



159159

- 1 -



G00002

TITLE OF THE INVENTION

METHOD AND APPARATUS FOR SERVO INFORMATION WRITING IN
A DISK DRIVE

BACKGROUND OF THE INVENTION

5 The present invention relates generally to a
servo information writing method of writing servo
information of a disk drive to a disk medium, and more
particularly, it relates to a method of writing servo
information including positioning correction
10 information.

In recent years, in a disk drive represented by a
hard disk drive, servo information (servo pattern) for
use in head positioning control is recorded on a disk
medium for use as a data recording medium.

15 In steps of manufacturing the disk drive, a servo
writing step of recording the servo information on the
disk medium is one of the important steps which
influence efficiency of the whole manufacturing steps.
Therefore, there have been proposed or developed
20 various types of servo writing methods in order to
enhance the efficiency. In the methods, there has
been noted a magnetic transfer method in which the
servo information is transferred and recorded from a
disk as a master board to the disk medium incorporated
25 in the disk drive by a magnetic transfer process.

Additionally, the servo information (hereinafter
referred to as the original servo information) of a

transferor recorded in the master board has a possibility that distortion is generated by, for example, an attaching error in attaching the master board to a device for writing the original servo
5 information.

Moreover, in the steps of manufacturing the disk drive, disk eccentricity is sometimes generated in the disk medium by an assembly error or the like in a step of assembling the disk medium into the drive.
10 Therefore, there is a high possibility that a positioning error is caused by the distortion of the original servo information and the disk eccentricity of the disk medium, when the head positioning control is executed in the disk drive by use of the original
15 servo information transferred to the disk medium as such.

To solve the problem, there is proposed a method of measuring the disk eccentricity for each disk medium in which the servo information is recorded to
20 record the disk eccentricity as positioning correction information on the disk medium (see, e.g., Jpn. Pat. No. 3295940).

A conventional method is a method of measuring the disk eccentricity (as a result, the distortion of the servo information) for each disk medium to produce
25 the positioning correction information, and recording the information on the disk medium. However, in this

method, time required for the servo writing step increases as much as time required for processing to produce the positioning correction information for each disk medium.

5 BRIEF SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention, there is provided a servo information writing method in which reduction of time for producing positioning correction information is realized to thereby reduce time required for a servo writing step, and efficiency can be enhanced as a result.

The method of servo information writing is a servo information writing method of writing servo information for use in head positioning control on a disk medium incorporated in a disk drive, comprising: executing the positioning control of a head included in the disk drive based on original servo information recorded on the disk medium; producing positioning correction information to correct a positioning error by the positioning control; recording the positioning correction information in storage means disposed outside the disk drive; and acquiring the positioning correction information to write the information to the disk medium incorporated in the disk drive.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated

in and constitute a part of the specification,
illustrate embodiments of the invention, and together
with the general description given above and the
detailed description of the embodiments given below,
5 serve to explain the principles of the invention.

FIG. 1 is a block diagram showing a main part of
a disk drive according to an embodiment of the present
invention;

FIG. 2 is a block diagram showing a control
10 system of positioning correction information according
to the present embodiment;

FIG. 3 is a diagram showing a recorded state of a
disk medium according to a modification of the present
embodiment;

15 FIG. 4 is a diagram showing one example of
recorded contents of a correction information
recording buffer according to the present embodiment;

FIG. 5 is a flowchart showing a procedure for
producing and recording the positioning correction
20 information according to the present embodiment; and

FIG. 6 is a flowchart showing a procedure for
writing the positioning correction information in the
disk medium according to the present embodiment.

DETAILED DESCRIPTION OF THE INVENTION

25 An embodiment of the present invention will be
described hereinafter with reference to the drawings.

(Constitution of Disk Drive)

A disk drive of the present embodiment has a constitution including a function (servo information writing device) of producing positioning correction
5 information described later, recording the information, and writing the information in a disk medium in a servo writing step included in manufacturing steps.

As shown in FIG. 1, in a constitution of the
10 present disk drive, there are incorporated a data recording/reproducing system, a head positioning control system (servo system), and a disk medium 1 which are constituting elements of the disk drive shipped as a product. The respective elements will be
15 described hereinafter specifically.

In the disk medium 1, original servo information transferred from an original board is recorded by, for example, a magnetic transfer method. It is to be noted that the disk medium 1 may be a disk medium in
20 which the original servo information is recorded by, for example, a patterned media recording method other than the magnetic transfer method.

The disk medium 1 is attached to a spindle motor 3, and rotated at a certain angular speed. A large
25 number of tracks 100 are constituted in the disk medium 1 at a product shipping time. Each track 100 is provided with: a servo area 110 in which the

original servo information and the positioning correction information are recorded; and a data area (data sector) 120 in which user data is recorded.

5 A head 2 executes a read/write operation for recording or reproducing data (including the positioning correction information in the present embodiment) with respect to the disk medium 1. The head 2 includes: a read head element 20 which performs the read operation (reproduction); and a write head
10 element 21 which performs the write operation (recording). The read head element 20 reads the servo information (including the positioning correction information) from a rotating disk medium 1 at a certain time interval.

15 The head 2 is mounted on an arm 4 included in an actuator, and the head is moved and controlled in a radial direction of the disk medium 1 by a voice coil motor (VCM) 5 which is a driving source of the actuator. The actuator is driven and controlled by a
20 servo system described later.

The data recording/reproducing system includes a signal processing circuit (read/write channel) 6 and a servo writing circuit 8. The signal processing circuit 6 has a function of reproducing a servo
25 information signal or a user data signal from a read signal read by the read head element 20, or a function of correcting an error of the reproduced signal.

The servo writing circuit 8 is a circuit which produces the servo information required for a servo information writing operation. Additionally, in the present embodiment, the servo writing circuit 8
5 produces the servo information which is not included in the original servo information.

A servo system includes a position detecting circuit 7, a VCM driving circuit 9, and a controller 10. The position detecting circuit 7 detects a
10 position of the head 2 on the disk medium 1 from the servo information signal reproduced by the signal processing circuit 6.

The controller 10 includes a microprocessor (CPU) 11, and a memory (ROM, flash EEPROM, or the like) 12, and executes a positioning control of the head 2, or
15 servo information write processing of the present embodiment. The CPU 11 is a main element of the controller 10, and executes a program stored in the memory 12 to thereby execute the positioning control
20 of the head 2 via the VCM driving circuit 9. Furthermore, the CPU 11 produces the positioning correction information described later. The memory 12 stores various types of control parameters in addition to the program of the CPU 11.

25 The VCM driving circuit 9 supplies a driving current to the VCM 5 to drive the actuator in accordance with the positioning control of the CPU 11.

A correction information recording buffer 13 is a memory (e.g., flash EEPROM) which is accessed by the CPU 11 and in which the positioning correction information is recorded. The correction information recording buffer 13 is an external memory of the disk drive, mounted on a printed board detachably attached to, for example, the disk drive, and connected to the CPU 11 via an interface mounted on the printed board.

The correction information recording buffer 13 has a capacity to store the positioning correction information corresponding to all tracks (all of the tracks in opposite surfaces), respectively, constituted in the disk medium 1 incorporated in the disk drive. Additionally, in the present embodiment, the disk medium 1 incorporated in the disk drive is one disk whose opposite surfaces are used as data recording surfaces.

(Control System of Positioning Correction Information)

FIG. 2 is a block diagram showing a control system for realizing a series of processes executed by the CPU 11 to produce, record, and write the positioning correction information in the disk medium 1.

A controller (tracking control unit, transmission function C) 210 corresponds to a head positioning control (feedback control) function of the CPU 11. A

control object (plant, transmission function P) 220 is the head 2, but is the VCM 5 of the actuator in a narrow sense.

5 An original servo pattern 200 is original servo information (servo pattern transferred from the original board) recorded in the disk medium 1. A corrected servo pattern is servo information (servo information for use by the disk drive as the product) including the original servo information recorded in
10 the disk medium 1 and the written positioning correction information.

 A block 230 is a processing system executed by the CPU 11 and including production processing (231) of the positioning correction information and
15 recording processing (232) in the correction information recording buffer 13. A block 240 is a processing system executed by the CPU 11 and including reproduction processing (241) of the positioning correction information, positioning correction control
20 (242) in which the positioning correction information is used, and write processing (243) of the positioning correction information in the disk medium 1.

(Servo Information Writing Method)

25 A servo information writing method of the present embodiment will be described hereinafter with reference to FIGS. 3 to 6 in addition to FIGS. 1 and 2.

As described above, the original servo information is transferred and recorded in the disk medium 1 from the original board by a magnetic transfer device. This disk medium 1 is incorporated
5 in the disk drive, and rotated at a certain angular speed by the spindle motor 3.

First, as shown in FIG. 2, the CPU 11 executes the feedback control to execute the positioning control of the head 2, and executes the processing
10 system of the block 230. That is, as shown in FIG. 5, the CPU 11 drives and controls the actuator via the VCM driving circuit 9 to thereby move the head 2 (step S1). Specifically, the CPU 11 moves (seeks) the head, for example, from an outermost peripheral track of the
15 disk medium 1 in an inner peripheral direction. Accordingly, the CPU 11 executes the positioning control of the head 2 for each track of the disk medium 1.

Here, in this positioning control, as shown in
20 FIG. 2, the controller (CPU 11) 210 executes a sampled value control to determine a control input value into the VCM driving circuit 9 in order to drive and control the control object (VCM 5) at the certain time interval. The controller (CPU 11) 210 acquires the
25 present position of the head 2 in synchronization with a rotation angle of the disk medium 1 based on the servo information signal reproduced from the servo

area of the disk medium 1.

5 The CPU 11 executes the positioning control of
the head 2 for each track of the disk medium 1, and
measures distortion of the original servo information
to produce the positioning correction information for
correcting a positional error based on the measurement
results (step S2). This method of producing this
positioning correction information is a method similar
to a method (measuring disk eccentricity) described
10 in, for example, the above-described prior-art
document. The method is similar to, for example, a
method of correcting a rotation synchronous component
of the disk medium having a residual error correction
element and utilizing a feedforward filter function.

15 As shown in FIG. 4, the CPU 11 associates the
positioning correction information (P-0 to P-N)
produced for each track with the corresponding track
number (0 to N) to record the information in the
correction information recording buffer 13 (step S3).
20 The CPU 11 repeats the processing system of the block
230 to produce and record the positioning correction
information corresponding to all of the tracks of the
disk medium 1 until an end (step S4).

25 Next, as shown in FIG. 2, the CPU 11 executes the
feedback control to execute the positioning control of
the head 2, and executes the processing system of the
block 240.

Here, it is assumed a case where the new disk medium 1 for use as the product is incorporated in the disk drive. Also in this disk medium 1, the original servo information is transferred and recorded from the original board by the magnetic transfer device as
5 described above.

As shown in FIG. 6, the CPU 11 executes the positioning control of the head 2 for each track while moving (seeking) the head, for example, from the
10 outermost peripheral track of the disk medium 1 in the inner peripheral direction (step S11).

The CPU 11 accesses the correction information recording buffer 13, and reads the positioning correction information corresponding to the track in
15 which the head 2 is positioned (step S12). The CPU 11 corrects the positioning control of the head 2 with respect to the track by use of the positioning correction information (step S13).

Moreover, the CPU 11 writes the positioning
20 correction information reproduced from the correction information recording buffer 13 into the servo area 110 of the track by means of the write head element 21 included in the head 2 (step S14).

The CPU 11 repeats the write processing of the
25 positioning correction information with respect to all of the tracks of the disk medium 1 till the end (step S15). That is, there is repeated the processing

system 240 including the positioning correction
control (242) in which the positioning correction
information is used, and the write processing (243) of
the positioning correction information in the disk
5 medium 1 with respect to all of the tracks till the
end.

It is to be noted that the above-described
positioning correction information is produced again,
and recorded in the correction information recording
10 buffer 13 in a case where the CPU 11 confirms
positioning precision, and judges that a rotation
synchronous component of the disk medium 1 is large at
a time of correction of the positioning control of the
head 2.

15 Here, the CPU 11 corrects the head positioning
control, when writing the positioning correction
information in the disk medium 1. Accordingly, the
positioning correction information can be written in a
region of the track in which the distortion of the
20 original servo pattern is corrected. Therefore, when
the positioning correction information is written into
the track region based on the original servo pattern
having the distortion, occurrence of a reading error
can be reduced.

25 As described above, according to the servo
information writing method of the present embodiment,
first the positioning correction information is

produced in accordance with the measurement results of the distortion of the original servo pattern by the positioning control of the head 2 based on the original servo information. The information is stored
5 in the correction information recording buffer 13 which is the external memory of the disk drive. Moreover, the positioning correction information stored in the correction information recording buffer 13 is written into the next disk medium without
10 executing any processing to produce the positioning correction information.

Therefore, since it is possible to save a step of producing the positioning correction information for each disk medium incorporated in the disk drive, it is
15 possible to reduce largely a time required for a step of writing the servo information including the original servo information due to magnetic transfer and the positioning correction information. In consequence, it is possible to enhance efficiency of
20 the step of writing the servo information with respect to the disk medium 1.

(First Modification)

In the present embodiment, the CPU 11 executes the processing to produce the positioning correction
25 information, record the information in the correction information recording buffer 13, and write the positioning correction information read from the

correction information recording buffer 13 in the disk medium 1.

In the present modification, the CPU 11 may execute processing to produce positioning correction information, store the information once in a correction information recording buffer 13, and write the information into an original board incorporated in a disk drive. In this method, it is possible to transfer and record the positioning correction information together with original servo information from the original board in the disk medium 1 for use as a product by a magnetic transfer method.

(Second Modification)

FIG. 3 is a diagram showing a recorded state in a disk medium 1 according to a second modification of the present embodiment.

In the present modification, in a case where original servo information (original servo pattern 200) is transferred from an original board onto a disk medium 1 by a magnetic transfer device, there are recorded original board inherent numbers 310 and inherent numbers 320 of the magnetic transfer devices.

A CPU 11 also records the original board inherent numbers 310 and the magnetic transfer device inherent numbers 320, when producing the positioning correction information to record the information in a correction information recording buffer 13 in the above-described

procedure.

Moreover, when the CPU 11 writes the positioning correction information into the next disk medium 1, the CPU reads from the correction information recording buffer 13 the positioning correction information corresponding to a combination of the original board inherent number 310 and the magnetic transfer device inherent number 320 recorded in the disk medium 1.

According to such method, in a case where the original servo information is transferred and recorded in the disk medium by use of a plurality of original boards and magnetic transfer devices, the positioning correction information adapted to the combination of the original board and the magnetic transfer device can be easily written in the disk medium.

That is, in a case where the combination of the original board and the magnetic transfer device is different, there is a high possibility that distortion of the original servo information transferred onto the disk medium 1 is different. Therefore, the CPU 11 can easily realize the writing in the disk medium the positioning correction information adapted to the combination of the original board and the magnetic transfer device by use of the original board inherent numbers 310 and magnetic transfer device inherent numbers 320 recorded in the disk medium 1.

It is to be noted that the original board
inherent numbers 310 and the magnetic transfer device
inherent numbers 320 are preferably recorded in a
region of the disk medium in which any pattern is not
transferred or a plurality of places on an outermost
or innermost peripheral side, when the original servo
pattern is transferred from the original board to the
disk medium 1.

It is to be noted that in the present embodiment,
it is assumed that a head 2 has a structure in which a
read head element 20 is mounted separately from a
write head element 21. In the head 2 having such
structure, even when the same data is accessed,
positions for positioning the respective elements 20,
21 at a write operation time is different from that at
a read operation time. Therefore, in actual, pieces
of the positioning correction information are required
for exclusive use in the read head element 20 and the
write head element 21, respectively.

Additionally, relative positions of the read head
element 20 and the write head element 21 differ owing
to manufacturing fluctuations of the head 2.
Therefore, one of the pieces of the positioning
correction information is information produced by use
of a small number of representative disk mediums by
means of the combinations of the original boards and
the magnetic transfer devices. The other positioning

correction information can be calculated by a linear interpolation method. This will be described hereinafter specifically.

For example, there will be described a case where
5 the positioning correction information at the read operation time is calculated by the linear interpolation. Assuming that a relative distance between the read head element 20 and the write head element 21 is d , and a positioning correction value of
10 a track n at the write operation time is $x(n)$, a positioning correction value y at the read operation time is calculated from the following equation (1):

$$y(n) = (x(n+1) - x(n)) / d + x(n) \quad \dots (1).$$

When the CPU 11 incorporates into the disk drive
15 the disk medium 1 onto which the original servo pattern of the original board is transferred, and writes the positioning correction information, the positioning correction information read from the correction information recording buffer 13 is written
20 as such as the positioning correction information corresponding to the write head element 21. On the other hand, the CPU 11 writes as the positioning correction information corresponding to the read head element 20 the correction value calculated by the
25 linear interpolation method using the positioning correction information corresponding to the write head element 21 by means of the equation (1).

It is to be noted that conversely, the positioning correction information read from the correction information recording buffer 13 may be written as such as the positioning correction information corresponding to the read head element 20, and the correction value calculated by the linear interpolation method may be written as the positioning correction information corresponding to the write head element 21.

In brief, the present embodiment relates to the servo information writing method of recording the positioning correction information for correcting the positioning error attributable to the distortion of the original servo information transferred from the original board onto the disk medium. The positioning correction information is written with respect to the disk medium in which the original servo information from the same original board is recorded.

According to the present embodiment, the positioning correction information produced based on the original servo information is written with respect to the disk medium in which the original servo information from the same original board is recorded without producing the positioning correction information for each disk medium. Therefore, it is possible to realize reduction of a time for producing the positioning correction information. As a result,

the time required for the servo writing step can be reduced to enhance efficiency.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore,
5 the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general invention concept as
10 defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method of writing servo information for use in head positioning control on a disk medium incorporated in a disk drive, comprising:

5 executing the positioning control of a head included in the disk drive based on original servo information recorded on the disk medium;

 producing positioning correction information to correct a positioning error by the positioning
10 control;

 recording the positioning correction information in storage means disposed outside the disk drive; and

 writing the positioning correction information to the disk medium incorporated in the disk drive.

15 2. The method according to claim 1, wherein the writing comprises: acquiring the positioning correction information from the storage means to write the information in the disk medium, after the disk medium having the recorded original servo information
20 has been incorporated in the disk drive.

3. The method according to claim 1, wherein the writing includes:

 acquiring the positioning correction information from the storage means, after the disk medium having
25 the recorded original servo information has been incorporated in the disk drive;

 positioning the head at a target position on the

disk medium at a time when executing the positioning control including positioning correction using the positioning correction information and writing the positioning correction information; and

5 writing the positioning correction information to the disk medium at the target position.

4. The method according to claim 1, wherein the producing produces the positioning correction information for each of all tracks constituted on the
10 disk medium, and

the recording records in the storage means the positioning correction information for each of all the tracks.

5. The method according to claim 1, further
15 comprising:

transferring and recording the original servo information to a disk medium incorporated in the disk drive from an original board in which the original servo information has been recorded.

20 6. The method according to claim 1, further comprising:

transferring to and recording on a disk medium incorporated in the disk drive the original servo information from an original board in which the
25 original servo information has been recorded,

wherein the recording records the positioning correction information in the original board as the

storage means.

7. The method according to claim 1, further comprising:

transferring to and recording on a disk medium
5 incorporated in the disk drive the original servo
information from an original board in which the
original servo information has been recorded; and
recording on the disk medium identification
information to identify the original board.

10 8. The method according to claim 1, further comprising:

transferring to and recording on a disk medium
incorporated in the disk drive the original servo
information from an original board in which the
15 original servo information has been recorded; and
recording on the disk medium identification
information to identify the original board,

wherein the recording associates the positioning
correction information with the identification
20 information to record the information in the storage
means.

9. A disk drive comprising:

a disk medium on which original servo information
has been recorded;

25 a head which records or reproduces data with
respect to the disk medium;

a unit which executes positioning control of the

head based on the original servo information recorded on the disk medium and which produces positioning correction information to correct a positioning error in the positioning control;

5 a recording unit which records the positioning correction information in a storage unit; and

 a servo writing unit which acquires the positioning correction information from the recording unit to write the information to the disk medium by
10 use of the head.

 10. The disk drive according to claim 9, wherein the servo writing unit includes a unit which positions the head at a target position over the disk medium at a time when the servo writing unit acquires the
15 positioning correction information from the storage unit, executes the positioning control including positioning correction using the positioning correction information, and writes the positioning correction information, and

20 the servo writing unit writes the positioning correction information at the target position to the disk medium.

 11. The disk drive according to claim 9, wherein the production unit produces the positioning
25 correction information for each of all tracks constituted on the disk medium, and

 the recording unit records in the storage unit

the positioning correction information for each of all
the tracks.

12. The disk drive according to claim 9, wherein
the disk medium records identification information to
5 identify an original board to which the original servo
information is transferred and recorded, and

the recording unit associates the positioning
correction information with the identification
information to record the information in the storage
10 unit.