

Magnetic data embedding apparatus having checking function

Technical field of the invention

The present invention relates to a magnetic data embedding
5 apparatus to write magnetic data (or embedded data) including a
servo pattern for detecting a magnetic head position, an ID pattern
for identifying a magnetic disk, and a program into a virgin or
unwritten magnetic disk. The data are written to meet the
customer's requirement and to serve as a product magnetic disk. The
10 magnetic data embedding apparatus is also called a disk servo writer.

The invention relates to such a magnetic data embedding
apparatus that comprises a master disk and a plurality of magnetic
disks all stacked together onto the shaft of a spindle motor and writes
15 the embedded data on the surfaces of each magnetic disk based on
magnetic data that is read out of the master disk simultaneously
through magnetic heads disposed in such a way that a plurality of
magnetic heads are arranged on each surface of the magnetic disk.

20 The invention relates, in particular, to a magnetic data
embedding apparatus having a checking function, in which checking
is executed for the embedded data written on the magnetic disk with
the magnetic data on the master disk, and correction is done for
errors if detected, simultaneously with the writing operation.

In the drawings, the same symbol represents the same or an equivalent part.

Background of the invention

5 Fig. 9 shows schematic arrangement of areas of magnetic data that are embedded (or written) on a virgin magnetic disk 1. PS2 represents servo pattern embedding areas arranged radially with an equal spacing (or in a sector spacing) on the both sides of the magnetic disk 1. DTA represents data areas for ID pattern for disk
10 identification or programs that are written on customer's request at a time of manufacturing the magnetic disk 1. The DTA can also represent data areas for data that are written by a user after production of the magnetic disk 1.

15 The servo pattern PS2 consists of information for sensing actual position of the magnetic head over the magnetic disk 1 in operation. The information includes a clock pattern for generating a synchronous clock and coordinate information such as a track address and a sector address.

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 Fig. 7 shows an example of a structure of a conventional magnetic data embedding apparatus for writing servo pattern PS2 on a magnetic disk 1. This magnetic data embedding apparatus 101 comprises a disk stack unit DSU consisting of M sheets (nine sheets

in the Fig. 7) of magnetic disks 1 and a sheet of a clock pattern disk 2K coaxially stacked together. The DSU is fixed to the shaft of a spindle motor SPM and turned at a high rotating speed.

5 On the clock pattern disk 2K, a clock pattern PC0 is written on the outermost circumference, for example as shown in Fig. 8, on a virgin magnetic disk 1 using this apparatus 101 before writing servo pattern PS2 on the magnetic disk 1. The servo pattern PS2 is written on the magnetic disk 1 synchronizing with the clock that is obtained
10 by reading out the clock pattern PC0.

The symbol 3K represents a clock head that writes and reads a clock pattern PC0 directly to and from the clock pattern disk 2K. The symbol 11K represents a clock head positioner that holds and
15 positions the clock head 3K at a fixed position of the outermost circumference of the clock pattern disk 2K in the example of Fig. 7. The symbol 9K represents a clock pattern generator that generates signals of the clock pattern PC0 to write on the clock pattern disk 2K.

20 The symbol 3 represents servo heads that are provided corresponding to each medium surface of the M sheets of magnetic disks 1 and write servo patterns PS2 directly on the medium surface. The symbol 11 represents a rotary positioner that holds and stacks the servo heads 3 and oscillates around the shaft 11a to move the

servo head 3 to a desired radial position on the magnetic disk 1.

The symbol 18 represents an encoder that is fixed coaxially with the rotary positioner and detects angular position of the rotary positioner 11. The symbol 19 represents a position detection section that obtains a radial position (an analogue value) on the magnetic disk of the servo head 3 from the angular position detected by the encoder 18.

10 Servo compensator 7 and power amplifier 8, together with the encoder 18 and the position detection section 19, constitute a feedback loop that controls positioning of the servo heads 3 through the rotary positioner 11 in the radial direction on the magnetic disk, that is, positioning to the center in the radial direction of a desired
15 track.

The servo compensator 7 receives and amplifies error signal between a target head position p_s and a detected head position p of the servo head 3 and obtain a servo compensation quantity to
20 minimize the error. Here, the target head position p_s is an analogue value corresponding to a radius of the center of the target track and the detected head position p is the actual radial position of the servo head 3 that is output from the position detection section 19. The power amplifier 8 outputs electric current for driving the rotary

positioner 11 according to the servo compensation quantity, to move the servo heads 3.

5 The servo pattern generator 9 generates servo pattern PS2 while receiving the clock from the clock head 3K and supplies each of the servo heads 3 stacked on the rotary positioner 11 with the generated servo pattern PS2.

10 Next, the operation of the apparatus of Fig. 7 as a whole will be described below. First, the clock head 3K records clock pattern PC0 generated by the clock pattern generator 9K at a desired radial position (at the outermost circumference in the example of Fig. 8) on the clock pattern disk 2K.

15 The actual radial position p of the servo head 3 is detected by the encoder 18 that is coaxial with the rotary positioner 11, and the position detection section 19. The error quantity between the detected head position p and the target head position p_s is fed back through the servo compensator 7 and the power amplifier 8 to the
20 rotary positioner 11 thereby positioning the servo heads 3 following-up the target position p_s .

 In this following-up state, each of the servo heads 3 simultaneously writes servo patterns PS2 generated by the servo

generator 9 on the corresponding surface of the magnetic disk 1, while synchronizing with the clock that is read out of the clock pattern disk 2K through the clock head 3K.

5 In addition to the servo pattern, ID data, programs, and other data are also written onto the data area DTA of the magnetic disk 1 by the servo heads 3 through the servo pattern generator 9, while synchronizing with the clock that is read out of the clock pattern disk 2K.

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Japanese Unexamined Patent Application Publication No. H5-189895 discloses a magnetic disk device comprising first and second access mechanisms, one of which writes data and the other reads and checks the data. Japanese Unexamined Patent Application
15 Publication No. H9-288873 discloses a magnetic disk device comprising two magnetic heads, both of which access to one magnetic disk surface, one of the two being dedicated to regeneration operation only.

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Japanese Unexamined Patent Application Publication No. H10-172254 discloses a technique with which a servo pattern read out of a master surface of a medium is written on medium surfaces excepting the master surface in a magnetic disk device comprising a plurality of medium surfaces. Japanese Unexamined Patent Application

Publication No. H8-235801 and Japanese Unexamined Patent Application Publication No. 2001-216750 discloses a technique, in which a magnetic disk device or a disk servo writer writes servo information on a plurality of magnetic disk surfaces at the same time.

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Problem to be solved by the invention

The conventional magnetic embedding apparatus, which is usually called a disk servo writer, described above simultaneously writes servo patterns generated by the servo pattern generator on the stacked magnetic disks while synchronizing with the clock pattern recorded in advance on a clock pattern disk. The time required for writing on the whole disk surfaces in one disk stack unit is equal to the time for one revolution of the disk times the number of tracks to be written in a disk.

15

With increase in track density on magnetic disks, the time required for writing operation increases, resulting in lower throughput. Since the track pitch decreases, more accurate writing is needed, and it becomes important to check the written pattern. This checking time also increases like the writing time, adversely affecting the through-put.

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By increasing the rotating speed of disks, the time for writing and checking can be reduced, whereas mechanical vibration increases

in a tradeoff relationship. The vibration makes it difficult to write accurate servo pattern.

If number of stacked magnetic disks is increased, while the
5 through-put per one sheet of disk is enhanced, the load on the spindle motor increases, and precision of rotation deteriorates. Since number of stacked magnetic heads also increases, it becomes difficult to confine the accuracy in attaching the magnetic heads within a specified limit.

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A conventional apparatus for embedding magnetic data employs a rotary encoder for detecting the position of the magnetic head. As recording density increases, the accuracy for detecting position of the magnetic head exceeds the resolution precision of the rotary encoder.
15 Therefore, a means for position detection with higher accuracy is needed.

Accordingly, an object of the present invention is to provide a magnetic data embedding apparatus having checking function that
20 allows correctly writing magnetic data on magnetic disks by virtue of higher accuracy in position detection than of a rotary encoder, and that allows decreasing the time for the processes from the start of writing to the end of checking. The aimed apparatus has to maintain the rotating speed of the magnetic disks and the number of stacked

magnetic disks unchanged.

Means to solve the problem

To solve the problems, a magnetic data embedding apparatus
5 having checking function 01, 02 of the present invention comprises:
a master magnetic disk 2 with magnetic data containing servo
information written on at least one surface thereof and a plurality of
object magnetic disks 1 in which information is written, the master
disk and the object disks being stacked and integrally installed on a
10 shaft of a spindle motor (SPM) ;
one or more writing-dedicated rotary positioner 11A, 11B, 11W
disposed around the magnetic disks, and stacking and holding
integrally and pivotably one or more read magnetic heads 5A, 5B,
51-54 and one or more write magnetic heads (servo heads 3A, 3B, 31
15 through 34), the read magnetic heads reading out the magnetic data
on the master disk and one or predetermined number of the write
magnetic heads being provided corresponding to each surface of the
object magnetic disks for accessing the surface, the rotary positioner
being provided so that a plurality of the write magnetic heads exist
20 for accessing every one surface of the object magnetic disks, wherein
each of the write magnetic heads belonging to one of the write-
dedicated rotary positioners writes the magnetic data that is read out
by the read magnetic head disposed on the master magnetic disk or
magnetic data made from the magnetic data that is read out from the

master disk (hereinafter the two types of magnetic data are collectively referred to as “embedded data”) onto one surface of the object magnetic disk corresponding to the write magnetic head in such a way that another write magnetic head corresponding to the same surface of the object magnetic disk and belonging to another writing-dedicated rotary positioner writes the embedded data in parallel while sharing a range of tracks; and the magnetic data embedding apparatus further comprises one or more checking-dedicated rotary positioners 12 disposed around the magnetic disks, and stacking and holding integrally and pivotably a first type checking head 15 and second type checking heads 13, the first type checking head reading out the magnetic data on the master disk for checking, and each of the second type checking heads being provided corresponding to one surface of the object disks for checking and reading out the embedded data corresponding to the magnetic data that is read out from the master disk by the first type checking head; and

the magnetic data embedding apparatus still further comprises, corresponding to each surface of the object disks, a comparison means (including comparison logic circuit 23 and CPU 28) that compares the embedded data that is read out from the surface of the object disk by the second type checking head with the magnetic data that is read out by the first type checking head simultaneously with writing operation of the write magnetic heads.

A magnetic data embedding apparatus having checking function advantageously further comprises an overwriting means (including correction servo pattern generator 27 and CPU 28) that overwrites onto the object disk, the embedded data corresponding to the magnetic data that is read out by the first type checking head, through the second type checking head disposed on the surface of the object disk in the case the comparison means detects inconsistency, simultaneously with the writing operation of the write magnetic heads.

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The magnetic data embedding apparatus of the invention comprises a master magnetic disk and a plurality of object magnetic disks that are stacked on a shaft of a spindle motor. The apparatus also comprises one or more read magnetic heads disposed on the master disk and a plurality of servo heads disposed on every surface of the object disks. The plurality of servo heads write embedded data based on the magnetic data that is read out from the master disk by the read magnetic head onto the surface of the object magnetic disk in parallel while sharing a range of tracks.

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The apparatus further comprises one or defined plurality of checking magnetic heads disposed on one surface of the master disk and every surface of the object disks. The checking magnetic head disposed on the master disk reads the magnetic data on the master

disk, and the checking magnetic heads disposed on the object disks read the embedded data on the corresponding surface of the object disks, during the servo heads are writing embedded data on the object disks. The magnetic data that is read out from the master disk is compared with the embedded data that is read out from the object disks, and errors, if any, are corrected. Thus, the contents in the master disk can be exactly written on every object magnetic disks. Moreover, the total time required by the processes from start of writing to end of checking can be reduced.

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Brief description of drawings

Fig. 1 shows a schematic construction of an example of embodiment of a magnetic data embedding apparatus having checking function according to the present invention.

15 Fig. 2 shows detailed construction of the functional sections on the checking side of Fig. 1.

Fig. 3 shows a structure of a magnetic data embedding apparatus having checking function of second example of embodiment according to the present invention.

20 Fig. 4 shows schematically an example of arrangement of servo information regions on a master disk in Figs. 1 through 3.

Fig. 5 shows an example of detailed structure of the servo information regions on the master disk in Fig. 4.

Fig. 6 is a timing chart illustrating an example of operation of

the writing side functional sections in Fig. 1.

Fig. 7 shows a schematic construction of a conventional example of a magnetic data embedding apparatus.

Fig. 8 shows a schematic structure of a clock pattern disk used in
5 the magnetic data embedding apparatus of Fig. 7.

Fig 9 shows a schematic arrangement of magnetic data regions on a magnetic disk.

Aspect of embodiment of the invention

10 Fig. 1 shows a constitution of an example of a magnetic data embedding apparatus having checking function 01 according to the first aspect of the invention. The apparatus of the Fig. 1 comprises a disk stack unit DSU in which a sheet of master disk 2 (at the bottom) and M sheets (M=9 in Fig. 1) of magnetic disks 1 are stacked. The
15 DSU is attached integrally to the shaft of a spindle motor SPM running at a high rotation speed.

The master disk 2 is prepared by writing accurate servo patterns and a clock pattern, which will be described later referring to Figs. 4
20 and 5, for every sector on a virgin magnetic disk that is similar to the magnetic disks 1.

The symbols 11A and 11B represent a rotary positioner that holds and swings magnetic heads, which accesses the disk stack unit

DSU. The rotary positioners 11A and 11B are for writing magnetic data to the magnetic disks 1, and are referred to as “writing side” rotary positioners.

5 The symbol 12 also represents a rotary positioner that holds and swings magnetic heads, which accesses the disk stack unit DSU. The rotary positioner 12 checks and corrects the magnetic data written on the magnetic disks 1 and is referred to as a “checking side” rotary positioner or a checking-dedicated rotary positioner.

10

 Description will be first made on the sections relating to writing operation. One of the writing side rotary positioners 11A holds a read magnetic head 5A that directly accesses to a surface of the master disk 2, the downward surface of the master disk in the example of Fig.
15 1, and servo heads 3A that directly access every surface of the M sheets of magnetic disks 1.

 Likewise, another write side rotary positioner 11B holds a read magnetic head 5B that directly accesses to the downward surface of
20 the master disk 2 and servo heads 3B that directly access every surface of the M sheets of magnetic disks 1.

 The writing side rotary positioners 11A and 11B, together with accompanying circuits, construct two head stack servo units 20A and

20B. Although the apparatus of Fig. 1 has two head stack servo units 20, one or more head stack servo units 20 may be added.

The head stack servo unit 20A comprises functional sections as
5 described below.

The read magnetic head 5A reads out magnetic data 4, which are the clock pattern PC 1 and the servo pattern PS1 shown in Fig. 4, from the downward surface of the master disk 2.

10

A section for detecting head position and clock 6A detects synchronization clock CLK, position information of the read magnetic head 5A, and sensed head position R based on the magnetic data 4 that is read out by the read magnetic head 5A. The clock CLK will be
15 described later referring to Fig. 6. The position information of the read magnetic head 5A includes a track address Trk, a sector address Sec, and a precise position PES in the disk radial direction defined within a track. The detected head position R is a precise radial position on the master disk 2 of the read magnetic head 5A and
20 obtained from the above-mentioned position information.

A servo pattern generator 9A generates a servo pattern PS2 of magnetic pattern signals 10 that are written on each surface of the magnetic disks 1 by a servo head 3A corresponding to the surface

based on the position information of the read magnetic head 5A while synchronizing with the clock CLK.

Each of the servo heads 3A writes the servo pattern PS2
5 generated by the servo pattern generator 9A on each surface of the magnetic disks 1.

The rotary positioner 11A rotates and positions the read
magnetic head 5A and the servo heads 3A.
10

A servo compensator 7A determines a servo compensation
quantity to minimize the magnitude of error between a target
position R_s and a detected position R of the read magnetic head 5A
detected by the section 6A for detecting head position and clock.
15

A power amplifier 8A outputs driving electric current for the
rotary positioner 11A based on the servo compensation quantity.

The read magnetic head 5A opposing one surface of the master
20 disk 2 and the servo heads 3A opposing corresponding surface of the magnetic disks 1 are attached on the rotary positioner 11A such that every head can access to the position of the same radius on the corresponding disk surface.

The head stack servo unit 20B also comprises the same functional sections as the head stack servo unit 20A. The head stack servo unit 20B comprises a read magnetic head 5B that reads the magnetic data 4 from the downward surface of the master disk 2, servo heads 3B that write servo patterns PS2 of magnetic pattern signals 10 generated from the magnetic data 4 read out by the read magnetic head 5B, and other means that are not explicitly drawn in Fig. 1.

The read magnetic head 5B opposing one surface of the master disk 2 and the servo heads 3B opposing corresponding surface of the magnetic disks 1 are attached on the rotary positioner 11B such that every head can access to the position of the same radius on the corresponding disk surface.

Fig. 4 shows schematically an example of arrangement of pattern regions on a master disk 2. Fig. 5 shows an example of detailed structure of the patterns on one track of the master disk 2. Fig. 5(a) shows examples of specific structures of the clock pattern PC 1 and the servo pattern PS1. Fig. 5(b) shows waveforms of magnetic data signals 4 read out from the pattern of Fig. 5(a). Of the magnetic data signals 4 in Fig. 5(b), positive pulse is generated at the left edge of the stripe of the pattern of Fig. 5(a), and the negative pulse is generated at the right edge.

As shown in Figs. 4 and 5, every sector of the master disk 2 includes clock patterns PC 1 and servo patterns PS 2 with high precision written by magnetic duplication or a magnetic head. A servo pattern PS 1 of each sector in this example consists of, in the sequence along the scanning direction (a head orbit represented by the dotted line), a pattern PS 11 of a track address (or track number, “Trk” described later), a pattern PS12 of a sector address (or sector number, “Sec” described later), and a pattern PS13 of a precise position (“PES” described later).

The precise position pattern PS13 is a staggered pattern, which is used in most magnetic disk devices. The magnetic pattern of the precise position pattern PS13 uses the change of the amplitude of the signals generated at the A portion or the B portion in Fig. 5(a), depending on the precise orbit of the magnetic head, and determines the precise radial position (referred to simply as precise position) PES (position error signal) within the track. The PES is defined by the following equation.

$$\text{PES} = (\text{amplitude of the signal from A portion} - \text{amplitude of the signal from B portion}) / (\text{amplitude of the signal from A portion} + \text{amplitude of the signal from B portion})$$

The contents written on the master disk 2 are restricted to the

clock patterns PC1 and the servo patterns PS1 for every sector.
 Consequently, the master disk need not provide a data area DTA,
 which is not the case of a magnetic disk 1 in which servo pattern PS2
 is written. As a result, the clock pattern PC1 and the servo pattern
 5 PS1 can be written on the whole surface of a master disk, thereby
 enhancing accuracy of the head position.

Fig. 6 is a timing chart illustrating operation of the writing side
 functional sections of a magnetic data embedding apparatus having
 10 checking function 01. Fig. 6(a) is the same as Fig. 5(b) and shows the
 magnetic data signals 4 from the master disk 2. Fig. 6(b) shows clock
 CLK regenerated from the portion of the clock pattern PC1 in the
 magnetic data signals 4. Fig. 6(c) shows binarized signals of the
 magnetic data signals 4. Fig. 6(d) shows track address Trk, sector
 15 address Sec, and precise position PES that are detected
 (demodulated) from the binarized signals of Fig. 6(c). Fig. 6(e) shows
 magnetic pattern signals 10 being written to the magnetic disk 1.

Operation of the writing side sections in Fig. 1 will be described
 20 referring to Fig. 6. The operation is performed by the head stack
 servo unit 20A or 20B in the range of tracks that is assigned to the
 servo unit 20A or the servo unit 20B respectively. The clock patterns
 PC1 and the servo patterns PS1 written in the master disk 2 are read
 by the read magnetic heads 5A and 5B to detect the actual radial

position R of the read magnetic head 5. The error quantity between the actual position R and the target position R_s is fed back through the servo compensator 7 and the power amplifier 8. With the feed back, the target position is followed up by the settled position of the read magnetic head 5, which is the stabilized position after finish of transient movement of positioning control. Consequently, the radial position over the magnetic disk surface of each servo head 3 that is fixed coaxially with the read magnetic head 5 also follows up the target position. Each of the servo heads 3 writes, in unison, servo pattern PS2 on each surface of the magnetic disks opposed by the servo head following the passage of successive sectors.

In the following up state, the section for detecting head position and clock 6 (specifically, the demodulation circuit 22 (See Fig. 2)) regenerates the clock CLK (Fig. 6(b)) from the clock pattern PC1 in the magnetic data signals 4 (Fig. 6(a)) obtained from the master disk 2. Synchronizing with the clock CLK, the track address $Trki$, the sector address $Seci$, and the precise position $PESi$ (position error signal) shown in Fig. 6(d) are detected from the binary signals (Fig. 6(c)) obtained by binarizing the magnetic data signals 4. The suffix "i" added to the symbol Trk , Sec , or PES represents the sequence of scanning sectors along the track.

In the following up state, the section for detecting head position

and clock 6 (more specifically the head position detection circuit 16 (See Fig. 2)) determines a detected head position R of the settled position of the read magnetic head 5 from a predetermined track pitch W, the track address Trki, the sector address Seci, and the
 5 precise position PESi by the equation below.

Formula 2

The settled position R in a sector address Seci = $\text{Trki} \times W + \text{PESi}$

10 The servo pattern generator 9 generates magnetic pattern signals 10 to be written on the magnetic disks 1 based on the track address Trk, the sector address Sec, and the precise position PES that are detected by the section for detecting head position and clock 6 as described above. The magnetic pattern signals 10 as shown in
 15 Fig. 6(e) consisting of clock patterns ci1, ci2, ci3, ... , track address patterns ti1, ti2, ti3, ... , and precise position patterns si1, si2, si3, ... , and precise position patterns pi1, pi2, pi3, ... are written on the respective area of the servo pattern PS2 of a magnetic disk 1 shown in Fig. 9 through the servo heads 3.

20

The above-described operation is executed by the rotary positioners 11A and 11B sharing the range of tracks to be written by each positioner at the same time. The writing operation is done by N sets of head stack servo units 20 using N servo heads 3 per every one

surface of the magnetic disks 1. Therefore the time for servo writing is reduced to $1/N$.

Next, description is made for the functional sections on checking side in Fig. 1. Fig. 2 shows detailed construction of the functional sections on the checking side of Fig. 1. The checking-dedicated rotary positioner 12 in Figs. 1 and 2 stacks and holds a checking magnetic head 15 and checking magnetic heads 13. The checking magnetic head 15 is a magnetic head that directly accesses the downward surface, in this example, of the master disk 2. The checking magnetic heads 13 are magnetic heads, each of which directly accesses each surface of the M sheets of magnetic disks 1.

The checking magnetic head 15 opposite to the master disk 2 and the checking magnetic heads 13 each opposite to the corresponding surface of the magnetic disks 1 are adjusted to access the same radius on the master disk 2 and the magnetic disks 1 respectively.

Each means in Fig. 2 depicted left side of the checking-dedicated rotary positioner 12 are the circuits involved with the positioner. The section for detecting head position and clock 6V, the servo compensator 7V, and the power amplifier 8V in the checking side respectively serve the same functions of the section for detecting head position and clock 6A, the servo compensator 7A, and the power

amplifier 8A in the writing side.

Thus, the section for detecting head position and clock 6V demodulates magnetic data 4V that is read out from the master disk 2 by the checking magnetic head 15. The modulation is executed through a head amplifier 21 and a demodulation circuit 22. The magnetic data 4V corresponds to the magnetic data 4 that is read out by the read magnetic head 5A. Just as described referring to Fig. 6, the section for detecting head position and clock 6V detects clock CLK for synchronization and position information of the checking magnetic head 15 including a track address Trk, a sector address Sec, and a precise position PES in disk radial direction within the track.

The section for detecting head position and clock 6V further detects, through a containing head position detection circuit 16, a detected head position R that is an actual radial position of the checking magnetic head 15 on the master disk 2 obtained from the above-mentioned position information.

Information detected by the section for detecting head position and clock 6V is given to a CPU 28 that supervises and controls every sections of the checking side. The clock CLK and the position information of the checking magnetic head 15 including the track address Trk, the sector address Sec, and the precise position PES are

given to a comparison logic circuit 23 and a correction servo pattern generator 27.

5 The servo compensator 7V and the power amplifier 8V receives
the error quantity between a target position R_s given by the CPU 28
and a detected position R of the checking magnetic head 15 detected
by the section for detecting head position and clock 6V. The checking-
dedicated rotary positioner 12 is pivoted and controlled by the servo
compensator and the power amplifier so that the settled position R of
10 the checking magnetic head 15 agrees with the target position R_s ,
which means the track position followed up by the checking magnetic
heads 15 and 13 agrees with the track position corresponding to the
target position R_s .

15 Comparison logic circuit 23 compares servo information in the
magnetic data 14 from each surface of the magnetic disks 1 with
servo information in the magnetic data 4V from the master disk 2
under control of the CPU28. The servo information including clock
CLK, track address Trk , sector address Sec , and precise position PES
20 in the magnetic data 14 is read out by the checking magnetic head 13
for each surface (that is, for each channel) of the magnetic disks 1 and
demodulated through head amplifier 21 and demodulation circuit 22
provided for each channel before being fed to the comparison logic
circuit 23. The servo information including clock CLK, track address

Trk, sector address Sec, and precise position PES in the magnetic data 4V is read out by the checking magnetic head 15 and demodulated through head amplifier 21 and demodulation circuit 22 in the section for detecting head position and clock 6V before being
5 fed to the comparison logic circuit 23.

Correction servo pattern generator 27 carries out two functions. One function is to generate a servo pattern on receiving servo information including clock CLK, track address Trk, sector address
10 Sec, and precise position PES that are output from the demodulation circuit 22 of the section for detecting head position and clock 6V at synchronization with the clock CLK. Another function is to switch on or off the output of a servo pattern to a checking magnetic head 13 for each surface (that is, for each channel) of the magnetic disks 1
15 according to a command of the CPU 28. A servo pattern is written to a surface of a magnetic disk 1 that is selected by the on-command.

Examples of operation of the functional sections in the checking side will be described in the following referring to Fig. 2. As
20 described previously, the functional sections in the checking side operates in parallel or simultaneously with the functional sections in the writing side.

The CPU 28 selects a range of tracks on a surface of the magnetic

disks 1 in a sequence predetermined by a means not illustrated in the Fig. 2 and sequentially checks magnetic data written in each track of the selected range of tracks.

5 First, the CPU 28 designates a track corresponding to the turn to be checked in the selected range of tracks in which magnetic data are finished writing. The designation of the track is made in terms of a target head position R_s , to which the checking magnetic head 15 follows up on the surface of the master disk 2. As a result, the
10 checking magnetic head 13 also follows up the same track on the surface of the magnetic disk 1 as the track on the master disk 2.

When the CPU 28 detects that the checking magnetic head 15 is settled at the aimed track by sensing the detected head position R of
15 the checking magnetic head 15 output from the head position detection circuit 16 of the section for head position and clock 6V, the CPU 28 outputs a comparison command $CM1$ for each channel to the comparison logic circuit 23.

20 Receiving the command, the comparison logic circuit 23 compares the servo information from each track output by the demodulation circuit 22 for each surface (that is, for each channel) of the magnetic disks 1 with the servo information from the track in the master disk 2 output by the demodulation circuit 22 of the section for detecting

head position and clock 6V. The servo information includes clock CLK, track address Trk, sector address Sec, and precise position PES.

If error (or inconsistency) is found, the comparison logic circuit 23
5 sends error channel signal 24 that indicates the magnetic disk surface including the error, error track signal 25 that indicates the track (that is followed up) including the error, and error substance signal 26 that indicates substance of the error to the CPU 28. On receiving the error signals 24, 25 and 26, the CPU 28 gives on-off
10 command by channel CM2 to a correction servo pattern generator 27 to turn-on output of a servo pattern to the magnetic disk surface (channel) including the error, thereby the servo pattern is overwritten on the track by the checking magnetic head 13 for the magnetic disk surface (channel).

15

After the overwrite, the CPU 28 gives again a comparison command by channel CM1 to the comparison logic circuit 23, which compares the magnetic data 14 overwritten on the track of the channel in the magnetic disk surface with the magnetic data 4V on
20 the track in the master disk surface to verify proper overwrite.

When the error correction is finished on the track in every channel containing an error, the CPU 28 designates a new target value Rs for the next track to be checked, and the correction

operation proceeds to the next track.

Although the checking-dedicated rotary positioner is only one in the apparatus of Fig. 1, a magnetic data embedding apparatus of the invention may generally have two or more sets of functional sections for checking side containing a checking-dedicated rotary positioner performing as described above.

Fig. 3 shows a structure of a magnetic data embedding apparatus having checking function of second example of embodiment according to the present invention. The essential difference between the magnetic data embedding apparatus having checking function 02 of Fig. 3 and the corresponding apparatus 01 of Fig. 1 exist in that the apparatus of Fig. 3 has only one writing side rotary positioner 11W that is different from the rotary positioner in Fig. 1. The rotary positioner 11W in Fig. 3 has a plurality of (four, in this example) read magnetic heads 51 through 54 that are arranged along nearly radial direction at regular intervals on the master disk 2 and access to the master disk and the same number of servo heads 31 through 34 as the number of the read magnetic heads 5, for each surface of the magnetic disks 1, the servo heads 3 for each magnetic disk surface being arranged along nearly radial direction at regular intervals on the magnetic disk surface and access the magnetic disk surface. The read magnetic heads 5 and the servo heads 3 are integrally stacked

and pivotably supported on the rotary positioner 11W.

The read magnetic head 5i opposing a surface of the master disk 2 and the servo heads 3i opposing respective surface of the magnetic disks 1 are attached on the rotary positioner 11W such that every heads access to the position of the same radius on the master disk 2 and the magnetic disks 1. Wherein "i" is a general suffix to the read magnetic head 5 and the servo heads 3 representative of the specific suffix 1, 2, 3, or 4.

10

In Fig. 3, the section for detecting head position and clock 6W detects the servo information in the magnetic data 4 that is read out by a read magnetic head 5i representative of the read magnetic heads 51 through 54. The servo pattern generator 9W receives the servo information and generates a servo pattern for the servo head 3i representative of the servo heads 31 through 34 provided on each surface of the magnetic disks 1. The servo pattern is written on the respective surface of the magnetic disks 1 by the corresponding servo head 3i.

20

The section for detecting head position and clock 6W detects a detected head position R that is an actual radial position on the master disk 2 of one read magnetic head, for example, read magnetic head 51, selected beforehand from the read magnetic heads 51

through 54.

The rotary positioner 11W is controlled and pivoted through the servo compensator 7W and power amplifier 8W so that the read
5 magnetic head 51 follows up the track corresponding to the target head position Rs.

Write operation of the servo pattern on each magnetic disk surface is executed simultaneously by a plurality of servo heads, four
10 servo heads 31 through 34 in this example.

Although the same number of read magnetic heads 5 as the number of the servo heads 3 is provided in the apparatus of Fig. 3, the number of the read magnetic head 5 can be only one. For
15 example, only the read magnetic head 51 that is used for following-up the track is provided. In that case, a certain means is to be appended that receives the servo information from the actually existing read magnetic head 51 and generates other servo information corresponding to virtual read magnetic heads 52, 53, and 54 by
20 transforming the servo information from the read magnetic head 51. The generated servo information is fed to the servo pattern generator.

Advantageous Effect of the invention

As described so far, a magnetic data embedding apparatus

having checking function according to the present invention
comprises a master magnetic disk and a plurality of object magnetic
disks that are stacked on a shaft of a spindle motor. The apparatus
also comprises one or more read magnetic heads disposed on the
5 master disk and a plurality of servo heads disposed on every surface
of the object disks. The plurality of servo heads write embedded data
based on the magnetic data that is read out from the master disk by
the read magnetic head onto the surface of the object magnetic disk in
parallel while sharing a range of tracks.

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The apparatus further comprises one or defined plurality of
checking magnetic heads disposed on one surface of the master disk
and every surface of the object disks. The checking magnetic head
disposed on the master disk reads the magnetic data on the master
15 disk, and the checking magnetic heads disposed on the object disks
read the embedded data on the corresponding surface of the object
disks, during the servo heads are writing embedded data on the
object disks. The magnetic data that is read out from the master disk
is compared with the embedded data that is read out from the object
20 disks, and errors, if any, are corrected.

Thus, the contents in the master disk can be exactly written on
every object magnetic disks. Moreover, the total time required by the
processes from start of writing to end of checking can be reduced.

Claims

1. A magnetic data embedding apparatus having checking function comprising:

5 a master magnetic disk with magnetic data containing servo information written on at least one surface thereof and a plurality of object magnetic disks in which information is written, the master disk and the object disks being stacked and integrally installed on a shaft of a spindle motor;

10 one or more writing-dedicated rotary positioner disposed around the magnetic disks, and stacking and holding integrally and pivotably one or more read magnetic heads and one or more write magnetic heads, the read magnetic heads reading out the magnetic data on the master disk and one or predetermined number of the write magnetic heads being provided corresponding to each surface of the object
15 magnetic disks for accessing the surface, the rotary positioner being provided so that a plurality of the write magnetic heads exist for accessing every one surface of the object magnetic disks, wherein each of the write magnetic heads belonging to one of the write-dedicated rotary positioners writes the magnetic data that is read out
20 by the read magnetic head disposed on the master magnetic disk or magnetic data made from the magnetic data that is read out from the master disk (hereinafter the two types of magnetic data are collectively referred to as embedded data) onto one surface of the object magnetic disk corresponding to the write magnetic head in

such a way that another write magnetic head corresponding to the same surface of the object magnetic disk and belonging to another writing-dedicated rotary positioner writes the embedded data in parallel while sharing a range of tracks; and

5 the magnetic data embedding apparatus further comprises one or more checking-dedicated rotary positioners disposed around the magnetic disks, and stacking and holding integrally and pivotably a first type checking head and second type checking heads, the first type checking head reading out the magnetic data on the master disk
10 for checking, and each of the second type checking heads being provided corresponding to one surface of the object disks for checking and reading out the embedded data corresponding to the magnetic data that is read out from the master disk by the first type checking head; and

15 the magnetic data embedding apparatus still further comprises, corresponding to each surface of the object disks, a comparison means that compares the embedded data that is read out from the surface of the object disk by the second type checking head with the magnetic data that is read out by the first type checking head simultaneously
20 with writing operation of the write magnetic heads.

2. A magnetic data embedding apparatus having checking function according to claim 1 further comprising an overwriting means that overwrites onto the object disk, the embedded data

corresponding to the magnetic data that is read out by the first type checking head, through the second type checking head disposed on the surface of the object disk in the case the comparison means detects inconsistency, simultaneously with the writing operation of
5 the write magnetic heads.