lookup table,
30 the first address corresponding to the second address, which the read-only

head reads out from the original disk to make the each of the servo heads write the magnetic data to be transferred in the position designated by the first address.

5 In summary, for obtaining the positions of magnetic heads in a disk servo writer including a spindle motor having a shaft mounting thereon a plurality of copy disks and an original disk storing magnetic data to be transferred to the copy disks and/or original disk data consulted as the magnetic data in writing data to the copy disks (such as servo patterns used
10 for detecting the magnetic head positions, ID patterns for identifying the disks, and programs) and rotating the copy disks and the original disk as a unit; and a rotary positioner on the periphery of the disks rotatably stacking a read-only head for reading data from the original disk and multiple sets of servo heads into a unit, each set including a plurality of servo heads on each
15 surface of each of the copy disks (alternatively, rotary positioners on the periphery of the disks, each of the rotary positioners stacking rotatably a read-only head for reading data from the original disk and a plurality of servo heads into a unit, the servo heads being on the respective surfaces of the copy disks) to make the servo heads corresponding to the read-only head
20 write data simultaneously to the respective track ranges assigned thereto, the method according to the invention employs the following steps:

 mounting calibration disks storing calibration data on the shaft of the spindle motor in substitution for the copy disks prior to writing magnetic data to the copy disks;

25 obtaining relative positional relations between the read-only head and the servo heads on the same rotary positioner from the address, which the read-only head reads out from the original disk and at which the read-only head is at present, and the addresses, which the servo heads corresponding to the read-only head read out from the respective calibration disks at the
30 instance when the read-only head is reading out the address thereof and at

which the servo heads are at present;

storing the data of the functions indicating the relative positional relations in an address lookup table;

obtaining the present addresses of the servo heads corresponding to
5 the read-only head with reference to the address lookup table based on the present address on the original disk, in which the read-only head is at present; and

making the servo heads write magnetic data to the positions designated by the respective present addresses obtained.

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The method according to the invention for obtaining the positions of magnetic heads in a disk servo writer facilitates obtaining the relative positional relations between a plurality of servo heads on the surface of a copy disk and a read-only head and making the servo heads write magnetic
15 data to the respective track ranges on the copy disk, to which the servo heads are assigned. Therefore, the method according to the invention facilitates shortening the period of time for writing magnetic data to the copy disks.

20 Brief Description of the Drawing Figures

FIG. 1 is a block diagram schematically showing the configuration in a disk servo writer, to which a method of obtaining the head positions therein according to a first embodiment of the invention is applied.

25 FIG. 2 is a block diagram schematically showing the configuration in a disk servo writer, to which a method of obtaining the head positions therein according to a second embodiment of the invention is applied.

FIG. 3 is a top plan view of an original disk showing the configuration
30 of the magnetic pattern written on the lower surface of the original disk.

FIG. 4 shows the structure of the servo sector on the original disk.

FIG. 5 is a block diagram schematically showing the configuration in the disk servo writer mounting calibration disks in substitution for the copy
5 disks for describing a calibration method according to a first embodiment of the invention.

FIG. 6 is a schematic for explaining the principle of the functions relating the position of the read-only head on the original disk and the
10 positions of the servo heads on the surface of a calibration disk.

FIG. 7 is a block diagram schematically showing the configuration in the disk servo writer mounting calibration disks in substitution for the copy disks for describing a calibration method according to a second embodiment
15 of the invention.

FIG. 8 is a schematic for explaining the principle of the functions relating the positions of the read-only heads on the original disk and the positions on the surface of a calibration disk of the servo heads on the
20 respective head stack servo units.

FIG. 9 is a block diagram schematically showing a conventional disk servo writer.

25 FIG. 10 is a top plan view of a clock pattern disk used in the disk servo writer of FIG. 9.

FIG. 11 is a top plan view of a magnetic disk.

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Modes for carrying out the Invention

Now the invention will be described in detail hereinafter with reference to the accompanied drawing figures which illustrate the preferred embodiments of the invention.

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Disk servo writer: Configuration 1

FIG. 1 is a block diagram schematically showing the configuration in a disk servo writer 01, to which a method of obtaining the head positions therein according to a first embodiment of the invention is applied.

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In the disk servo writer 01, a disk stack unit 5 including a plurality (9 sheets in FIG. 1) of magnetic disks (copy disks) 4 stacked, to which the servo data is to be written, and an original disk 3 below disk stack unit 5 are mounted on the shaft of a spindle motor 6 rotating at several thousands

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Servo heads 10 (10_1 through 10_N), which are N pieces of magnetic heads, are arranged radially like a fan on each surface of copy disks 4. Hereinafter, servo heads 10_1 through 10_N arranged radially like a fan on a disk surface will be referred to collectively as a “fan-shaped head $10_1 - 10_N$ ”.

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A rotary positioner 2 mounts rotatably on an axis 2_s a stack of fan-shaped heads $10_1 - 10_N$ on the surfaces of copy disks 4 and a read-only magnetic head (hereinafter referred to as a “read-only head”) 7 on one of the surfaces (the lower surface in the figure) of original disk 3.

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Original disk 3 is a magnetic disk 4, to which the servo data described below is written in advance. FIG. 3 is a top plan view of original disk 3 showing a configuration of the magnetic patterns written on the lower surface of original disk 3. Original disk 3 is used also as a calibration disk

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14 described later.

Tracks are arranged concentrically on original disk 3 as shown in FIG. 3. Each track is divided into servo sectors 15 at every certain degrees of angle. Servo sectors 15 are arranged in the entire surface of original disk 3. In contrast to magnetic disk 4 used in the sector servo system for the hard disk drives, any data recording region DTA is not arranged on original disk 3.

The above described servo sector arrangement facilitates improving the tracking accuracy of read-only head 7 in tracking the designated track. In using original disk 3 as a calibration disk 14, the above described servo sector arrangement facilitates detecting the accurate position of the servo head for reading data from calibration disk 14.

FIG. 4 shows the structure of servo sector 15 on original disk 3. In servo sector 15, a clock signal region 16, a servo mark region 17, a servo region 18, and a burst signal region 19 are arranged one by one in the order of the description to the scanning direction of magnetic head.

Cyclic signals are stored in clock signal region 16. A clock signal CLK necessary for synchronizing the writing and reading data to and from disk 3, 14 or 4 is generated by reproducing the cyclic signals. The amplitude of clock signal CLK is used for automatic gain control (AGC).

A certain bit pattern or dibit pulses are stored in servo mark region 17 to indicate the start of servo region 18.

In servo region 18, track data signals obtained by coding the track numbers (referred to also as the "track addresses" or the "track Nos.") Trk

into gray codes and servo data signals indicating the sector numbers (referred to also the “sector addresses” or the “sector Nos.”) Sec are recorded.

In burst signal region 19, four columns of burst signals, offset by half the track width in the radial direction, are recorded and used for calculating the deviation of the magnetic head from the center of the track that the magnetic head is tracking and for detecting a precise radial position [Rr] (cf. FIG. 6) indicating the accurate distance of head 7 (or 10) from the disk center.

For obtaining an angular position [Θ θ] (cf. FIG. 6) of head 7 (or 10) on disk 3 (or 14), a reference position for angle measurement is set, for example, at the starting point of servo mark region 17 in the sector No. 1 on disk 3 (or 14), to which magnetic head 7 (or 10) is assigned. The angular position [Θ θ] of head 7 (or 10) on disk 3 (or 14) is obtained from the sector No. and the clock pulses which magnetic head 7 (or 10) has counted from the starting point of servo mark region 17 in the sector.

Referring again to FIG. 1, the magnetic heads designated by the same reference numeral in fan-shaped heads $10_1 - 10_N$ on the surfaces of the respective copy disks 4 are adjusted to be accessible to the equidistant radial positions on the respective copy disks 4. Read-only head 7 is adjusted to be accessible to the radial position on original disk 3 equidistant to the radial position on magnetic disk 4, to which any servo head in fan-shaped head 10_1 through 10_N , for example servo head 10_1 , is accessible.

A head position and clock detector 8 generates clock CLK from the signal of clock signal region 16 in servo sector 15 in a read signal RD1 that read-only head 7 reads out from original disk 3. At the same time, head position and clock detector 8 detects R as the foregoing precise radial

position [Rr] of read-only head 7 from the signal of burst signal region 19 in servo sector 15. Still at the same time, head position and clock detector 8 detects track No. Trk and sector No. Sec as the position address of head 7 from the signal of track and servo data region 18 in servo sector 15.

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Head position address generator 31 outputs the position addresses of servo heads 10_1 through 10_N on copy disks 4 as position address signals 31a based on the position address (that is, track No. Trk and sector No. Sec) of read-only head 7 detected by head position and clock detector 8, consulting
10 an address lookup table 30 described later, and synchronizing with clock CLK.

A servo pattern generator 9 generates servo patterns PS2 corresponding to the position address of servo heads 10 on the surfaces of
15 copy disks 4 based on position address signals 31a outputted from head position address generator 31 and synchronizing with clock CLK and feeds servo patterns PS2 as write signals WR2 to servo heads 10.

A servo compensator 12 obtains a servo compensation value that
20 minimizes the error between the foregoing precise radial position R of read-only head 7 detected by head position and clock detector 8 and a reference head position R_s fed from the outside. A power amplifier 13 outputs a current for driving rotary positioner 2 based on the servo compensation value.

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The feedback loop feeds back the error between the precise radial position R of read-only head 7 and the reference head position R_s to rotary positioner 2 through servo compensator 12 and power amplifier 13 to make read-only head 7 track the reference head position R_s .

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In the tracking state, position addresses are obtained for servo heads 10 on the surfaces of copy disks via head position address generator 31, servo patterns PS2 corresponding to the position addresses are generated via servo pattern generator 9 synchronizing with clock CLK and fed to servo heads 10, and servo patterns PS2 are written in the respective copy disks 4 via the respective servo heads 10.

Since servo patterns PS2 are written to the surface of copy disk 4 by N pieces of servo heads 10_1 through 10_N (or by a fan-shaped head $10_1 - 10_N$) which make (or makes) access to the surface of copy disk 4, the servo write time is shortened to be $1/N$ of the conventional servo write time.

If data to be written into data region DTA of copy disks 4 exists, the data is stored in a write data memory 32 shown in FIG. 1. In response to position address signals 31a inputted from head position address generator 31, write data memory 32 outputs data Data corresponding to the position addresses of servo heads 10_1 through 10_N for the surface of copy disk 4 to servo pattern generator 9 synchronizing with clock CLK.

Subsequently to writing servo patterns PS2, servo head 10 writes data Data in data region DTA having the same position address.

Disk servo writer: Configuration 2

FIG. 2 is a block diagram schematically showing the configuration in a disk servo writer 02, to which a method of obtaining the head positions therein according to a second embodiment of the invention is applied.

Disk servo writer 02 according to the second embodiment is different from disk servo writer 01 according to the first embodiment in that N sets (3 sets in FIG. 2) of rotary positioners 2 ($2_1, 2_2, \dots, 2_N$) are arranged on the

periphery of copy disks 4. Each rotary positioner 2 ($2_1, 2_2, \dots$, or 2_N) stacks servo heads 10 for all the surfaces of copy disks 4 and mounts the stack of servo heads 10 and a read-only head 7 rotatably on an axis $2s$.

5 In FIG. 2, rotary positioner 2_1 is shown representing all the rotary positioners 2_1 through 2_N . Although not shown in FIG. 2, the other rotary positioners 2_2 through 2_N are provided with the respective circuits having the configuration same with that of the circuit for rotary positioner 2 in FIG. 1. Each rotary positioner 2 ($2_1, 2_2, \dots$, or 2_N) and the circuit thereof
10 constitute a head stack servo unit 1 ($1_1, 1_2, \dots$, or 1_N). Therefore, disk servo writer 02 in FIG. 2 includes N head stack servo units 1 ($1_1, 1_2, \dots$, 1_N).

In FIG. 2, the servo head on a rotary positioner 2 ($2_1, 2_2, \dots$, or 2_N) is designated by the reference numeral 10 ($10_1, 10_2, \dots$, or 10_N) and the
15 read-only head for rotary positioner 2 ($2_1, 2_2, \dots$, or 2_N) by the reference numeral 7 ($7_1, 7_2, \dots$, or 7_N) for the sake of clear distinction.

Servo heads 10_1 are adjusted to make access to the radial positions on the respective copy disks 4 equivalent to the radial position on original disk
20 3, to which read-only head 7_1 makes access. Similarly, servo heads 10_2 are adjusted to make access to the radial positions on the respective copy disks 4 equivalent to the radial position on original disk 3, to which read-only head 7_2 makes access. Finally, servo heads 10_N are adjusted to make access to the radial positions on the respective copy disks 4 equivalent to the radial
25 position on original disk 3, to which read-only head 7_N makes access. Since N pieces of servo heads 10_1 through 10_N simultaneously write data into the respective track ranges on the surface of the copy disk 4 assigned thereto, the servo write time is shortened to be $1/N$ of the conventional servo write time.

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For making fan-shaped head $10_1 - 10_N$ on the surface of copy disk 4 in FIG, 1 and servo heads 10_1 through 10_N on the surface of copy disk 4 in FIG, 2 write servo patterns accurately into the respective track ranges keeping an accurate track spacing of $1\ \mu\text{m}$ or narrower therebetween, it is necessary
5 to know the accurate position address of each servo head 10 on copy disk 4 corresponding to the position address on original disk 3 of read-only head 7 in rotary positioner 2.

For facilitating this, it is necessary to know in advance the relative
10 positional relations including mounting errors between read-only head 7 and servo heads 10 on rotary positioner 2.

According to the invention, the relative positional relation between read-only head 7 and every servo head 10 is found (hereinafter referred to
15 also as “calibrated” or “calibration”) using calibration disks 14 stacked in disk stack unit 5 in substitution for copy disks 4.

In the calibration, various kinds of calibration processing are conducted by a calibrating means (not shown), to which read signals RD2
20 read out from calibration disks 14 via servo heads 10 and read signals RD1 read out from original disk 3 via read-only head 7 (or the position data of read-only head 7 obtained from head position and clock detector 8) are inputted.

25 As described earlier, magnetic disks 4 storing the magnetic data, same with the magnetic data on original disk 3 and described earlier with reference to FIGs. 3 and 4, on both major surfaces thereof are used for calibration disks 14.

First embodiment: Calibration

Now the calibration according to a first embodiment of the invention will be described below in connection with disk servo writer 01 of FIG. 1.

5 FIG. 5 is a block diagram schematically showing the configuration in disk servo writer 01 mounting calibration disks 14 in substitution for copy disks 4 for describing the calibration method according to the first embodiment.

10 The precise radial positions $[R_r]$ and the angular positions $[\Theta \theta]$ of servo heads 10_1 through 10_N are obtained from the signals obtained from the foregoing servo sectors 15 in read signals RD2 from servo heads 10 (10_1 through 10_N) on calibration disks 14.

15 Now the method for knowing the relations between the position coordinates of servo heads 10_1 through 10_N on calibration disks 14 and the position coordinates of read-only head 7 on original disk 3 will be described below in connection with representative servo heads 10_1 through 10_N (fan-shaped head $10_1 - 10_N$) on one surface of calibration disk 14.

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FIG. 6 is a schematic for explaining the principle of the functions f_1 through f_N (designated generally by f_i) described later and relating the position of read-only head 7 on original disk 3 and the positions of servo heads 10_1 through 10_N (designated generally by 10_i) on a surface of calibration disk 14.

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Referring now to FIG. 6, rotary positioner 2 is rotated to make servo head 10_1 scan calibration disk 14 from the inner circumference to the outer circumference thereof and to make servo head 10_1 read calibration disk 14 for obtaining polar position coordinates (r_1, θ_1) consisting of a distance r_1 as

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the precise radial position $[R_r]$ and an angle θ_1 as the angular position $[\Theta \theta]$. At the same time, read-only head 7 is made to read original disk 3 for obtaining polar position coordinates (R, Θ) consisting of a distance R as the precise radial position $[R_r]$ and an angle Θ as the angular position $[\Theta \theta]$.
 5 Then, the data indicating the relation between the polar position coordinates (r_1, θ_1) and (R, Θ) (hereinafter referred to as a function “ $f_1 = f[(R, \Theta) \rightarrow (r_1, \theta_1)]$ ”) is obtained and stored in address lookup table 30 in FIG. 1.

10 By repeating the same operations for servo heads 10_2 through 10_N one by one, the data of the functions $f_2, f_3, \dots, f_N$ are stored in address lookup table 30. Generally describing, the function f_i for a servo head 10_i is expressed as $f_i = f[(R, \Theta) \rightarrow (r_i, \theta_i)]$.

15 Functions f_1 through f_N are obtained for all the servo heads 10_1 through 10_N on all the surfaces of copy disks 4 and the data thereof is stored in address lookup table 30.

The functions f_1 through f_N stored in address lookup table 30 are the
 20 data for obtaining the polar position coordinates (r_i, θ_i) (that is, the position addresses) fed to servo heads 10_1 through 10_N (designated generally by 10_i) on copy disks 4 from the polar position coordinates (R, Θ) (that is, the position address) of read-only head 7 on original disk 3 in writing servo patterns to copy disks 4 as described later. Therefore, the relations between
 25 the polar position coordinates (R, Θ) on original disk 3 and the polar position coordinates (r_i, θ_i) on calibration disks 14 are important.

In obtaining the relative positional relations in practice, the position coordinates (r_i, θ_i) , which servo head 10_i reads from calibration disk 14 at

the instance when read-only head 7 reads the position coordinates ($R, \Theta=0$), are stored in address lookup table 30. Every time when the precise radial position R (in other words, the track address) of read-only head 7 is changed while keeping the condition ($\Theta=0$), the position coordinates (r_i, θ_i) obtained
5 are stored in address lookup table 30.

Since the reference position for measuring θ_i may be set at an arbitrary position, an angular position obtained by adding or subtracting a certain value to or from the angular position θ_i that servo head 10_i has read
10 out may be stored as an angular position θ_i in address lookup table 30 with no problem.

In writing the servo patterns to copy disks 4, the position coordinates (r_i, θ_i) to be fed to servo heads 10_i on copy disks 4 corresponding to the
15 present position coordinates (R, Θ) of read-only head 7 on original disk 3 are obtained in the following way from address lookup table 30. First, the position coordinates (r_i, θ_i) corresponding to the position coordinates ($R, \Theta = 0$) are obtained from address lookup table 30. Then, the radial position r_i as obtained from address lookup table 30 is used without conversion. The
20 angular position θ_i used for writing servo pattern is obtained by adding the present angular position Θ of read-only head 7 on original disk 3 to the value θ_i obtained from address lookup table 30.

In practically writing the servo patterns to copy disks 4 in disk servo
25 writer 01 in FIG. 1, the position address (track No. Trk, sector No. Sec) corresponding to the position coordinates (R, Θ) of read-only head 7 is fed from head position and clock detector 8 to head position address generator 31 as soon as read-only head 7 on original disk 3 reaches the position coordinates (R, Θ). Head position address generator 31 obtains the position

coordinates (r_i, θ_i) for every servo head 10_i corresponding to the position coordinates (R, Θ) using the data of the function f_i stored in address lookup table 30 as described above.

5 Head position address generator 31 feeds the position addresses corresponding to the position coordinates (r_i, θ_i) obtained to servo pattern generator 9 to make servo heads 10_i write the respective servo patterns.

10 Thus, it is possible to know the position addresses of servo heads 10_1 through 10_N and to make servo heads 10_1 through 10_N write magnetic data simultaneously.

15 For preventing servo heads 10_1 through 10_N on one surface of copy disk 4 from writing magnetic data erroneously outside the assigned track ranges, head position address generator 31 incorporates therein a means for preventing position address signal 31a as the position address for every servo head 10_i from being outputted, when the position address is outside the track range assigned to servo head 10_i .

20 Second embodiment: Calibration

Now the calibration according to a second embodiment of the invention will be described below in connection with disk servo writer 02 of FIG. 2.

25 FIG. 7 is a block diagram schematically showing the configuration in disk servo writer 02 mounting calibration disks 14 in substitution for copy disks 4 for describing the calibration method according to the second embodiment.

30 FIG. 8 is a schematic for explaining the principle of the functions F_1 through F_N (designated generally by F_i) relating the positions of read-only

heads 7_1 through 7_N (designated generally by 7_i) on original disk 3 and the positions of servo heads 10_1 through 10_N (designated generally by 10_i) on a surface of calibration disk 14.

5 As shown in FIG. 8, rotary positioners 2 ($2_1, 2_2, \dots, 2_N$) position read-only heads 7 ($7_1, 7_2, \dots, 7_N$) on the same precise radial position on original disk 3. In the similar manner as according to the first embodiment, the data indicating the relative positional relations (represented by the functions $F_i = F[(R_i, \Theta_i) \rightarrow (r_i, \theta_i)]$) between the position coordinates (r_1, θ_1), (r_2, θ_2), $\dots$, (r_N, θ_N) (designated generally by (r_i, θ_i)), which servo
10 heads 10 ($10_1, 10_2, \dots, 10_N$) obtain from calibration disk 14, and the position coordinates (R_1, Θ_1), (R_2, Θ_2), $\dots$, (R_N, Θ_N) (designated generally by (R_i, Θ_i)), which read-only heads 7 ($7_1, 7_2, \dots, 7_N$) obtain from original disk 3, is obtained.

15 Rotary positioners 2 ($2_1, 2_2, \dots, 2_N$) are rotated to make heads $7_1, 7_2, \dots, 7_N, 10_1, 10_2, \dots, 10_N$ scan disks 3 and 14 from the inner circumferences to the outer circumferences thereof and to obtain the functions $F_1, F_2, \dots, F_N$.

20 The data of the function F_1 is stored in address lookup table 30 in head stack servo unit 1_1 , the data of the function F_2 in address lookup table 30 in head stack servo unit 1_2 , and so on. The data of the function F_N is stored in the address lookup table 30 (not shown) in head stack servo unit 1_N .
25 Generally describing, the data of the function F_i is stored in address lookup table 30 in head stack servo unit 1_i .

Acquisition of the data to be stored in address lookup table 30 and utilization of the stored data in the calibration according to the second

embodiment are conducted in the same manner as the data acquisition and utilization according to the first embodiment simply by using the function $f_i = f[(R, \Theta) \rightarrow (r_i, \theta_i)]$ according to the first embodiment for every rotary positioner 2_i according to the second embodiment and by replacing f_i with F_i and (R, Θ) with (R_i, Θ_i) .

Practical servo pattern writing to copy disks 4 in disk servo writer 02 in FIG. 2 will be described below as an example in connection with head stack servo unit 1_i . The position address (track No. Trk, sector No. Sec) corresponding to the position coordinates (R_i, Θ_i) of read-only head 7_i on rotary positioner 2_i is fed from head position and clock detector 8 in head stack servo unit 1_i to head position address generator 31 in servo unit 1_i as soon as the read-only head 7_i on original disk 3 reaches the position coordinates (R_i, Θ_i) . Head position address generator 31 in head stack servo unit 1_i obtains the position coordinates (r_i, θ_i) for every servo head 10_i on rotary positioner 2_i corresponding to the position coordinates (R_i, Θ_i) using the data of the function F_i stored in address lookup table 30 in head stack servo unit 1_i . Head position address generator 31 feeds the position addresses of all the servo heads 10_i to servo pattern generator 9 as position address signals 31a.

By conducting the operations described above for all the head stack servo units 1_1 through 1_N , it becomes possible to position servo heads 10_1 through 10_N in the respective track ranges and to make servo heads 10_1 through 10_N write servo patterns simultaneously to the assigned track ranges.

For preventing servo heads 10_1 through 10_N on one surface of copy disk 4 from writing magnetic data erroneously outside the respective track ranges assigned, head position address generator 31 in every head stack

servo unit 1_i incorporates therein a means for preventing position address signal 31a as the position address for every servo head 10_i on rotary positioner 2_i from being outputted, when the position address is outside the track range assigned to servo head 10_i .

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Advantageous Effects of the Invention

As described above, the method according to the invention for obtaining the positions of magnetic heads in a disk servo writer, which includes a spindle motor having a shaft mounting thereon a plurality of copy disks and an original disk storing magnetic data to be transferred to the copy disks and/or original disk data consulted as the magnetic data in writing data to the copy disks (such as servo patterns used for detecting the magnetic head positions, ID patterns for identifying the disks, and programs) and rotating the copy disks and the original disk as a unit; and a rotary positioner on the periphery of the disks rotatably stacking a read-only head for reading data from the original disk and multiple sets of servo heads into a unit, each set including a plurality of servo heads on each surface of each of the copy disks (alternatively, rotary positioners on the periphery of the disks, each of the rotary positioners stacking rotatably a read-only head for reading data from the original disk and a plurality of servo heads into a unit, each of the servo heads being on each surface of each of the copy disks) to make the servo heads corresponding to the read-only head write data simultaneously to the respective track ranges assigned thereto, includes:

mounting calibration disks storing calibration data on the shaft of the spindle motor in substitution for the copy disks prior to writing magnetic data to the copy disks;

obtaining relative positional relations between the read-only head and the servo heads on the same rotary positioner from the address, which the read-only head reads out from the original disk and at which the read-only head is at present, and the addresses, which the servo heads corresponding

to the read-only head read out from the respective calibration disks at the instance when the read-only head is reading out the address thereof and at which the servo heads are at present;

storing the data of the functions indicating the relative positional
5 relations in an address lookup table;

obtaining the present addresses of the servo heads corresponding to the read-only head consulting the address lookup table based on the present address of the read-only head on the original disk; and

making the servo heads write magnetic data to the respective track
10 ranges indicated by the present addresses obtained.

The method according to the invention for obtaining the positions of magnetic heads in a disk servo writer facilitates obtaining the relative positional relations between a plurality of servo heads on the surface of a
15 copy disk and a read-only head and making the servo heads write magnetic data to the respective track ranges on the copy disk, to which the servo heads are assigned. Therefore, the method according to the invention facilitates shortening the period of time for writing magnetic data to the copy disks and reducing the manufacturing costs of the copy disks.

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Claim

WHAT IS CLAIMED:

1. A method for obtaining magnetic head positions in a magnetic data writing apparatus including a spindle motor having a shaft mounting thereon a plurality of first magnetic disks, thereto magnetic data is to be transferred, and a second magnetic disk storing at least in one major surface thereof original disk data including the magnetic data to be transferred to the first magnetic disks and/or the magnetic data consulted in writing magnetic data to the first magnetic disks, the spindle motor rotating the first magnetic disks and the second magnetic disk as a unit; and a rotary positioner on the periphery of the first and second magnetic disks, the rotary positioner stacking rotatably multiple sets of first magnetic heads and a second magnetic head for reading the original disk data from the second magnetic disk into a unit, each set of first magnetic heads including a predetermined number of first magnetic heads assigned to each surface of each of the first magnetic disks for writing magnetic data to the each surface of the first magnetic disk, whereby to make the first magnetic heads simultaneously write the magnetic data determined based on the original disk data, which the second magnetic head reads out from the second magnetic disk, to the respective track ranges assigned thereto on the each surface of the first magnetic disk, the method comprising:

mounting third magnetic disks on the shaft of the spindle motor in substitution for the first magnetic disks prior to writing magnetic data to the first magnetic disks, the third magnetic disks storing calibration data, which facilitates making the first magnetic heads accurately read therefrom first addresses indicating the addresses of the tracks and sectors, therein the first magnetic heads are at present, on each surface of each third magnetic disk; and

reading out a second address from the original disk data, which the second magnetic head reads out from the second magnetic disk, the second address indicating the address of the track and sector on the second magnetic disk, therein the second magnetic head is at present, and reading
5 out the first addresses from the third magnetic disks simultaneously with reading out the second address, whereby to obtain the relations between the position address of the second magnetic head and the position addresses of the first magnetic heads.

2. A method for obtaining magnetic head positions in a magnetic data
10 writing apparatus including a spindle motor having a shaft mounting thereon a plurality of first magnetic disks, thereto magnetic data is to be transferred, and a second magnetic disk storing at least in one major surface thereof original disk data including the magnetic data to be transferred to the first magnetic disks and/or the magnetic data consulted in writing
15 magnetic data to the first magnetic disks, the spindle motor rotating the first magnetic disks and the second magnetic disk as a unit; and a plurality of rotary positioners on the periphery of the first and second magnetic disks, each of the rotary positioners stacking rotatably first magnetic heads making access to the respective surfaces of the first magnetic disks and a
20 second magnetic head for reading the original disk data from the second magnetic disk into a unit, the first magnetic heads on each surface of each of the first magnetic disks being assigned to the respective track ranges on the each surface of the first magnetic disk for writing magnetic data to the respective track ranges, the second magnetic heads being assigned to the
25 respective track ranges on one surface of the second magnetic disk corresponding to the track ranges of the corresponding first magnetic heads, whereby to make the first magnetic heads simultaneously write the magnetic data determined based on the original disk data, which the second magnetic heads read out from the second magnetic disk, to the respective
30 track ranges assigned thereto on the each surface of the first magnetic disk,

the method comprising:

mounting third magnetic disks on the shaft of the spindle motor in substitution for the first magnetic disks prior to writing magnetic data to the first magnetic disks, the third magnetic disks storing calibration data, which facilitates making the first magnetic heads accurately read therefrom first addresses indicating the addresses of the tracks and sectors, therein the first magnetic heads are at present, on the surface of the third magnetic disks; and

reading out second addresses from the original disk data, which the second magnetic heads read out from the respective track ranges on the second magnetic disk, the second addresses indicating the addresses of the tracks and sectors on the second magnetic disk, therein the second magnetic heads are at present, and reading out the first addresses from the third magnetic disks simultaneously with reading out the second addresses, whereby to obtain the relations between the position addresses of the second magnetic heads and the position addresses of the first magnetic heads.

3. The method according to Claim 1 or 2, the method further comprising:

comparing the first address, which each of the first magnetic heads reads out while scanning the third disk surface including at least a track range assigned to the each of the first magnetic heads, and the second address corresponding to the first address, whereby to prepare an address lookup table indicating the relations between the position addresses of the first magnetic heads and the position address of the second magnetic head corresponding to the first magnetic heads; and

obtaining the first address of each of the first magnetic heads with reference to the address lookup table, the first address corresponding to the second address, which the second magnetic head reads out from the second magnetic disk, whereby to make the each of the first magnetic heads write the magnetic data to be transferred in the position designated by the first address.