Description

Background of the Invention

When using separate heads for reading and writing data in a disk file, such as magneto-resistive (MR) heads for reading and inductive heads for writing, it is difficult to position alternately the read head to the track during reading, and the write head to the track during writing. This is not a serious problem when the misalignment between the read head and the write head is much smaller than the overall track misregistration and the track pitch of the system. However, in high track density applications or in systems with rotary actuators, where the read to write misalignment is no longer insignificant when compared to the track pitch, one is faced with two choices: (1) increase the degree of write-wide and read-narrow, i.e., (a) increase the write track width which results in lower track density, or (b) reduce read track width which results in lower signal-to-noise ratio -- either of which results in performance degradation; or (2) devise a servo scheme to position the write head on the track for writing and the read head on the track for reading.

One arrangement heretofore proposed to independently position the read and the write heads to the track is described in the October 1978 issue of the IBM Technical Disclosure Bulletin at page 2005. When positioning the head for writing, the write head is used to read the sector servo information. When positioning the head for reading, the read head is used to read the sector servo information.

Another arrangement proposed to solve this misalignment problem is described in the June 1974 issue of the IBM Technical Disclosure Bulletin, at page 217. It requires reading a calibration pattern with both the read head and write head, and using that calibration pattern to measure the misalignment between the read and write heads. The misalignment is then stored and used by the head positioning servo system to offset the head position during read to compensate for the misregistration between the read and write elements. This approach requires the write head to read servo type information only during the calibration phase, which can be done in the factory, but requires a write head designed to read the calibration pattern and electronic circuitry that will permit reading with the write head.

In both approaches, the write head not only has to write data but also has to read the servo information. This requirement put significant limitations on applicability of the scheme, especially in high track density applications with MR-read/inductive-write heads. First, inductive heads have lower signal-to-noise ratio; and although this problem can be remedied to some degree with more turns in the coil, it adds process complexity and cost to head fabrication. Second, an inductive head optimized for writing will most likely have difficulty reading data at data frequency; and although servo information can be written at lower data rate, it adds to the real estate taken up for servo. Third, this arrangement requires one additional read channel for the write head. Finally, and also most importantly, thin film inductive heads with very narrow pole widths are likely to have domain problems for reading purposes, rendering them unusable for high track density applications.

US Patent 4,575,775 describes a sector servo pattern for a multiple element head, wherein each element reads its own sector servo information and reads and writes data onto its specific tracks.

There is a need to compensate for misalignment of separate read and write heads when reading and writing data on a magnetic disk whether such misalignment varies due to the arcuate direction of access with a rotary actuator or is of essentially constant magnitude due to variations in the relative positions at which the heads are mounted during manufacture of a radial linear actuator.

Disclosure of the Invention

Accordingly, the present invention provides a method of positioning separate but linked read and write heads relative to data tracks on a disk, the read and write heads being misaligned with each other radially of the disk at least at certain track positions, the method including the steps of: generating for each track on the disk two sets of servo information, the two sets for each track being radially displaced with respect to each other by a distance equal to the respective misalignment between the read and write heads at that respective track; and using one of said sets during writing of data and the other during reading of data to align the write head over a selected data track during writing and align the read head over said selected data track during reading of data, thereby compensating for misalignment of said heads.

The invention also provides a disk file having dedicated but linked read and write heads respectively for reading and writing data on a disk, means for positioning the heads relative to the same data tracks on the disk, the heads being misaligned with each other radially of the disk when positioned on at least certain of the tracks; characterised by:- two sets of servo information written on the disk to define the data track positions, the two sets for each track being radially displaced with respect to each other by a distance equal to the respective misalignment between the read and write heads at that respective track position.

Brief Description of the Drawings

Figs. 1A and 1B are schematic diagrams depicting one prior art approach to the positioning of

separate write and read heads.

Figs. 2A and 2B are schematic diagrams depicting how two sets of servo information are successively generated according to the method of the invention;

Fig. 3 is a schematic diagram depicting how a read head is aligned with the first set of servo information of Fig 2 while a write head is aligned with the second set of servo information during writing of data;

Fig. 4 is a schematic diagram depicting how the read head is aligned with the second set of servo information during reading of data; and

Fig. 5 is a schematic diagram of portions of a disk file according to the invention.

Description of Prior Art

As illustrated in Fig. 1A during writing of data on a selected track of a magnetic disk (not shown), write head 10 is aligned with and reads the servo information 11 on the track; and read head 12 is misaligned a distance d from the write head and servo information. As illustrated in Fig. 1B, during reading of data, read head 12 is aligned with and reads the servo information 11, while the write head 10 is now misaligned the distance d from the read head and servo information.

Description of Preferred Embodiment

As illustrated in Fig. 2A, while overlapped but misaligned write head 20 and read head 21 are travelling in the direction of arrow 22, the write head is used to write and generate a first set 23 of sector servo information at a selected track. Read head 21 will be misaligned the distance d from the write head and set 23 at this time.

A second set 24 of sector servo information is now generated, as illustrated in Fig. 2B, for that same selected track by aligning read head 21 with servo information set 23 and then writing the second servo information set 24 with write head 20.

The steps just described are repeated in sequence for each respective track of the disk, so as to generate two sets of servo information unique to each track. Note that if the heads are mounted on a rotary actuator, the misalignment distance d will vary from track to track because of the non-radial (i.e., arcuate) path traversed by the actuator and hence the heads during track access.

As illustrated in Fig. 3, data is written at a selected track by aligning read head 21 to the first set 23 of servo information and then writing data on that track with write head 20. Since the data thus written is aligned with the second set 24, misalignment d of the heads will be automatically compensated for when the data is subsequently read in the following manner.

As illustrated in Fig. 4, data is read at a selected track by aligning read head 21 to the second set 24 of servo information and then reading the data with the read head. At this time, write head 20 will be misaligned distance d from read head 21 and second set 24 of servo information.

Fig. 5 depicts a sector servo control apparatus for implementing the invention. This apparatus comprises a dual element head structure 30 comprising a read head 31 and a write head 32. As illustrated, head structure 30 is mounted on a rotary actuator 33 that moves the head structure 30 in an arcuate path to a selected track on magnetic or optical disk 29. An external position reference sensor 34 provides position information to servo control electronic circuitry 35 for actuator 33 which controls position of head structure 30 using a voice coil motor 36. Write circuits 37 provide signals to the write head 32 to write and to thereby generate the first set 23 of servo information on the disk. Next, read head electronic circuitry 38 processes the signals from read head 31 to provide position information to actuator servo control circuitry 35. This is used to position read head 31 over the first set 23 of servo information while writing and hence generating the second set 24 of servo information. The foregoing operation is controlled by timing and control electronic circuitry 39. Amplifiers 40, 41 amplify the write signal and read signal, respectively.

As earlier noted, the distance d will vary track to track if the heads are mounted on a rotary actuator. However, the invention is also of value when the heads are mounted on a radial linear actuator, especially in high track density applications. In this latter case, variations in distance d can occur from actuator to actuator due to the relative positioning of the heads during the manufacturing process; however, the misalignment distance d will be substantially constant for any given radial linear actuator.

The invention has been successfully implemented using a magneto-resistive read head and an inductive write head mounted on a rotary actuator. The invention can also be implemented with any sector servo arrangement, provided two sets of servo information are generated -- one for writing and one for reading.

Although the servo arrangement herein disclosed requires additional storage capacity to provide the two sets of servo information, it desirably permits achievement of higher track densities by eliminating design concerns over misalignment of read and write heads.

Claims

1. A method of positioning separate but linked read and write heads (31,32) relative to data tracks on

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separate write and read heads.

Figs. 2A and 2B are schematic diagrams depicting how two sets of servo information are successively generated according to the method of the invention;

Fig. 3 is a schematic diagram depicting how a read head is aligned with the first set of servo information of Fig 2 while a write head is aligned with the second set of servo information during writing of data;

Fig. 4 is a schematic diagram depicting how the read head is aligned with the second set of servo information during reading of data; and

Fig. 5 is a schematic diagram of portions of a disk file according to the invention.

Description of Prior Art

As illustrated in Fig. 1A during writing of data on a selected track of a magnetic disk (not shown), write head 10 is aligned with and reads the servo information 11 on the track; and read head 12 is misaligned a distance d from the write head and servo information. As illustrated in Fig. 1B, during reading of data, read head 12 is aligned with and reads the servo information 11, while the write head 10 is now misaligned the distance d from the read head and servo information.

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The steps just described are repeated in sequence for each respective track of the disk, so as to generate two sets of servo information unique to each track. Note that if the heads are mounted on a rotary actuator, the misalignment distance d will vary from track to track because of the non-radial (i.e., arcuate) path traversed by the actuator and hence the heads during track access.

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As illustrated in Fig. 4, data is read at a selected track by aligning read head 21 to the second set 24 of servo information and then reading the data with the read head. At this time, write head 20 will be misaligned distance d from read head 21 and second set 24 of servo information.

Fig. 5 depicts a sector servo control apparatus for implementing the invention. This apparatus comprises a dual element head structure 30 comprising a read head 31 and a write head 32. As illustrated, head structure 30 is mounted on a rotary actuator 33 that moves the head structure 30 in an arcuate path to a selected track on magnetic or optical disk 29. An external position reference sensor 34 provides position information to servo control electronic circuitry 35 for actuator 33 which controls position of head structure 30 using a voice coil motor 36. Write circuits 37 provide signals to the write head 32 to write and to thereby generate the first set 23 of servo information on the disk. Next, read head electronic circuitry 38 processes the signals from read head 31 to provide position information to actuator servo control circuitry 35. This is used to position read head 31 over the first set 23 of servo information while writing and hence generating the second set 24 of servo information. The foregoing operation is controlled by timing and control electronic circuitry 39. Amplifiers 40, 41 amplify the write signal and read signal, respectively.

As earlier noted, the distance d will vary track to track if the heads are mounted on a rotary actuator. However, the invention is also of value when the heads are mounted on a radial linear actuator, especially in high track density applications. In this latter case, variations in distance d can occur from actuator to actuator due to the relative positioning of the heads during the manufacturing process; however, the misalignment distance d will be substantially constant for any given radial linear actuator.

The invention has been successfully implemented using a magneto-resistive read head and an inductive write head mounted on a rotary actuator. The invention can also be implemented with any sector servo arrangement, provided two sets of servo information are generated -- one for writing and one for reading.

Although the servo arrangement herein disclosed requires additional storage capacity to provide the two sets of servo information, it desirably permits achievement of higher track densities by eliminating design concerns over misalignment of read and write heads.

Claims

1. A method of positioning separate but linked read and write heads (31,32) relative to data tracks on

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a disk (29), the read and write heads being misaligned with each other radially of the disk at least at certain track positions, the method characterised by the steps of:

generating for each track on the disk two sets (23,24) of servo information, the two sets for each track being radially displaced with respect to each other by a distance equal to the respective misalignment between the read and write heads at that respective track; and

using one of said sets during writing of data and the other during reading of data to align the write head over a selected data track during writing and align the read head over said selected data track during reading of data, thereby compensating for misalignment of said heads.

2. A method as claimed in claim 1, in which the generating step includes:

writing said one set of servo information with the write head; and

writing said other set with the write head while the read head is aligned with said one set.

3. A disk file having dedicated but linked read and write heads (31,32) respectively for reading and writing data on a disk (29), means (33) for positioning the heads relative to the same data tracks on the disk, the heads being misaligned with each other radially of the disk when positioned on at least certain of the tracks; characterised by:-

two sets (23,24) of servo information written on the disk to define the data track positions, the two sets for each track being radially displaced with respect to each other by a distance equal to the respective misalignment between the read and write heads at that respective track position.

4. A disk file as claimed in claim 3, in which the disk is magnetic, said read head is a magneto-resistive head and said write head is an inductive head.

5. A disk file as claimed in either claim 3 or claim 4 in which the positioning means comprises a rotary actuator, so that the misalignment between the read and write heads varies from track to track, the displacement between said two sets of servo information varying correspondingly.

6. A disk file as claimed in either claim 3 or claim 4 in which the positioning means comprises a radial linear actuator so that the misalignment between the read and write heads is constant, the displacement between the two sets of servo information also being constant.

7. A disk file as claimed in any one of claims 3 to 6 in which the read and write heads are mounted in a unitary dual head structure.

8. A disk file as claimed in claim 5 in which the read and write heads are disposed longitudinally of the actuator.

Patentansprüche

1. Ein Verfahren, um separate, jedoch verbundene Lese- und Aufnahmeköpfe (31,32) im Verhältnis zu den Datenspuren auf einer Platte (29) zu positionieren, indem wenigstens in bestimmten Spurpositionen Lesekopf gegenüber Aufnahmekopf radial zur Platte versetzt wird, wobei das Verfahren durch die Schritte gekennzeichnet wird:
auf jeder Spur auf der Platte zwei Sätze (23,24) von Servo-Informationen zu erzeugen, indem die beiden Sätze für jede Spur in bezug zueinander um einen gleichen Abstand zu dem jeweiligen Versatz zwischen Lese- und Aufnahmekopf in der jeweiligen Spur radial verschoben werden; und
einen dieser Sätze während der Aufnahme von Daten und den anderen während des Lesens von Daten zu benutzen, um den Aufnahmekopf über einer ausgewählten Datenspur während der Aufnahme auszurichten und den Lesekopf über der ausgewählten Datenspur während des Lesens von Daten auszurichten, indem dadurch der Versatz dieser Köpfe kompensiert wird.

2. Ein Verfahren wie in Anspruch 1 angemeldet, in dem der Schritt zur Erzeugung enthält:
das Schreiben des einen Satzes von Servo-Informationen mit dem Aufnahmekopf; und
das Schreiben des anderen Satzes mit dem Aufnahmekopf, während der Lesekopf mit dem einen Satz ausgerichtet wird.

3. Ein Plattenantrieb mit bestimmtem, jedoch verbundenem Lese- beziehungsweise Aufnahmekopf (31,32), um Daten auf eine Platte (29) zu lesen und zu schreiben, Mittel (33), um die Köpfe in bezug auf die gleichen Datenspuren auf der Platte zu positionieren, wobei die Köpfe gegenseitig radial zur Platte versetzt werden, wenn die Köpfe wenigstens in bestimmten Spuren positioniert werden; dadurch gekennzeichnet, daß:
zwei Sätze (23,24) von Servo-Informationen zur Definition der Datenspurpositionen in die Platte geschrieben werden, indem die beiden Sätze für jede Spur in bezug zueinander um einen gleichen Abstand zu dem jeweiligen Versatz zwischem Lese- und Aufnahmekopf in der jeweiligen Spurposition radial verschoben werden.

4. Ein Plattenantrieb wie in Anspruch 3 angemeldet, in dem die Platte magnetisch, der Lesekopf ein Magneto-Widerstandskopf und der Aufnahmekopf ein induktiver Kopf ist.

5. Ein Plattenantrieb wie entweder in Anspruch 3 oder Anspruch 4 angemeldet, in dem die Positioniermittel einen rotierenden Aktuator enthalten, so daß der Versatz zwischen Lese- und Aufnahmekopf von Spur zu Spur schwankt und dementsprechend die Verschiebung zwischen den beiden Sätzen von Servo-Informationen schwankt.

6. Ein Plattenantrieb wie entweder in Anspruch 3 oder Anspruch 4 angemeldet, in dem die Positioniermittel einen radial-linearen Aktuator enthalten, so daß der Versatz zwischen Lese- und Aufnahmekopf konstant ist und die Verschiebung zwischen den beiden Sätzen von Servo-Informationen ebenfalls konstant ist.

7. Ein Plattenantrieb wie in irgendeinem der Ansprüche 3 bis 6 angemeldet, in dem Lese- und Aufnahmekopf in einer einheitlichen Doppelkopfstruktur montiert sind.

8. Ein Plattenantrieb wie in Anspruch 5 angemeldet, in dem Lese- und Aufnahmekopf längs zu dem Aktuator angeordnet sind.

Revendications

1. Procédé pour positionner des têtes de lecture et d'écriture distinctes mais solidaires (31, 32) par rapport à des pistes de données sur un disque (29), les dites têtes de lecture et d'écriture étant en désaxage entre elles radialement au disque sur au moins certaines positions de piste, le procédé étant caractérisé par les étapes consistant à :
générer pour chaque piste du disque deux ensembles (23, 24) d'informations d'asservissement, les deux ensembles pour chaque piste étant décalés radialement l'un par rapport à l'autre d'une distance égale au désaxage respectif entre les têtes de lecture et d'écriture sur cette piste respective; et
utiliser l'un des dits ensembles au cours de l'écriture de données et l'autre au cours de la lecture de données pour aligner le tête d'écriture sur une piste de données sélectionnée au cours de l'écriture de données et la tête de lecture sur ladite piste de données sélectionnée au cours de la lecture de données, pour compenser ainsi le désaxage entre les dites têtes

2. Procédé selon la revendication 1, dans lequel l'étape de génération comprend les étapes consistant à :
écrire l'un des dits ensembles d'informations d'asservissement avec la tête d'écriture; et
écrire l'autre des dits ensembles d'informations d'asservissement avec la tête d'écriture pendant que la tête de lecture est alignée avec ledit premier ensemble.

3. Fichier sur disque ayant des têtes de lecture et d'écriture spécialisées mais solidaires (31, 32) pour écrire et lire respectivement des données sur un disque (29), comprenant un dispositif (33) pour positionner les têtes par rapport aux pistes de données du disque, les têtes étant en désaxage entre elles radialement au disque lorsqu'elles sont positionnées sur au moins certaines des dites pistes, caractérisé par :
deux ensembles (23, 24) d'informations d'asservissement écrites sur le disque pour définir les positions des pistes de données, les deux ensembles pour chaque piste étant décalés l'un par rapport à l'autre d'une distance égale au désaxage respectif entre les têtes de lecture et d'écriture sur cette position de piste respective.

4. Fichier sur disque selon la revendication 3, dans lequel le disque est magnétique, ladite tête de lecture est une tête magnétorésistive et ladite tête d'écriture est une tête inductive.

5. Fichier sur disque selon la revendication 3 ou 4, dans lequel le dispositif de positionnement comprend un actionneur rotatif, de sorte que le désaxage entre les têtes de lecture et d'écriture varie d'une piste à l'autre, le décalage entre les dits deux ensembles d'informations d'asservissement variant proportionnellement.

6. Fichier sur disque selon la revendication 3 ou 4, dans lequel le dispositif de positionnement comprend un actionneur à translation radiale, de sorte que le désaxage entre les têtes de lecture et d'écriture est constant, le décalage entre les deux ensembles d'informations d'asservissement étant également constant.

7. Fichier sur disque selon l'une quelconque des revendications 3 à 6, dans lequel les têtes de lecture et d'écriture sont montées dans une structure unitaire à deux têtes.

8. Fichier sur disque selon la revendication 5, dans lequel les têtes de lecture et d'écriture sont disposées longitudinalement par rapport à l'actionneur.