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TITLE OF THE INVENTION

METHOD AND APPARATUS FOR PERFORMING SELF-SERVO WRITING
IN A DISK DRIVE

BACKGROUND OF THE INVENTION

5 The present invention generally relates to a disk drive. More particularly, the invention relates to a method of perform servo writing for recording servo data on a disk-shaped medium.

10 Most disk drives, a represented by hard disk drives, incorporate a servo system. The servo system controls the positioning of the head (magnetic head), or moves the head to a desired track on the disk-shaped medium, i.e., a data recording medium. The servo system controls the positioning of the head, by
15 using the servo data recorded on the disk-shaped medium.

20 A method of manufacturing a disk drive includes a servo writing step, i.e., the step of recording servo data on the disk-shaped medium. A self-servo writing method is known, which is performed in the servo writing step. The self-servo writing method uses the head and actuator that are incorporated in the disk drive.

25 The disk drives developed in recent years incorporate a head that comprises a read-head element and a write-head element, both mounted on the same slider and separated from each other. The write-head



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element records data on a disk-shaped medium. The read-head element reads the data recorded on the disk-shaped medium. The read-head element has an MR (magnetoresistive) element in most cases.

5 The self-servo writing method uses the write-head element of the head incorporated in the disk drive, thereby writing servo data on the disk-shaped medium. The read-head element reads the servo data thus written on the disk-shaped medium.

10 In the servo writing step, it is necessary to write the servo data, precisely at a prescribed position on the disk-shaped medium. The head incorporated in the disk drive comprises two discrete elements, i.e., the read-head element and the write-
15 head element. A position offset inevitably exists between these elements. The position offset corresponds to the distance between the centerlines of the read- and write-head elements. Hence, the head-positioning control must be carried out in the
20 self-servo writing step, in accordance with the position offset between the read- and write-head elements.

 More specifically, the position offset must be measured and the offset must be adjusted in accordance
25 with the position offset measured, in order to control the positioning of the head. A method is proposed and developed, in which the position offset is measured by

using a measuring pattern written on the disk shaped medium. (See, for example, Jpn. Pat. Appln. KOKAI Publication No. 8-129732.) This prior-art method uses a servo-burst pattern contained in the servo data,
5 thereby to writing a measuring pattern on the disk-shaped medium. In this method, the measuring pattern is used, determining the distance between the centerline of the read-head element and one end of the write-head element and also the distance between the
10 centerline and the other end of the write-head element. The distance from the centerline of the write-head element is obtained from the average of these distances determined. The position offset is thereby calculated.

15 Another prior-art method is proposed, which uses a servo-burst pattern to measures the position offset. (See, for example, Jpn. Pat. Appln. KOKAI Publication No. 10-334428.) In this method, the servo data for measuring the offset is written on the disk-shaped
20 medium and the position error read from this servo data is applied as the position offset between the read- and write-head elements.

In short, the pattern for measuring the offset is merely a servo-burst pattern that is repeated, each
25 time for one of the tracks provided on the disk-shaped medium. However, the position offset between the read- and write-head elements used in the disk drives

developed in recent years amounts to several track intervals. This is because these disk drives record data on the disk-shaped medium at a high linear recording density.

5 With the conventional method using the measuring pattern that is only a servo-burst pattern, it is difficult to measure the position offset between the read- and write-head elements, directly and accurately. Unless the position offset is measured
10 with high accuracy, no successful self-servo writing step can be carried out.

 The conventional method using the measuring pattern that is only a servo-burst pattern can hardly measure the position offset between the read- and
15 write-head elements, directly and accurately. It is therefore demanded that the position offset between the read- and write-head elements be measured with high precision to perform a successful self-servo writing step.

20 BRIEF SUMMARY OF THE INVENTION

 In accordance with one embodiment of the invention, there is provided a self-servo writing method that can measure an accurate position offset between the read-head element and write-head element
25 incorporated in a disk drive, before servo data is recorded on the disk-shaped medium that is provided in the disk drive.

The self-servo writing method comprises: reading
positioning servo data recorded on the disk-shaped
medium by using the read-head element; positioning the
write-head element at a desired track provided on the
5 disk-shaped medium, by using the positioning servo
data read by the read-head element; recording
measuring servo data in the desired track by using the
write-head element; and calculating a position offset
between the read-head element and the write-head
10 element, from the positioning servo data and the
measuring servo data, both read by the read-head
element from the disk-shaped medium.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated
15 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,
serve to explain the principles of the invention.

20 FIG. 1 is a block diagram showing the major
components of a disk drive and servo writer according
to an embodiment of the present invention;

FIG. 2 is a diagram outlining a method of writing
servo data in the embodiment;

25 FIG. 3 is a diagram illustrating the positional
relation between the read-head element and the write-
head element, both provided in the embodiment;

FIGS. 4A to 4C are diagrams showing how the position offset between the read- and write-head elements varies;

5 FIG. 5 is a diagram representing an example of servo data recorded on the disk-shaped medium used in the embodiment;

FIGS. 6A and 6B are diagrams defining the position offset between the read- and write-head elements in the embodiment;

10 FIGS. 7A to 7C are diagrams explaining the sequence of writing the servo data in the embodiment;

FIGS. 8 and 9 are diagrams a method of measuring the position offset in the embodiment;

15 FIG. 10 is a diagram explaining a modification of the method of measuring the position offset;

FIGS. 11A and 11B are graphs demonstrating the advantage of the modified method; and

20 FIG. 12 is a flowchart explaining the sequence of a self-servo writing method according to the embodiment.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of this invention will be described, with reference to the accompanying drawings.

25 (Disk Drive and Servo Writer)

FIG. 1 shows a disk drive 1 and a servo writer 10, both according to the present embodiment.

The disk drive 1 incorporates a drive mechanism. The drive mechanism comprises a head 2, an actuator 3, a voice coil motor (VCM) 4, a spindle motor 5, and a disk-shaped medium 6. The head 2 is mounted on the actuator 3. The disk-shaped medium 6 is secured to the spindle motor 5. The disk drive 1 comprises a circuit unit 7, in addition to the drive mechanism. The circuit unit 7 includes a head amplifier IC, a read/write channel, a microprocessor, a disk controller and the like.

The actuator 3 moves in the radial direction of the disk-shaped medium 6 when driven by the voice coil motor 4. It is a mechanism for positioning the head 2 over the disk-shaped medium 6. The head 2 has a write-head element and a read-head element. The write-head element is designed to write data on the disk-shaped medium 6. The read-head element is configured to read data from the disk-shaped medium 6.

As FIG. 3 shows, the head 2 is of the type in which the read-head element 21 and the write-head element 22 are mounted on a slider 20, spaced from each other. The read-head element 21 is a magnetoresistive element, as in most cases. The write-head element 22 is a thin-film, inductive head element. The head elements 21 and 22 are arranged, one staggered with respect to the other.

FIGS. 4A to 4C are diagrams showing how the

position offset between the head elements 21 and 22 changes. As seen from FIGS. 4A to 4C, the offset changes from d1 to d2, and thence to d3, as the head moves over the disk-shaped medium 6.

5 More precisely, FIG. 4A shows the position offset d1 that exists when the head 2 stays over an inner track provided on the disk-shaped medium 6. FIG. 4B indicates the position offset d2 that exists when the head 2 stays over an intermediate track provided on
10 the medium 6. FIG. 4C depicts the position offset d3 that exists when the head 2 stays over an outer track provided on the medium 6.

 It is desired that the read-head element 21 and the write-head element 22 assumes the same positional
15 relation, at wherever position over the disk-shaped medium 6, as in any disk drive that perform the self-servo writing method. That is, the head elements 21 and 22 should be positioned as illustrated in FIG. 3 (thereby providing an offset). In other words, the
20 read-head element 21 should be closer to the center of the disk-shaped medium 6 than the write-head element 22.

(Outline of Self-Servo Writing Method)

 A self-serve writing method performs a self-servo
25 writing step in the present embodiment. The self-serve writing method is to record servo data on the disk-shaped medium 6, by using the head 2 and the

actuator mechanism (including VCM 4) that are incorporated in the disk drive 1.

The servo writer 10 has a CPU 100 and a circuit unit 110. The CPU 100 (including software) controls the VCM 4 of the disk drive 1 to position the head 2 at a desired track. The CPU 100 performs the self-servo writing control including the calculation of a position offset, which characterizes the present embodiment. The circuit unit 110 has various circuits. One circuit generates a servo pattern that corresponds to servo data to be recorded on the disk-shaped medium 6. Another circuit generates timing signals.

As seen from FIG. 2, the self-servo writing method uses the write-head element 22 of the head 2 incorporated in the disk drive, to record servo data (servo pattern) 201 in the desired track on the disk-shaped medium 6. The method uses the servo data 200 that the read-head element 21 of the head 2 has read from the medium 6, to move the write-head element 21 to the position where data should be written on the disk-shaped medium 6.

As FIG. 2 shows, the reference position 220 is set for the read-head element 21 on the basis of the position offset between the read-head element 21 and the write-head element 22, so that the write-head element 22 may be positioned right over the desired

track 210.

The CPU 100 of the servo writer 10 receives the servo data 200 read by the read-head element 21. From the servo data 200 the CPU 100 calculates the position error the read-head element 21 has with respect to the reference position 220. In accordance with the position error the CPU 100 controls the positioning of the read-head element 21. To accomplish the self-servo writing method in success, it is necessary to store the data that represents the positional relation (position offset) between the read-head element 21 and the write-head element 22.

(Self-Servo Writing Step)

FIG. 5 is a diagram representing the servo data 500 written in the self-servo writing step on the disk-shaped medium 6 that is provided in the disk drive 1. The servo data 500 has a servo-burst pattern (position error pattern) 502, a track (cylinder)-address code 503, a servo-mark signal 504, and a dummy signal 505. The servo-mark signal 504 indicates a servo area. The dummy signal 505 is used to adjust the servo-data write timing. The process of adjusting the servo-data write timing is called "padding."

The servo writer 10 causes the write-head element 22 to write the servo data 500 in a track 501 when the head 2 of the disk drive 1 is positioned at the track 501 as the CPU 100 controls the positioning of the

write-head element 22. At this time, the servo writer 10 controls the positioning of the head 2 to position the read-head element 21 with respect to the reference position 510 that has been set on the basis of the position offset between the read- and write-head elements.

In the servo writing step, the write width W_b of the servo-burst pattern contained in the servo data 500 is determined by the track density only, irrespective of the width of the write-head element 22. That is, the write width W_b is equivalent to the feed pitch of the write-head element 22. The boundary of the servo data 500 does not lie on the centerline of the write-head element 22. Rather, it is defined by one end of the centerline of the element 22.

Thus, the servo writer 10 writes the servo data 500 in the track 501, while the position of the write-head element 22 is adjusted on the basis of the position offset between the read- and write-head elements.

The position offset between the read- and write-head elements, which exists during the self-servo writing step, will be defined with reference to FIGS. 6A and 6B.

FIG. 6A illustrates the position offset W_n between the read- and write-head elements, which should be considered to achieve normal read/write

operation of the disk drive 1. In the normal
read/write operation, a position offset is applied to
enable the read-head element 21 to read user data from
the disk. This position offset corresponds to the
5 distance between the centerline of the read-head
element 21 and the centerline of the write-head
element 22. It is defined as a position offset W_n
between the read- and write-head elements.

In the self-servo write step, the position offset
10 W_s between the read- and write-head elements is set on
the basis of the write width W_b of the servo-burst
pattern (i.e., feed pitch of the write-head element
22), as may be understood from FIG. 6B. To more
specific, this position offset W_s is defined as the
15 distance between a specific point and the center of
the read-head element 21, the specific point existing
at a predetermined distance ($W_b/2$) from the end of the
write-head element 22.

Namely, the position offset W_s that should be
20 taken into account in the self-servo writing step
differs from the position offset W_n that should be
considered to achieve normal read/write operation of
the disk drive 1.

(Sequence of the Self-Servo Writing Method)

25 In the self-servo writing method according to
this embodiment, the write-head element 22 is
positioned in accordance with the servo data the

read-head element 21 has read from the medium 6, at the same time the write-head element 22 writes other servo data on the disk-shaped medium 6. To accomplish this, two servo-data items are recorded on the disk-shaped medium 6.

More precisely, one servo-data item is the servo data (ordinary servo data) that is used to perform normal read/write operation. The other servo-data item is the measuring servo data that is used to measure the position offset between the read- and write-head elements. The measuring servo data is identical in format to the servo data for positioning the head 2.

The sequence of the self-servo writing step that uses these two servo-data items will be explained, with reference mainly to the flowchart of FIG. 12.

As auxiliary servo pattern is recorded on the disk-shaped medium 6 incorporated in the disk drive 1. More specifically, the auxiliary servo pattern is recorded in a few innermost or outermost tracks (at least one track). The servo writer 10 causes the read-head element 21 to read the auxiliary servo pattern. In accordance with the auxiliary servo pattern thus read, the servo writer 10 drives the VCM 4, which in turn rotates the actuator 3. The actuator 3 brings the write-head 22 to the track in which the first servo data should be written. The write-head

element 22, thus positioned, records the first servo data (i.e., head-positioning servo data) in that track.

Next, the servo writer 10 causes the read-head
5 element 21 to read the positioning servo data, i.e., the servo data already recorded. In accordance with the positioning servo data the servo writer 10 positions the write-head element 22 at the first track in which servo data should be written (Steps S1 and
10 S2). The servo writer 10 makes the write-head element 22 record the servo data in the first track (Step S3). The servo data thus recorded by the write-head element 22 is measuring servo data that has the same format as the positioning servo data. The measuring servo data
15 is a copy of the positioning servo data recorded at the position that has been set on the basis of the position offset the between the head elements 21 and 22.

From the positioning servo data and the measuring
20 servo data, both recorded on the disk-shaped medium 6, the servo writer 10 determines the position offset that the head elements 21 and 22 had during the servo writing operation (Step S4). Then, the servo writer 10 causes the head 2 to record servo data (both
25 positioning servo data and measuring servo data) on the medium 6, while controlling the positioning of the head 2 in accordance with the position offset between

the head elements 21 and 22 (Step S5).

When finishing the self-servo writing, the servo writer 10 erases the measuring servo data (including the auxiliary servo pattern) from the disk-shaped medium 6 (Step S6). As a result, only the positioning servo data remains recorded on the disk-shaped medium 6. The positioning servo data is ordinary servo data the disk drive 1 uses to perform the ordinary read/write operation.

FIGS. 7A to 7C are diagrams showing the self-servo writing method that uses two servo-data items. That is, the method uses servo data (T) and servo data (M), to control the positioning of the head 2.

The servo data (T) corresponds to, for example, the positioning servo data, whereas the servo data (M) corresponds to the measuring servo data. As FIG. 7B shows, the read-head element 21 is positioned in accordance with the servo data (T), and the write-head element 22 writes the servo data (M) in addition to the servo data (T).

Alternatively, the read-head element 21 may be positioned in accordance with the servo data (M), and the write-head element 22 writes the servo data (T) in addition to the servo data (M), as is illustrated in FIG. 7C.

(Measuring the Positional Offset between the Head Elements)

FIG. 8 is a diagram explaining how to measure the position offset W_s in the self-servo writing step carried out in the embodiment.

The servo writer 10 uses the servo data 803 (e.g., positioning servo data) already recorded on the medium 6, to moving the read-head element 21 at a predetermined position. To position the head element 21 in this way, the servo writer 10 sets the reference position 801 for the read-head element 21, regardless of the position offset between the read- and write-head elements.

The distance 802 shown in FIG. 8 is the predetermined distance ($W_b/2$) between the above-mentioned specific point and the end of the write-head element 22. The servo writer 10 causes the write-head element 22 to write (copy) the servo data 803 read by the read-head element 21, which is used as measuring servo data 804. As indicated above, the measuring servo data 804 is identical in format to the positioning servo data 803 and written in the same way as the positioning servo data 803.

Thus, the measuring servo data 804 is written at a distance equal to the position offset W_s , from the position where the positioning servo data 803 has been written. The data 803 and the data 804 contains a

servo mark each. The servo writer 10 performs a process, making the servo marks contained in the data items 803 and 804 different from each other. Hence, the positioning servo data 803 and the measuring servo data 804 can be distinguished from each other, with
5 reference to the servo marks.

The measuring servo data 804 is identical in format to the positioning servo data 803. Therefore, no servo-data decoding circuit needs to be used.
10 Containing a cylinder code, the measuring servo data 804 can be reliably detected even if the position offset W_s between the head elements 21 and 22 extends over several tracks.

The method of measuring the position offset W_s from the measuring servo data 804 will be described in detail, with reference to FIG. 9.
15

The servo writer 10 drives the VCM 4, moving the read-head element 21 (to the reference position 801), in accordance with the positioning servo data 803 that
20 the read-head element 21 has read. At the same time, the servo writer 10 read causes the read-head element 21 to read the measuring servo data 804. Note that the position error data (i.e., servo-burst pattern) read from the positioning servo data 803 is different
25 from the position error data (i.e., servo-burst pattern) read from the measuring servo data 804.

The position offset W_s between the read- and

write-head elements is given as follows:

$$W_s = PES_d - PEST \quad (1)$$

where PEST is the position error data read from the positioning servo data 803 and PESd is the position error data read from the measuring servo data 804.

Thus, the servo writer 10 can accurately measure an offset required for controlling the positioning the write-head element 22, from the position offset W_s calculated by the equation (1) in the self-servo writing step. To cancel the error detected, it is desirable to find an average of the position errors obtained from the servo data items written in each track of the disk-shaped medium 6, and to calculate the position offset W_s from the average position error.

(Modification of the Positional-Offset Measuring Method)

FIG. 10 is a diagram explaining a modification of the method of measuring the position offset between the read- and write-head elements in the present embodiment. The modified method uses the measuring servo data after the position offset has been adjusted in accordance with the offset W_s measured beforehand.

To state it more precisely, the servo writer 10 adjusts the position offset in accordance with the offset W_s already determined, and then moves the

read-head element 21 to a position in accordance with positioning servo data 1003. The read-head element 21 thus positioned reads measuring servo data 1004.

5 In this case, the position offset W_e is given as follows:

$$W_e = PES_d - PEST \quad (2)$$

where $PEST$ is the position error data read from the positioning servo data 1003 and PES_d is the position error data read from the measuring servo
10 data 1004.

This position offset W_e is a difference between the position offset W_s already obtained and the actual position offset between the read- and write-head elements. The normal position offset W_t between the
15 read- and write-head elements is therefore given as follows:

$$W_t = W_s - W_e \quad (3)$$

In the modified method, the servo writer 10 can update the normal position offset W_t on the basis of
20 the position offset W_s already measured and the actual position offset W_e between the read- and write-head elements. That is, the servo writer 10 can update the normal position offset W_t , while moving the head 2 over the disk-shaped medium 6 during the self-servo
25 writing step. To apply the updated (or adjusted) offset effectively to the positioning of the head 2, it is necessary to move the read-head element 21 for a

distance equal to or longer the position offset W_s between the read- and write- head elements.

As described above, the position offset between the read- and write-head elements can be updated as the head 2 is moved in the modified method of measuring the position offset. This renders it possible to record the servo data in the self-servo writing step, with high precision in accordance with the track density.

FIG. 11A shows the relation that the cylinder number and the track pitch have when the actual position offset is adjusted on the basis of the measured position offset W_s . The reference value for the track pitch is 1. It is desired that the actual track pitch fall within a narrow range above and below the reference value. FIG. 11B shows the relation that the cylinder number and the track pitch have when the actual position offset is not adjusted at all. Both FIG. 11A and FIG. 11B illustrate the results of the experiments in which servo data was recorded by the self-servo writing method, in addition to the servo data written at the normal track pitch.

The self-servo writing method according to the embodiment uses two servo-data items, i.e., the positioning servo data and the measuring servo data, whereby the position offset between the read- and write-head elements is measured and updated

repeatedly. Namely, the offset is adjusted on the basis of the measured position offset, thus positioning the write-head element 22 with high precision. The high-precision servo data can
5 therefore be written, while maintaining the high track density.

As has been described in detail, the embodiment of the invention can measure the position offset between the read- and write-head elements incorporated
10 in the disk drive, with high precision in the self-servo writing step. As a result, the embodiment can write high-precision servo data on the disk-shaped medium.

Additional advantages and modifications will
15 readily occur to those skilled in the art. Therefore, 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
20 spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method of self-servo writing in a disk drive that has a head and a disk-shaped medium, the head having a write-head element and a read-head element, the method comprising:

- (a) reading positioning servo data recorded on the disk-shaped medium by using the read-head element;
- (b) positioning the write-head element at a desired track provided on the disk-shaped medium, by using the positioning servo data read by the read-head element;
- (c) recording measuring servo data in the desired track by using the write-head element; and
- (d) calculating a position offset between the read-head element and the write-head element, from the positioning servo data and the measuring servo data, both read by the read-head element from the disk-shaped medium.

2. The method according to claim 1, wherein in the step (d), the displacement of the read-head element is measured from the positioning servo data and the measuring servo data, both read by the read-head element, and the position offset is calculated from the displacement measured.

3. The method according to claim 1, wherein the measuring servo data contains all positioning servo data and other data distinguished from the positioning

servo data.

4. The method according to claim 1, wherein in the step (d), the position offset is calculated from a difference between two position errors obtained from, respectively, the positioning servo data and the measuring servo data, both read by the read-head element.

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

10 moving the write-head element over the disk-shaped medium by using the positioning servo data read by the read-head element and the position offset; and recording the positioning servo data in all data area of the disk-shaped medium, by using the write-head element.

15 6. The method according to claim 5, wherein the write-head element records the positioning servo data and the measuring servo data in all data area of the disk-shaped medium.

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

positioning the write-head element over the disk-shaped medium by using the positioning servo data read by the read-head element and the position offset; and erasing the measuring servo data from the disk-shaped medium after the write-head element records the positioning servo data in all data area of the

disk-shaped medium.

8. The method according to claim 1, wherein in the step (d), position error data items are calculated for a plurality positions on the disk-shaped medium, from the positioning servo data and the measuring servo data, and the position offset is calculated from an average of the position error data items.

9. The method according to claim 1, wherein in the step (b), the offset is adjusted by using a preset position offset in order to position the write-head element at the desired track in accordance with the positioning servo data.

10. The method according to claim 1, further comprising setting, as normal position offset, a position offset obtained from a difference between the position error data contained in the positioning servo data read by the read-head element positioned by adjusting the offset and the position error data obtained from the difference between the measuring servo data and the positioning servo data.

11. A self-servo writing apparatus for use in a disk drive having a head including a read-head element and a write-head element, and a disk-shaped medium, said apparatus comprising:

a first unit which causes the write-head element to record positioning servo data and measuring servo data on the disk-shaped medium; and

a second unit which uses the positioning servo data and measuring servo data read by the read-head element, thereby to calculate a position offset between the read-head element and the write-head element.

12. The apparatus according to claim 11, wherein the first unit causes the read-head element to read the positioning servo data recorded on the disk-shaped medium, positions the write-head element at a desired track provided on the disk-shaped medium in accordance with the positioning servo data, and causing the write-head element to write the measuring servo data in the desired track.

13. The apparatus according to claim 11, wherein the positioning servo data contains all positioning servo data and also contains other data distinguished from the positioning servo data.

14. The apparatus according to claim 11, wherein the first unit uses the positioning servo data read by the read-head element and the positioning offset, thereby to move the write-head element over the disk-shaped medium, and causes the write-head element to record the positioning servo data and the measuring servo data on all data area of the disk-shaped medium.

15. The apparatus according to claim 11, wherein the first unit uses the positioning servo data read by the read-head element and the position offset, thereby

to move the write-head element over the disk-shaped medium, and causes the write-head element to erase the measuring servo data from the disk-shaped medium after the positioning servo data is recorded on all data
5 area of the disk-shaped medium.

16. A disk drive comprising:

a disk-shaped recording medium;

a head which has a read-head element and a write-head element spaced apart from each other;

10 a first unit which causes the write-head element to record positioning servo data on the disk-shaped recording medium, the positioning servo data being to be used to position the head;

a second unit which positions the write-head
15 element at a desired track in accordance with the positioning servo data read by the read-head element and which causes the write-head element to record measuring servo data on the disk-shaped recording medium; and

20 a third unit which uses the positioning servo data and measuring servo data read by the read-head element, thereby to calculate a position offset between the read-head element and the write-head element.

25 17. The disk drive according to claim 16, wherein the measuring servo data contains all positioning servo data and also contains other data distinguished

from the positioning servo data.

18. The disk drive according to claim 16, further comprising a fourth unit which uses the positioning servo data read by the read-head element and the
5 position offset, thereby to move the write-head element over the disk-shaped recording medium and which causes the write-head element to record the positioning servo data and measuring servo data on all data area of the disk-shaped recording medium.

10 19. The disk drive according to claim 16, further comprising a fifth unit which uses the positioning servo data read by the read-head element and the position offset, thereby to move the write-head element over the disk-shaped recording medium, and
15 causes the write-head element to erase the measuring servo data from the disk-shaped recording medium after the positioning servo data is recorded on all data area of the disk-shaped medium.