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TITLE OF INVENTION

MAGNETIC DISK APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a magnetic disk apparatus having servo information on a data surface and, more particularly, to a servo pattern which has a detection sensitivity distribution in a direction of a track as in a magneto-resistive head (hereinbelow, referred to as an MR head) and is suitable for a reproducing head in which a linear reproducing area width is relatively narrower than that of a conventional inductive head.

As a magnetic disk apparatus having a servo function, there are an apparatus having a dedicated servo surface which is used only for a servo, an apparatus having servo information on a surface to record data, and an apparatus using both of the above two types. In the dedicated servo surface, since a width of the servo head is not restricted, a head wider than a track pitch is used in order to realize an improvement of a recording efficiency of a position signal, a reduction of a frequency upon seeking, and an assurance of linearity of the position.

On the other hand, on the data surface, a width of the head is 70% to 80% of the track pitch from a viewpoint of the recording and reproduction of data. Therefore, according to JP-A-4-98661, in order to obtain

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the linearity of the position signal on the data surface, a two-phase pattern whose pattern period is set to a two-track pitch is recorded.

In a sector servo method whereby servo information is interspersed as in the above prior art or the like, in order to decide a position upon seeking, an identification (ID) code called a gray code which differs by only one bit every track is generally used. Since such a track identification (ID) code (Fig. 1, 100) can decide a range of two tracks on a construction, an arbitrary position can be decided when also considering that the two-phase servo pattern is a repeat of the two-track pitch.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a magnetic disk apparatus which can record accurately at a high density without widening a track ID code and a servo area.

Namely, it is an object of the present invention to improve a linearity of positional signals in a magnetic disk apparatus provided with a head having a detection sensitivity in a direction of a track like an MR head, without widening a track ID code and a servo area.

The above conventional technique has been developed in an inductive head in which a recording head is also used as a reproducing head commonly used. A

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width of such a head is equal to or larger than 70% of a track pitch and a detection sensitivity in the track direction of the head is almost constant. In a separating type head in which a recording head and a reproducing head are separated, however, there is also a case where a width of the reproducing head is equal to or less than 70% of the track pitch. In the case where a detection sensitivity has a distribution in the direction of the track width like an MR head, particularly, it has been found that a case where an effective width such that a good linearity for the position is obtained is equal to or less than 1/2 of the track pitch occurs.

Fig. 6 is a model diagram showing a correlation when a magnetic head reads a servo pattern, namely, a position detection pattern. A positional signal is obtained by the difference between the output amplitude of the signal region of the (N+1) track and the output amplitude of the N track region. Fig. 7 shows an example in which the magnetic head shown in Fig. 6 has two kinds of sensitivity distributions as shown in a and b of Fig. 8. Fig. 8 is a diagram showing a case (a) where the sensitivity distribution shows an isosceles triangle and a case (b) where the sensitivity distribution when assuming a conventional head is constant. In case of having the sensitivity distribution of a triangle, consequently, an area in which the sensitivity distribution of only about 30% of the track width regarded to be linear is obtained. The MR head has an intermediate

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sensitivity distribution between the triangle and the shape of the conventional type.

According to the invention, in the disk apparatus of the data surface servo method such as a sector servo method or the like, even in the case where an effective linear reproducing area width of the reproducing head is narrower than the track pitch, a good position detection can be realized without widening the track ID code and the servo area.

A magnetic disk apparatus of the invention comprises: a magnetic disk having servo patterns of a plurality of phase for positioning and a plurality of data tracks; a magneto-resistive head for reading out servo patterns and information recorded on the data tracks; and a positioning mechanism for positioning the magneto-resistive head to a predetermined data track on the basis of the read-out servo pattern information, wherein a width of the servo pattern is equal to or less than that a width of a linear reproducing area of the magneto-resistive effective type head.

Since the magnetic disk apparatus to which the invention is applied has such a construction, a two-phase servo pattern repetitive period can be set to 4/3 (2 × 2/3) of the track pitch or to be equal (2 × 1/2) to the track pitch. Even when the effective linear reproducing width of the reproducing head is narrow, since a state in which an output is not changed for a position change doesn't occur, a position signal can be preferably

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demodulated. Since the width of the track ID code is set to 2/3, 1/3, or 1/2 of the track pitch, the position can be accurately detected by the track ID code and the position signal. Since the width of the track ID code is also set to a value that is integer times as wide as the minimum feeding width upon recording of the servo pattern, a burden upon servo writing by the recording of the ID code doesn't occur as well.

A linearity of the position signal for the track position of the head can be improved and even in the reproducing head whose track width is substantially equal to or less than 1/2 of the track pitch, the position can be decided at an arbitrary position. A stability of the servo system and a positioning at a high precision can be accomplished, thereby realizing a high density of the magnetic disk.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing an embodiment of a servo pattern of the invention;

Fig. 2 is a diagram for explaining a state in which a position signal and a track ID signal are demodulated from the pattern in Fig. 1;

Fig. 3 is a diagram showing another embodiment of the invention;

Fig. 4 is a diagram for explaining a state in which a position signal and a track ID signal in a pattern in Fig. 3 are demodulated;

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Fig. 5 is a schematic constructional diagram of a disk apparatus;

Fig. 6 is a diagram for describing an example of a relation between a moving direction and a pattern;

Fig. 7 is a diagram showing outputs of position signals of two magnetic heads; and

Fig. 8 is a diagram for explaining a detection sensitivity distribution of the magnetic head.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention relates to a positioning of heads in an apparatus of a data surface servo method such as a sector servo method or the like. Embodiments of the invention will now be described hereinbelow with reference to the drawings. Fig. 1 shows two-phase servo patterns 101 of the invention and shows an example in which a pattern period 103 is equal to 4/3 of a track pitch and an ID code width is equal to 2/3 of the track pitch. On the left side, a relative relation of a recording head (HW) and a reproducing head (HR) for a pitch is shown. In order to record such a pattern, a pattern is overwritten by an apparatus generally called a servo track writer while sequentially repeating a recording of the pattern, a feeding of the head, a recording of the pattern, a feeding of the head, ... from the outer rim side or inner rim side. When recording the pattern, since it is executed on the basis of a clock synchronized with a rotation, a phase in the radial direction can be

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matched. In case of Fig. 1, the track ID code 100 and the pattern are simultaneously recorded by feeding at a pitch of 1/3 of the track pitch. A fact that the pattern can be written at the 1/3 pitch is obtained by an effect such that the width of the track ID code 100 is set to be smaller than the track pitch and is matched with the pattern period 103. When the width of the track ID code 100 is set to be equal to the track pitch, the head has to be fed at a 1/6 pitch. In Fig. 1, reference numeral 102 denotes a data area and 104 indicates a track center. 105 denotes a width of a data track. (P) denotes a track pitch. In Fig. 1, A and B denote one phase, and C and D denote another phase.

Fig. 2 shows a situation of relations among the track position, the position signal obtained from the example of Fig. 1, and the track ID code 100. Demodulations of position signals N and Q are obtained as N: [(signal amplitude of an A portion) - (signal amplitude of a B portion)] and Q: [(signal amplitude of a C portion) - (signal amplitude of a D portion)]. A symbol (d) in Fig. 2 denotes a repeatability of the position signal. The track ID signal is a code called a gray code in which a code differs by only one bit between the adjacent tracks. Three codes are allocated every two tracks. Due to the nature of the gray code, either one of the two codes which are neighboring at arbitrary positions can be recognized and a decision range in the ID code is equal to 4/3 of the track pitch. On the other

hand, since the repetitive period of the position signal is equal to 4/3 (d) of the track pitch, the position of the head can be decided by also considering a state of the position signal and Gray code. Such a point results in an effect that is obtained by setting the gray code to be smaller than the track pitch. In the case where the effective track width of the reproducing head that is substantially equal to only about 1/3 of the track pitch is obtained, if the track ID code 100 has a width of 1/3 of the track pitch in the pattern in Fig. 1, then a similar effect is also obtained.

Although the invention relates to the servo pattern 101, a schematic construction and the operation of the disk apparatus when using the pattern in Fig. 1 will now be described.

Fig. 5 is a schematic constructional diagram of a control system of the disk apparatus. When a target track is given from a controller 9, a difference between the present position and a target position is calculated and a head movement (seeking operation) is started. All of controls for the seeking operation and a following operation at the target track are executed by a DSP (digital signal processor) 6. As for a position of a head 10, a read back signal of the MR head is amplified by a reproducing amplifier 2, amplitudes of A, B, C, and D areas are detected as mentioned above by a demodulator 3, and those information is transmitted to the DSP 6 through an A/D converter 5, thereby performing the

position detection [arithmetic operations of (A - B) and (C - D)] described in Fig. 2. The track ID code 100 of the signal after completion of the amplification is converted to the code by a discriminator 4, thereby recognizing the track ID code 100 by the DSP. The DSP detects a position every sector from the track ID signal and the position signal and calculates a signal for a control. As mentioned above, while detecting the head position, the head is moved to the target position and the recording and reproducing operations are performed at the target position. Although the control system of the disk apparatus in Fig. 5 is not directly described in the above explanation, the control system has an HDA (head disk assembly) 1, the discriminator 4, a D/A converter 7, and a power amplifier 8.

In Fig. 2, for example, T0, T1, ... indicate target positions upon recording. Data areas at that time are shown in Fig. 1. The head which is used in the invention is a combination head in which the MR head and a head only for recording are integrated. When the positions of the recording head and the reproducing head (MR head) are deviated, a recording area is also deviated from the track center 104 in accordance with the deviation amount between the reproducing head and the recording head.

As mentioned above, since the track ID code 100 doesn't correspond to a track number in a one-to-one corresponding manner different from the conventional

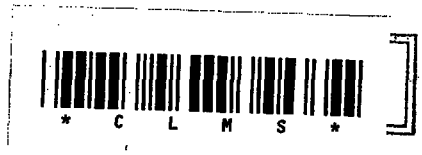
apparatus, the DSP has therein a lookup table 61 of the track ID code 100 for the track. For example, in a T2 track, since the ID code exists at a boundary between 0010 and 0110, an ID code for T2 is set to 0010 or 0110. On the other hand, in case of the track T1, the ID code is set to 0011. The track ID code 100 indicates an area and the position in such an area is decided by the position signal. For example, in T2, a position signal of Q is negative and N indicates a position of O. As mentioned above, when either one of N and Q is used as a control signal, another one specifies an area narrower than the track ID range.

As described above, the magnetic disk apparatus performs a closed loop control. When considering a necessity of the offset operation of the head, it is important to assure the linearity at an arbitrary position of the position signal in order to obtain a necessary positioning precision. In Fig. 2, the linearity at an arbitrary position is accomplished by alternately switching the linear areas of P and Q (bold line portions in Fig. 2). At this time, a using range of each of P and Q is equal to the 1/3 track pitch and there is an effect that is obtained by setting the period of the servo pattern 101 to a value smaller than the track pitch.

According to the invention, the track ID signal and the servo pattern 101 are devised for the head which has the sensitivity distribution in the direction of the

track width and whose linear area is narrower than the track pitch as in the MR head. The invention is not limited to a demodulating circuit, a discriminating method, the number of phases of the patterns, address information, a control technique, and the like.

As for a head having a further narrow track width, a pattern such that the repetitive period of the servo pattern 101 is equal to the track pitch has been devised. Figs. 3 and 4 show diagrams corresponding to Figs. 1 and 2. In this case, the head is fed every 1/4 track pitch and the track ID signal and the servo pattern 101 are recorded. The width of the track ID signal is set to a value that is equal to or less than the 1/2 track pitch width from a viewpoint of the position signal repeatability (d).



WHAT IS CLAIMED IS:

1. A magnetic disk apparatus comprising:

a magnetic disk having servo patterns for positioning of a plurality of phases and a plurality of data tracks;

a magneto-resistive head for reading out said servo patterns and information recorded in said data tracks; and

a positioning mechanism for positioning said magneto-resistive effective type head to a predetermined data track on the basis of said read-out servo pattern information,

wherein a width of said servo pattern is smaller than a width of said data track.

2. An apparatus according to claim 1, wherein the width of said servo pattern is equal to 2/3 of the width of said data track.

3. An apparatus according to claim 1, wherein the width of said servo pattern is equal to 1/2 of the width of said data track.

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