

Description

The present invention relates to a method and an arrangement for detecting error signals in a magnetic disk drive which has a step motor positioning system by means of a magnetic test disk which has a plurality of test tracks in the useful recording area of the magnetic disk, the test signals of the test tracks consisting of adjustment signals which are recorded alternately on either side of the center line of the track and are of the same amplitude, and orientation signals which divide the adjustment signals into groups and whose amplitude differs from that of the adjustment signals, and the test signals being read by means of a head and deviations of the read signals from their set-point position and set-point amplitude being determined and mean values of the deviations being formed, and a magnetic test disk for carrying out the measures.

The quality of the writing and/or reading operation in a disk drive is determined by the positioning of the magnetic head above the disk as they move relative to one another. Particularly in the case of flexible recording media, eg. FlexyDisk®, and their associated write and/or read apparatus, it is important to displace the apparatus, in particular the magnetic head and/or the head adjustment unit, relative to the recording medium. This operation is referred to as track adjustment. Adjustment or CE disks bearing control signals are used for this purpose. For example, according to German Laid-Open Application DOS 2,554,083, the control signals are magnetic flux changes which extend alternately on either side of the center line of the track and which are recorded on a single or not more than a few test tracks expressly only in the central region of the disk. These control signals are adjustment signals which are provided around the test track and are divided into groups by orientation signals which differ in amplitude. By using

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different adjustment signals and orientation signals, the signals can be better distinguished, and represented on an oscilloscope in a simple manner, so that an image of the entire extent of the test track can be produced, thus permitting a simple head position check and head adjustment. In this process, it is not possible to take errors in the motor step into account.

German Laid-Open Application DOS 3,117,911 discloses the use of a test element which has pairs of scanning tracks which are partially or completely adjacent to one another and have a positive or negative track displacement with respect to a normal position of a scanning track. To align the scanning head, the scanning tracks with displacement are read, and as soon as a read error of predetermined magnitude occurs, the mean of the read signals of the pair of scanning tracks is formed and is used to readjust the scanning head. The said publication furthermore states that, in the case of errors of equal magnitude which occur in two non-adjacent scanning tracks, it is possible to form the mean of the read signal of one positive scanning track and of the read signal of the second negative scanning track and to use this mean value to produce a signal for head adjustment. The said publication furthermore discloses that, for a maximum, still processable deviation of the test signals read, the absolute value of the particular positive track displacement and of the particular negative track displacement can be registered, and a mean value constituting a quality parameter can be formed from the two values.

In any case, two error signals are thus averaged, and the mean value is used as a measure of the quality of head positioning. By using the said pairs of scanning tracks, twice the read time is required compared with a track scan. Moreover, the maximum number of test tracks which can be accommodated is only half of all theoretically possible test tracks. By using indistinguishable test signals of the same

5 magnitude in a track, information dependent on angular position, eg. information about eccentricity, can only be obtained by a complicated procedure. When tracks have to be kept free for controlling the test program, it is precisely in this track area that information about deviations is lost.

10 EP-A 106 661 discloses that, for a test disk, it is possible to use different types of test signals which are arranged in test tracks which are distributed between useful track areas in a plurality of different regions and have different numbers and pitches from one another in the regions. The said EP-A furthermore discloses that the track deviation can be used to check, for different motor phases of a step motor, 15 whether radial deviation is due to imprecise rotation of the step motor or to the linear positioner. However, the said EP-A does not disclose the calculation of a mean value calculation [sic] over all test tracks of a test disk for correcting the position of the magnetic head. 20

It is an object of the present invention to provide a method, an arrangement and a magnetic test disk for improved and more comprehensive error signal detection and evaluation, in which the possibilities for measurement and control should be improved, 25 especially with regard to errors in the motor step.

We have found that this object is achieved by the subjects of claims 1 and 8 and 6, respectively.

Depending on the precision required, this makes 30 it possible for error signals to be detected, over the total possible number of test tracks in the maximum case and as a function of particular parameters or in connection with particular error effects in the normal case, and, if required, to be evaluated, for example 35 for a quality check, or, if appropriate, to be used for head adjustment, for example in production of the apparatuses, for adjustment of the head, for example during read operation, or, if required, for theoretical

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correction of read signals (during read operation of the apparatus).

In the claims, the pitches of the test tracks are based on the customary pitch of the useful tracks of the magnetic disks. An important measure in claims 1 and 8 is that, for drives having step motor positioning systems, position, number and pitches of test tracks on the test disk are chosen, and the tracks scanned, so that they are just out of coincidence with the number of motor phases of the step motors. By this means, it is surprisingly easy also to detect the error signals occurring during the individual steps of the step motor, and to avoid suppressing precisely these signals.

For drives having a 4-phase step motor positioning system, the test tracks should have a pitch corresponding to three useful track pitches and accordingly, in a 3-phase step motor positioning system, a pitch corresponding to four useful track pitches.

For each of the step motor positioning systems, a special magnetic test disk is thus required. Advantageously, even for drives having 3-phase or 4-phase step motor positioning systems, the test tracks can have a pitch corresponding to two or three useful track pitches, resulting in a combination magnetic test disk, which then has the test signals in, for example, the second, fifth and seventh track, etc. Appropriate scanning and evaluation according to the method are required.

In practice, it is also advantageous if the test signals are read and processed serially, beginning with a reference test track, in the direction of increasing or decreasing track numbers, after which the test signals of the tracks are read and processed serially in the direction of, respectively, decreasing or increasing track numbers, and the mean values from the two directions are summed to give the overall mean value, and the overall mean value determined is

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subtracted from the track mean value of the reference test track, and the resulting mean value is either used for head position correction on the reference test track or for the direct correction of the write or read signal.

This makes it possible to measure the hysteresis of head positioning by scanning in both directions in relation to a given track, so that the hysteresis effects can be included in the overall mean value.

Furthermore, optimum error compensation is achieved in relation to the available recording area if the reference track is appropriately arranged.

A magnetic test disk for the method according to the invention has test signals which are known per se and which consist of adjustment signals which are recorded alternately on either side of the center line of the track and have the same amplitude and orientation signals which divide the adjustment signals into groups and have a distinguishable amplitude, and is equipped, according to the invention, with a large number of such test tracks, the test tracks having essentially the same test signals being recorded alternately in radial positions which correspond to the positions of useful tracks provided at two and three useful track pitches.

This provides a CE disk (CE = customer engineer) which is simple to manufacture, has a wide range of applications and can be used for 3-phase and 4-phase step motor positioning systems. If, for example, another test disk is provided with the maximum possible number of test tracks with test signals, it is of course also possible to actuate any desired track sequences, for example only every third or fourth track, depending on the step motor just used, for the detection of error signals. Consequently, the disk has a very wide range of uses for checking a very large variety of types of apparatus.

In the magnetic test disk according to the invention, it is also possible for test tracks to have

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three useful track pitches or four useful track pitches each over some or all of the recording area. This provides an individual test disk for apparatuses having 4-phase or 3-phase step motors.

5 In an arrangement for carrying out the method according to the invention, a novel magnetic test disk and a circuit arrangement are provided, the latter containing a control stage for controlling the positioning system in a scanning cycle corresponding to
10 the pitches of the test tracks on the magnetic test disk, and containing, connected to the magnetic head, an evaluation stage, a mean value calculation stage and a storage stage for the error signals, as well as a display and/or write stage for the overall mean value.

15 A circuit arrangement of this type can be produced economically with commercial electronic circuit elements.

Here, the arrangement may have a magnetic test disk with test tracks at a pitch corresponding to 2 and
20 3 useful track pitches or to 3 or 4 useful track pitches, with a corresponding scanning cycle which is produced by the control stage. In another practical embodiment, a control stage is provided which controls the positioning system so that the head system,
25 starting from the reference test track, scans the test tracks in the direction of increasing or decreasing track numbers and, after reversing direction, then scans the test tracks in the direction of, respectively, decreasing or increasing track numbers. This
30 makes the circuit arrangement suitable for measuring the positioning hysteresis without a substantially more complicated circuit being required.

In another embodiment of the circuit arrangement, a control stage is provided which, after
35 determining the overall mean value, guides the head system, via the positioning system, to the reference test track, and the track mean value is either determined once again by means of the mean value calculation stage or is taken from the storage stage and, after

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subsequent subtraction of the overall mean value from the track mean value, the resulting mean value is displayed by means of the display or write stage and/or is made available for automatic head adjustment.

5 This makes it possible for the head system to be adjusted in a simple manner manually or by direct correction of write or read signals in the storage stage or by means of an automatic head adjusting apparatus.

10 The method and the arrangement, and the magnetic test disk for this purpose, are further described below for an embodiment which is shown in the drawing.

In the drawing,

15 Figure 1 shows schematically a test disk with a disk drive according to the invention,

Figure 2 shows geometric serial test signals in a test track or disk,

20 Figure 3 shows a group of test signals between the dashed lines 20 and 21 in Figure 2,

Figure 4 shows the curve for the measured deviations for a large number of test tracks on a disk, and

25 Figure 5 shows a novel circuit arrangement for carrying out the method.

30 The adjustment and control system 19 essentially consists of a drive shaft 16 (shown schematically), a magnetic test disk 15, and a head positioning system 11 with a spindle 12 and a head 13. The head 13 can be moved on the spindle 12 in the directions indicated by the double arrow d. 14 denotes a central circular track on the disk 15. Arrow a indicates the direction of rotation of the drive shaft 16. The part 17 of the drive shaft, which protrudes through the disk 15, is slightly conical in order to facilitate centering of the disk 15.

35 Figure 2 shows an embodiment of geometrically serially arranged test signals which extend from the center line 18 of the track, eg. the said track 14. b

denotes the track width. The test signals consist of a large number of magnetic flux changes. In Figure 2, a total of six groups of signals (I to VI) is recognizable, each of the groups having a length c . Each group consists of three orientation signals 1 to 3 which are arranged symmetrically on the center line 18 of the track, and of six adjustment signals, 4, 5 and 8, 9 which extend alternately on either side of the center line 18. The amplitudes of the orientation and adjustment signals are advantageously chosen so that they are readily distinguishable. This can be achieved in a simple manner, for example, if the orientation signals 1 to 3 consist of alternating signals of different frequency, eg. of $2f$, $1f$, $2f$. Here, the frequency f is the recording frequency of the data system. In the case of the floppy disk system, this frequency f is 250 kHz at 360 rpm. In this case, the adjustment signals advantageously have the frequency one f .

Figure 3 shows an oscillogram of the signals between the dashed lines 20 and 21, which include the orientation signals 1 to 3 and adjustment signals 4, 5 and 8, 9 of group II, as well as the orientation signals 1 to 3 of group IV. The azimuth signals 6 and 7 are not shown in this oscillogram. As indicated in the drawing, the read voltage U scanned by the magnetic head 13 is plotted in the y direction as a function of the time t in the x direction.

The orientation signals 1 to 3 are distinguishable as read voltages U_{2fc} , U_{1fc} and U_{2fc} , the voltage U_{1fc} having a larger amplitude than U_{2fc} . In the Example shown, the amplitudes of the read voltages U_{1fi} and U_{1fo} are the same. Since the amplitudes of the read voltages produced by the magnetic head 13 depend on the position of the head relative to the test track 14, the fact that the read voltages U_{1fi} and U_{1fo} have the same amplitude shows that

- a) the head and disk adjustment is correct,
- b) the test disk is located absolutely centrically on the drive shaft,



- c) the disk or the floppy disk has an accurate circular shape,
- d) the drive shaft is exactly centric and
- e) the magnetic head is functioning properly.

5 Where Ulfi and Ulfo differ in amplitude, a positive difference indicates that the test disk 15 is displaced inward toward the axis, while a negative difference indicates a displacement in the opposite direction, ie. outward.

10 The track displacement s from its set-point position is given by the equation

15 wherein the track displacement s and the track width s of the read head are both expressed in . By adjusting the head on the spindle 12, it is possible to correct, or at least to compensate, such track/head adjustment errors with great accuracy. Such compensation is advantageously accomplished by adjusting the difference in
20 amplitude of the read voltages of signal group n (where n is one of the groups I to VI) and of the voltages of the group $n + 3$ so that they are equal, this being achieved by adjusting the head. In this way, radial
25 eccentricity can at least be reduced to a minimum. In this example of compensating for eccentricity, the number of signal groups has been assumed to be 6. For a different number N of signal groups, in the case of track displacement in the signal group n the same
30 displacement should be introduced into signal group $n + \frac{N}{2}$ in order to reduce the radial error.

35 The frequencies $1f$ and $2f$ may be used, but it is possible in general to use all frequencies suitable for the scanning speeds in question or for the signal lengths. The frequency $2f$ of the read voltages U_{2fc} may advantageously be used for adjusting the azimuth angle of the head. However, better adjustment of the azimuth angle is achieved by the measures described below.

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5 In Figure 2, two azimuth signals 6 and 7 for controlling the azimuth angle of the head H are provided, for example between the adjustment signals 5 and 8. These azimuth signals 6 and 7 can be provided in any of the groups I-VI, but are preferably provided only in a single track, for example in track 1 of a test disk.

The test signals, orientation signals, adjustment signals and azimuth signals are referred to below by the general term test signals TS.

10 The test disk 15 described can be provided with a large number of test tracks of this type. Compared with conventional floppy disks, which have 37 or 74 useful tracks, either every third or every fourth useful track, or every second and subsequent third useful track, can be provided with the test signals. In principle, however, the number of test tracks provided can be determined by the maximum amplitudes of the test signals, for example 2 useful track widths and in addition a suitably broad border extending to the neighboring test tracks. To permit broad application and to increase the accuracy of adjustment and control, it is advantageous to record, and to use, the maximum number of test tracks for the particular purposes.

25 A combination test disk may also have test tracks distributed alternately in every second and in every subsequent third useful track, over the entire recording area. In this embodiment, test tracks are recorded in, for example, the second, fifth, seventh (etc.) useful track. In this case, of course, scanning is carried out at a pitch of only every second or only every third useful track in testing an apparatus, depending on whether a 3-phase or 4-phase step motor is present in the positioning system 11.

35 The error signals are detected as follows: the scanning head H, which may be a single head or a head in a double-head arrangement, is adjusted to any predetermined test track, and the test signals (orientation signals and adjustment signals) are read. A particularly suitable reference track S_R is useful track

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No. 16 or 32 (for 48 or 96 tpi floppy disks), since this track lies roughly in the center, relative to the recording capacity of the areas to the outer edge and to the inner edge. The orientation and adjustment signals are transmitted as sine waves by head H, and are converted to d.c. signals in the read amplifier by means of a point-contact rectifier AM. The orientation signals are separated via a filter F which responds to the frequency $2f$, and are fed directly to the microprocessor MP, where they are used for synchronization to eliminate fluctuations in rotary speed. The adjustment signals are also fed to the microprocessor, via an A/D converter. The microprocessor MP determines the signal amplitudes, forms the mean values, feeds individual signals or averaged signals to the EPROM or RAM memories, and furthermore serves, via the line L to the drive interface SS, for controlling the drive functions necessary for error signal detection. The microprocessor MP is also connected to a display or write unit and/or an automatic head adjustment unit D and an input unit, for example a keyboard T. The entire circuit arrangement enclosed within the dashed line in the drawing is denoted by 25.

After determination of the adjustment signal amplitude and synchronization by the orientation signals, the microprocessor MP first forms the mean value of the individual adjustment signals (signal mean value), then the mean value of the adjustment signals of each of the groups I-VI (group mean value) and thereafter the mean value for the entire test track (track mean value).

Before the mean values can be calculated, the track error (TE) on the one hand and the eccentricity error (ES) on the other hand are invariably determined via the instantaneous amplitudes of the adjustment signals, and are stored in the RAM memory.

When error signal detection on reference track S_R is complete, the next test track is approached, eg. useful track 19, and the process is repeated until the

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last test track, eg. useful track 35 or 74, has been scanned and the measured values stored or the mean values of all test tracks calculated.

(Note: for the purposes of the present invention, mean value is the arithmetic mean>)

For 37 useful tracks, there are six track mean values (No. 16, 20, ..., 36) with the 4-track pattern and eight track mean values (No. 16, 19, .. 34, 37) with the 3-track pattern, from which the overall mean value IM can be formed. These numbers apply to single-direction tests.

As stated above, it is also possible for the useful tracks 2, 5, 7, 10, 12, 15, 17, 20, 22, 25, 27, 30, 32, 35 and 37, ie. every 2nd and every subsequent 3rd track, to be provided with test signals TS, so that 8 or 7 measured values are then available in the case of 37 useful tracks.

It is also possible to scan the test tracks S in the area of useful track No. 0 to No. 16 in order to obtain the complete distribution of the error signals TE (cf. the left-hand S curve in Figure 4). The arrow A indicates the direction from which the test tracks are approached, as described above. In this case, for example, approach is from the outer track S_x toward the inner track S_1 , via the reference track S_R .

The solid curve S is therefore formed by detecting the TE signals. The adjacent dashed S curves represent the distribution of the eccentricity values (ES).

After reaching the innermost test track S_1 in the method described above, the direction of track approach is changed from A to B (see arrow) and this process of error signal detection is repeated until the outermost test track is reached. Preferably, the overall mean value is formed from the error signals TE and TE' of both track approach directions, so that advantageously the positioning hysteresis is also measured and can be evaluated. The right-hand, parallel S curve, comprising the TE' signals of the solid S

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curve and the ES distribution curves, is obtained at a distance HY away. This two-direction test method also gives twice the number of measured deviations.

5 In a double-head drive, it is also possible to determine the displacement 0 between the heads on the reference track S_R , and to use it to determine the maximum error signal TE_{max} .

10 The overall mean value obtained via an approach direction A or B or approach directions A and B can be represented as a straight line IM (actual mean value). The distance TE between this straight line and the track mean value for reference track S_R corresponds to the difference between the overall mean value IM and the track mean value. The scanning head H over the
15 reference track S_R must be displaced by the distance TE in order to minimize the error signals over the entire recording area, ie. in order to optimize the recording and playback quality of the apparatus. In the drawing, this corresponds to the parallel straight line
20 OM. Relative to this, the positive maximum PMX (lower right) is obtained, the double-head displacement 0 as well as the maximum eccentricity value E being taken into account; the negative maximum (NMX) appears at the top left, the sum of the maximum TE value (TE_{max}) being
25 generated. The positive and negative TE_{max} values thus differ very greatly in magnitude.

These maximum values TE_{max} (positive and negative), the value TE and, where relevant, the hysteresis value HY can be fed for display to the stage
30 D, for example a visual display unit, and constitute quality criteria for the particular apparatus tested. The value TE furthermore serves for manual head adjustment, or is converted, via an automatic means, to a motor-driven head adjustment, which is then available
35 as a facility at D. However, it is also possible, without carrying out head adjustment, to determine each TE value, based on the average mean value OM for each test track, and to make an appropriate correction to the write or read signal by computational and electronic

means in order to compensate or minimize these errors either directly during the write operation or during the read operation.

5 In Figure 5, the control commands for carrying out the method according to the invention are contained in the erasable memory EPROM and can thus easily be altered. The input unit T can be in the form of a keyboard, and is used to start the measuring or adjustment process.

10 Using the novel method and the arrangement for this purpose, it was possible in practice to increase the compatibility of the apparatuses by about 20%, to reduce the rejection rate during manufacture by about 15%, and to minimize servicing.



Patent Claims

1. A method for detecting error signals in a magnetic disk drive (19) which has a step motor positioning system (11) by means of a magnetic test disk (15) which has a plurality of test tracks (5) [sic] in the useful recording area of the magnetic disk, the test signals (TS) of the test tracks (S) consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line (18) of the track and are of the same amplitude, and of orientation signals (4,5 and 8,9) which divide the adjustment signals (1 to 3) into groups (I to VI) and whose amplitude differs from that of the adjustment signals, and the test signals (TS) being read by means of a head and deviations of the read signals from their set-point position and set-point amplitude being determined and mean values of the deviations being formed, wherein a plurality of test tracks (S) is provided, the test tracks (TS) being recorded in radial positions corresponding to the useful tracks, and the pitches of the test tracks being greater than or equal to the pitch of the two useful tracks, wherein the multiple of the useful track pitch used at least partially does not correspond to the number of the motor phases of the step motor, wherein within each group (I to VI) of the read adjustment signals (1 to 3), their position and amplitude are determined, a group mean value of each individual group and a track mean value of each individual test track (S) being formed, and wherein, over the large number of test tracks, the track mean values are used to calculate mean values of the magnetic test disk, which are used for head position correction on a reference test track (S_R) or for the direct correction of the write or read signal.
2. A method as claimed in claim 1, wherein, for drives having a 3-phase or 4-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to two or three useful track pitches.



(S)

3. A method as claimed in claim 1, wherein for drives having a 4-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to three useful track pitches.

4. A method as claimed in claim 1, wherein, for drives having a 3-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to four useful track pitches.

5. A method as claimed in any of claims 1 to 4, wherein the test signals (TS) are read and processed serially, beginning with a reference test track (S_R), in the direction of increasing or decreasing track numbers, after which the test signals (TS) of the test tracks are read and processed serially in the direction of, respectively, decreasing or increasing track numbers, and the mean values from the two directions are summed to give the overall mean value (IM), and the overall mean value determined is subtracted from the track mean value of the reference test track (S_R), and the resulting mean value is used for head position correction on the reference test track (S_R) or for the direct correction of the write or read signal.

6. A magnetic test disk for a method as claimed in claim 2, having a plurality of test tracks in the useful recording area of the magnetic disk, the test signals consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line of the track and are of the same amplitude, and orientation signals (4,5 and 8,9) which divide the adjustment signals into groups (I to VI) and have a different amplitude, wherein a large number of test tracks (S) are distributed uniformly over the recording area and have essentially the same test signals (TS), which are recorded alternately in radial positions which correspond to the positions of useful tracks provided at two and three useful track pitches.

7. A magnetic test disk for a method as claimed in either of claims 3 or 4, having a plurality of test tracks in the useful recording area of the magnetic



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disk, the test signals consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line of the track and are of the same amplitude and orientation signals (4,5 and 8,9) which divide the adjustment signals into groups (I to VI) and have a different amplitude, which comprises a large number of test tracks (S) which have essentially the same test signals (TS) and are recorded in radial positions which correspond to the positions of useful tracks provided at three or four useful track pitches.

8. An arrangement for carrying out a method for detecting error signals in a magnetic disk drive (19) which has a step motor positioning system (11) by means of a magnetic test disk (15) which has a plurality of test tracks (5) [sic] in the useful recording area of the magnetic disk, the test signals (TS) of the test tracks (S) consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line (18) of the track and are of the same amplitude, and orientation signals (4,5 and 8,9) which divide the adjustment signals (1 to 3) into groups (I to VI) and whose amplitude differs from that of the adjustment signals, and the test signals (TS) being read by means of a head and deviations of the read signals from their set-point position and set-point amplitude being determined and mean values of the deviations being formed, which comprises a magnetic test disk which is provided with a plurality of test tracks (S), the test tracks (TS) being recorded in radial positions corresponding to the useful tracks, the pitches of the test tracks being greater than or equal to the pitch of the two useful tracks and the multiple of the useful track pitch used at least partially not corresponding to the number of the motor phases of the step motor, and a head by means of which the test signals are read and a circuit arrangement which contains a control stage for controlling the head positioning system in a pitch [sic] cycle corresponding to the pitches of the test tracks, and which contains,



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connected to the magnetic head, an evaluation stage, a mean value calculation stage and a storage stage for the error signals, as well as a display and/or write stage for the overall mean value, by means of which, within each group (I to VI) of the read adjustment signals (1 to 3), their position and amplitude are determined for forming a group mean value of each individual group and a track mean value of each individual test track (S) and for determining mean values of the magnetic test disk from the track mean values over the large number of test tracks, the mean values of the magnetic test disk being stored, displayed and/or written for head position correction on a reference test track (S_R) or for the direct correction of the write or read signal.

9. An arrangement as claimed in claim 8, wherein the test tracks have a pitch corresponding to two and three useful track pitches, and the scanning cycle of the control stage for the head positioning system is a corresponding 2-track and 3-track cycle.

10. An arrangement as claimed in claim 8, wherein the test tracks of the magnetic test disk all have either three useful track pitches or four useful track pitches, and the scanning cycle of the control stage for the head positioning system is a corresponding 3-track cycle or 4-track cycle, respectively.

11. An arrangement as claimed in claim 8, which comprises a control stage which controls the positioning system so that the head system, starting from the reference test track (S_R), scans the test tracks (S) in the direction of increasing or decreasing track numbers and, after reversing direction, then scans the test tracks (S) in the direction of, respectively, decreasing or increasing track numbers.

12. An arrangement as claimed in claims 8 and 11, which comprises a control stage which, after determining the overall mean value (IM), guides the head system, via the positioning system, to the reference test track (S_R), and the track mean value is either



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determined once again by means of the mean value calculation stage or is taken from the storage stage and, after subsequent subtraction of the overall mean value from the track mean value, the resulting mean value is displayed by means of the display or write stage and/or is made available, in the storage stage, for automatic head adjustment or direct correction of the write or read signal.



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As printed

Claims

- 5 1. A method for detecting error signals in a magnetic disk drive (19) which has a step motor positioning system (11) by means of a magnetic test disk (15) which has a plurality of test tracks (S) in the useful recording area of the magnetic disk, the test signals (TS) of the test tracks (S) consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line (18) of the track and are of the same amplitude, and of orientation signals (4, 5 and 8, 9) which divide the adjustment signals (1 to 3) into groups (I to VI) and whose amplitude differs from that of the adjustment signals, and the test signals (TS) being read by means of a head and deviations of the read signals from their set-point position and set-point amplitude being determined and mean values of the deviations being formed, wherein a plurality of test tracks (S) is provided, the test tracks (TS) being recorded in radial positions corresponding to the useful tracks, and the pitches of the test tracks being greater than or equal to the pitch of two useful tracks, wherein the multiple of the useful track pitch used at least partially does not correspond to the number of motor phases of the step motor, wherein within each group (I to VI) of the read adjustment signals (1 to 3), their position and amplitude are determined, a group mean value of each individual group and a track mean value of each individual test track (S) being formed, and wherein, over the large number of test tracks, the track mean values are used to calculate mean values of the magnetic test disk, which are used for head position correction on a reference test track (S_R) or for the direct correction of the write or read signal.
2. A method as claimed in claim 1, wherein, for drives having a 3-phase or 4-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to two or three useful track pitches.
3. A method as claimed in claim 1, wherein, for drives having a 4-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to three useful track pitches.
4. A method as claimed in claim 1, wherein, for drives having a 3-phase step motor positioning system (11), the test tracks (S) have a pitch corresponding to four useful track pitches.
5. A method as claimed in any of claims 1 to 4, wherein the test signals (TS) are read and processed serially, beginning with a reference test track (S_R), in the direction of increasing or decreasing test track numbers, after which the test signals (TS) of the test tracks are read and processed serially in the direction of, respectively, decreasing or increasing track numbers, and the mean values from the two directions are summed to give the overall mean value (IM), and the overall mean value determined is subtracted from the track mean value of the reference test track (S_R), and the resulting mean value is used for head position correction on the reference test track (S_R) or for the direct correction of the write or read signal.
- 35 6. A magnetic test disk for a method as claimed in claim 2, having a plurality of test tracks in the useful recording area of the magnetic disk, the test signals consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line of the track and have the same amplitude and orientation signals (4, 5 and 8, 9) which divide the adjustment signals into groups (I to VI) and have a different amplitude, wherein a large number of test tracks (S) are distributed uniformly over the recording area and have essentially the same test signals (TS), which are recorded alternately in radial positions which correspond to the positions of useful tracks provided at two and three useful track pitches.
- 40 7. A magnetic test disk for a method as claimed in either of claims 3 or 4, having a plurality of test tracks in the useful recording area of the magnetic disk, the test signals consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line of the track and have the same amplitude and orientation signals (4, 5 and 8, 9) which divide the adjustment signals into groups (I to VI) and have a different amplitude, which comprises a large number of test tracks (S) which have essentially the same test signals (TS) and are recorded in radial positions which correspond to the positions of useful tracks provided at three or four useful track pitches.
- 45 8. An arrangement for carrying out a method for detecting error signals in a magnetic disk drive (19) which has a step motor positioning system (11) by means of a magnetic test disk (15) which has a plurality of test tracks (S) in the useful recording area of the magnetic disk, the test signals (TS) of the test tracks (S) consisting of adjustment signals (1 to 3) which are recorded alternately on either side of the center line (18) of the track and are of the same amplitude, and of orientation signals (4, 5 and 8, 9) which divide the adjustment signals (1 to 3) into groups (I to VI) and whose amplitude differs from that of the adjustment signals, and the test signals (TS) being read by means of a head and deviations of the read signals from their set-point position and set-point amplitude being determined and mean values of the deviations being formed, which comprises a magnetic test disk which is provided with a large number of test tracks (S), the test tracks (TS) being recorded in radial positions corresponding to the useful tracks, the pitches of the test tracks being greater than or equal to the pitch of the two useful tracks and the multiple of the useful track pitch used at least partially not corresponding to the number of the motor phases of the step motor, and a head by means of which the test signals are read and a circuit arrangement which contains a control stage for controlling the head positioning system in a scanning cycle corresponding to the pitches of the test tracks, and which contains, connected to the magnetic head, an evaluation stage, a mean value calculation stage and a storage stage for the error signals, as well as a display and/or write stage for the overall mean value, by means of which, within each group (I to VI) of the read adjustment
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signals (1- to 3), their position and amplitude are determined for forming a group mean value of each individual group and a track mean value of each individual test track (S) and for determining mean values of the magnetic test disk from the track mean values over the large number of test tracks, the mean values of the magnetic test disk being stored, displayed and/or written for head position correction on a

5 reference test track (S_R) or for direct correction of the write or read signal.

9. Arrangement as claimed in claim 8, wherein the test tracks have a pitch corresponding to two and three useful track pitches, and the scanning cycle of the control stage for the head positioning system is a corresponding 2-track and 3-track cycle.

10. An arrangement as claimed in claim 8, wherein the test tracks of the magnetic test disk all have either three useful track pitches or four useful track pitches, and the scanning cycle of the control stage for the head positioning system is a corresponding 3-track cycle or 4-track cycle, respectively.

11. An arrangement as claimed in claim 8, which comprises a control stage which controls the positioning system so that the head system, starting from the reference test track (S_R), scans the test tracks (S) in the direction of increasing or decreasing track numbers and, after reversing direction, then scans the test tracks (S) in the direction of, respectively, decreasing or increasing track numbers.

12. An arrangement as claimed in claims 8 and 11, which comprises a control stage which, after determining the overall mean value (IM), guides the head system, via the positioning system, to the reference test track (S_R), and the track mean value is either determined once again by means of the mean value calculation stage or is taken from the storage stage and, after subsequent subtraction of the overall mean value from the track mean value, the resulting mean value is displayed by means of the display or write stage and/or is made available, in the storage stage, for automatic head adjustment or direct correction of the write or read signal.

25 Revendications

1. Procédé pour l'établissement d'un signal d'erreur dans un mécanisme de disques magnétiques (19) muni d'un système de positionnement à moteur pas-à-pas (11), au moyen d'un disque magnétique d'essai (15) qui possède une pluralité de pistes d'essai (S) dans la zone d'enregistrement utilisable du disque magnétique, les signaux d'essai (TS) des pistes d'essai (S) étant constitués d'impulsions de position (1 à 3) de mêmes amplitudes, enregistrées alternativement de chaque côté de l'axe de piste (18) et d'impulsions d'orientation (4, 5 et 8, 9) d'amplitudes différentes de celles des impulsions de position et séparant celles-ci en groupes (I à IV) et les signaux d'essai (TS) étant lus au moyen d'une tête magnétique et les écarts des signaux de lecture étant déterminés par rapport à leur position et leur amplitude de consigne et les valeurs moyennes des écarts étant formées, caractérisé par le fait qu'il est prévu une pluralité de pistes d'essai (S), les signaux d'essai (TS) étant enregistrés en positions radiales correspondant aux pistes utiles, les écartements entre les pistes d'essai étant supérieurs ou égaux à l'écartement entre deux pistes utiles, les multiples d'écartement entre pistes utiles qui sont appliqués ne concordant pas, au moins en partie, avec le nombre de phases de moteurs pas-à-pas, qu'à l'intérieur de chaque groupe (I à VI) des impulsions de position (1 à 3) lues, on détermine leur position et leur amplitude, en formant une valeur moyenne de groupe de chaque groupe particulier et une valeur moyenne de piste de chaque piste d'essai (S) particulière, et que, sur la pluralité des pistes d'essai, sont formées, à partir des moyennes de piste, des moyennes du disque magnétique d'essai, qui sont utilisées pour la correction de position de la tête magnétique sur une piste d'essai de référence (S_R) ou pour la correction directe du signal d'enregistrement ou de lecture.

2. Procédé selon la revendication 1, caractérisé par le fait que pour les mécanismes à système de positionnement (11) par moteur pas-à-pas à 3 ou 4 phases, les pistes d'essai (S) sont écartées de deux et trois écarts entre pistes utiles.

3. Procédé selon la revendication 1, caractérisé par le fait que pour les mécanismes à système de positionnement (11) par moteur pas-à-pas à 4 phases, les pistes d'essai (S) sont écartées de trois écarts entre pistes utiles.

4. Procédé selon la revendication 1, caractérisé par le fait que pour les mécanismes à système de positionnement (11) par moteur pas-à-pas à 3 phases, les pistes d'essai (S) sont écartées de quatre écarts entre pistes utiles.

5. Procédé selon l'une des revendications 1 à 4, caractérisé par le fait que les signaux d'essai (TS) sont lus et traités en série suivant les numéros de pistes croissants ou décroissants en partant d'une piste d'essai de référence (S_R), puis les signaux d'essai (TS) des pistes d'essai sont lus et traités en série suivant les numéros de piste décroissants ou croissants et les deux moyennes sont additionnées pour donner la moyenne d'ensemble (IM), et après détermination de cette moyenne d'ensemble celle-ci est soustraite de la moyenne de piste de la piste d'essai de référence (S_R) et la moyenne résultante est utilisée pour la correction de position de tête sur la piste d'essai de référence (S_R) ou pour la correction directe du signal d'enregistrement ou de lecture.

6. Disque magnétique d'essai pour un procédé selon la revendication 2, muni d'une pluralité de pistes d'essai dans la zone d'enregistrement utilisable du disque magnétique, les signaux d'essai étant constitués d'impulsions de position (1 à 3) de mêmes amplitudes, enregistrées alternativement de chaque



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côté de l'axe de piste (18) et d'impulsions d'orientation (4, 5 et 8, 9) d'amplitudes différentes de celles des impulsions de position et séparant celles-ci en groupes (I à VI), caractérisé par le fait que, répartie uniformément sur la zone d'enregistrement, est prévue une pluralité de pistes d'essai (S) avec des signaux d'essai (TS) sensiblement les mêmes, qui sont enregistrés alternativement en positions radiales, qui correspondent aux positions de pistes utiles prévues à deux et trois écartements de pistes utiles.

7. Disque magnétique pour un procédé selon les revendications 3 ou 4, muni d'une pluralité de pistes d'essai dans la zone d'enregistrement utilisable du disque magnétique, les signaux d'essai étant constitués d'impulsions de position (1 à 3) de mêmes amplitudes, enregistrées alternativement de chaque côté de l'axe de piste (18) et d'impulsions d'orientation (4, 5 et 8, 9) d'amplitudes différentes de celles des impulsions de position et séparant celles-ci en groupes (I à VI), caractérisé par une pluralité de pistes d'essai (S) qui présentent des signaux d'essai (TS) sensiblement les mêmes et qui sont enregistrés en positions radiales correspondant aux positions des pistes utiles prévues à trois ou quatre écartements de pistes utiles.

8. Agencement pour la mise en œuvre d'un procédé pour l'établissement d'un signal d'erreur dans un mécanisme de disques magnétiques (19) muni d'un système de positionnement à moteur pas-à-pas (11), au moyen d'un disque magnétique d'essai (15) qui possède une pluralité de pistes d'essai (S) dans la zone d'enregistrement utilisable du disque magnétique les signaux d'essai (TS) des pistes d'essai (S) étant constitués d'impulsions de position (1 à 3) de mêmes amplitudes, enregistrées alternativement de chaque côté de l'axe de piste (18) et d'impulsions d'orientation (4, 5 et 8, 9) d'amplitudes différentes de celles des impulsions de position et séparant celles-ci en groupes (I à VI), et les signaux d'essai (TS) étant lus au moyen d'une tête magnétique et les écarts des signaux de lecture étant déterminés par rapport à leur position et leur amplitude de consigne et les valeurs moyennes des écarts étant formées, caractérisé par un disque magnétique d'essai qui est pourvu d'une pluralité de pistes d'essai (S), les signaux d'essai (TS) étant enregistrés en positions radiales correspondant aux pistes utiles, les écartements entre les pistes d'essai étant supérieurs ou égaux à l'écartement entre deux pistes utiles, les multiples d'écartement entre pistes utiles qui sont appliqués ne concordant pas, au moins en partie, avec le nombre de phases de moteur pas-à-pas et par une tête magnétique avec laquelle sont lus les signaux d'essai et par un circuit comportant un étage de commande pour la commande du système de positionnement de la tête magnétique dans un cycle d'écartement correspondant aux écartements entre les pistes d'essai et qui comporte un étage d'interprétation raccordé à la tête magnétique, un étage d'établissement de valeur moyenne et un étage de mémoire pour les signaux d'erreur, ainsi qu'un étage indicateur et/ou d'enregistrement pour la valeur moyenne d'ensemble, grâce à quoi, à l'intérieur de chaque groupe (I à VI) des impulsions de position (1 à 3) sont déterminées leur position et leur amplitude, pour former une moyenne de groupe pour chaque groupe particulier et une moyenne de piste pour chaque piste d'essai (S) particulier, et pour déterminer des valeurs moyennes du disque magnétique d'essai à partir des moyennes de piste, sur la pluralité des pistes d'essai, les moyennes du disque magnétique d'essai étant mémorisées, indiquées et/ou enregistrées pour la correction de position de la tête magnétique sur une piste d'essai de référence (S_a) ou pour la correction directe du signal d'enregistrement ou de lecture.

9. Agencement selon la revendication 8, caractérisé par le fait que les pistes d'essai sont à un écartement de deux ou trois écartements de pistes utiles et le cycle d'exploration de l'étage de commande pour le système de positionnement de tête magnétique est un cycle 3 correspondant à piste 2 et piste 3.

10. Agencement selon la revendication 8, caractérisé par le fait que les pistes d'essai du disque magnétique d'essai présentent uniformément soit trois écartements de pistes utiles soit quatre écartements de pistes utiles et le cycle d'exploitation de l'étage de commande pour le système de positionnement de tête magnétique est un cycle correspondant à piste 3 ou piste 4.

11. Agencement selon la revendication 8, caractérisé par un étage de commande qui commande le système de positionnement de manière que le système de tête magnétique explore les pistes d'essai (S) selon les numéros de piste croissants ou décroissants, en commençant par la piste d'essai de référence (S_a) puis, après inversion de sens, explore les pistes d'essai (S) suivant les numéros de piste décroissants ou croissants.

12. Agencement selon les revendications 8 et 11, caractérisé par un étage de commande qui, après établissement de la valeur moyenne d'ensemble (IM), commande le système de tête magnétique, par l'intermédiaire du système de positionnement, sur la piste d'essai de référence (S_a) et la moyenne de piste, au moyen de l'étage de formation de valeur moyenne, est, soit déterminée encore une fois, soit prélevée de l'étage de mémorisation, et, après soustractions suivantes de la moyenne d'ensemble de la moyenne de piste, la moyenne résultante, est indiquée au moyen de l'étage indicateur ou enregistreur et/ou rendre disponible dans l'étage de mémorisation pour réglage automatique de la tête ou correction directe du signal d'enregistrement ou de lecture.