Description

Magnetic data storage or recording apparatus typically uses a magnetic storage or recording medium in which data is stored in tracks. Moreover, the trend in computer technology is to increase the amount and density of data stored in such media. This generally involves narrower and closer tracks to increase the density of tracks per inch (TPI). For example, high density storage disks typically have track densities of about 500 to 1000 TPI.

As track density increases, a narrow transducer or head is required for writing/reading the data in tracks and, futhermore, more precise tracking is needed to insure writing/reading of the desired track so that data can be retrieved correctly. To this end, it is vital that the transducer be located accurately on a selected track.

The art has recognized the need for accurate head tracking and various approaches to this end, including servo controlled head positioning systems, have been used with varying degrees of success.

In particular, it is important not only that the tracking technique be reliable but it is also highly desirable that it be easy and inexpensive to implement and also that it be able to handle the inevitable slight variations that are usual in data storage apparatus and media commercially available at reasonable prices.

In U.S. patent application Serial No. 898,527, there is a described magnetic data storage apparatus in which the storage medium, typically a disk, includes a pattern of optical tracks over which is superimposed the magnetic data. The optical pattern is formed on a transparent base material and comprises a large number of lines arranged in concentric rings that are essentially opaque to light radiation, spaced apart by gaps that are essentially transparent to light radiation. The base is overcoated, generally on both sides, with a layer of magnetic recording medium that is thin enough to be substantially light transparent.

The optical pattern in the disk typically is used as a Ronchi grating adapted for cooperation with a reference grating located outside the disk on a radially displaceable read/write transducer assembly that is part of the drive associated with the disk, when the disk is in an operative position. Illumination, provided from a light source on one side of the disk, passes through both the Ronchi grating on the disk and the reference grating on the head assembly and is detected.

Movement of the reference grating with the head relative to the Ronchi grating modulates the intensity of the light reaching the detector in a substantially linear manner from track to track so as to provide head position error signal information to a servo system used to position the read/write transducer in the desired alignment with a chosen track on the disk.

The particular apparatus described, while useful, has room for improvement in performance. In particular, for controlling tracking of magnetic heads on opposite sides of a double sided disk it utilizes a common illumination source along with a common detector that are relatively far apart and so subject to a variety of problems, such as parallax. Moreover, because a common detector is used for tracking control of both sides of the disk, it is not possible to optimize the spatial relationship of the various elements involved in the tracking for each of the two sides being tracked, such as having the detector on the same side as the active read/write head.

This is a particular problem when a replaceable storage medium, such as a flexible or floppy disk, is employed because one of the heads in the drive generally is mounted for movement toward and away from the opposite head between a confronting operative position and a spaced apart loading position to allow disk insertion and withdrawal. Also, the moveable head is typically mounted on a gimbal arrangement which allows it to better orient itself with respect to the flexible recording medium. Given the movable nature of the gimbal mounted head, its magnetic transducer can not be maintained in fixed spaced relation to a single common detector thereby resulting in incorrect error position signals.

Additionally, the signal-to-noise ratio of the relatively simple detection arrangement used in that system has room for improvement. In particular, it would be useful to have a detection scheme that is less vulnerable to roughness and non-uniformities along the edges of the optical pattern, is able to average detection over relatively large areas to minimize the effect of localized non-uniformities or clumping of particles in the thin magnetic recording layers, is able to adjust for some offset between the magnetic center and optical center of the circular tracks, and is more amenable to adjustment to compensate for variations that may exist among different disks, transducers, and disk drives as the result of being manufactured at different times.

Various other improvements are possible as will appear from the subsequent detailed description of the invention taken in conjunction with the drawings.

Summary of the Invention

The present invention provides a number of features for improvement of the magnetic data storage apparatus described in the earlier application. It should be noted that some of the features are

independent of others of the features so that a particular embodiment of the invention need not include all of the novel features to be described.

A first feature of the invention is the inclusion in a head carriage assembly of a pair integrated heads each including its own read and/or write transducer, light source and detector and adapted for use to provide tracking control on a respective one of the two opposite sides of the disk or other storage medium. This arrangement substantially relaxes head alignment tolerances especially in the case of a flexible disk drive wherein the spaced relation between the transducer and its corresponding detector is fixed by this integrated head construction.

Additionally, another feature of the invention is that each of two separate detectors includes a photosensitive sensor which is designed to serve as the reference grating in its optical system to avoid the need for a separate or discrete reference grating. This integration of functions has the advantage of eliminating any gap between the reference grating and the sensor,thereby eliminating potential optical interference and diffraction.

Additionally, in its preferred form, the detector is a quadrature detector comprising four photocells interleaved to provide a desired spatial phase difference between cells that is useful for reducing common mode noise and averaging out minor local deviations from uniformity in the recording layers . Additionally, the quadrature detector introduces an additional degree of freedom that can be used to compensate for variations from disk to disk or drive to drive.

In particular, the preferred detector of an illustrative embodiment includes a plurality of elongated active photosensitive strip elements, typically sixteen, equally divided among four, uniformly interleaved but separate, photocells in which the width of each element is equal to the width of each of the opaque lines forming the optical grating in the disk and also of the transparent gaps between the opaque lines. Moreover, the elements are spaced apart by opaque optical stops one half the width of each of the elements. By properly interconnecting the four photocells in a novel circuit arrangement that includes several parameters that are variable, there results a detector that can be used to improve the signal-to-noise ratio, to average out non-uniformities in the recording layers, and to compensate for variations in different drives and different disks.

Moreover, one embodiment of the invention involves providing optical systems for each side of the disk in which collimated illumination from a quasi-point or quasi-line source or array of line sources causes the media grating to self image by diffraction on the reference grating to reduce the effect of any necessary separation of the two gratings.

Accordingly, magnetic storage apparatus in accordance with preferred embodiments of the invention are configured for use with a double sided storage medium, such as a disk, having a light transmissive support for first and second light transmissive recording layers on its opposite surfaces and including intermediate between the two storage layers an optical grating made up of opaque lines and light transmissive gaps of substantially equal widths.

Additionally, the head carriage assembly, that is mounted for radial movement relative to the disk, supports in addition to a separate read/write transducers adjacent to each of the two storage layers, first and second light sources on respective opposite sides of the disk, and first and second detectors aligned with the respective sources on opposite sides of the disk for defining a pair of separate light paths through the disk. Each of the detectors preferably includes a sensor formed by an integral multiple of four interleaved photosensitive elements appropriately spaced to serve as a reference grating for cooperation with the optical grating in the disk. Moreover, the photosensitive elements are interconnected to form four separate photocells which in turn are then interconnected in a circuit for developing a servo signal indicative of the position of the active head relative to a selected track. Additionally, the circuit includes parameters that may be varied for calibration purposes to compensate for variations from disk to disk.

Additionally, the efficiency, and hence accuracy, of the servo system can be further enhanced by the inclusion of novel illumination sources to cause the optical grating in the disk to self image by diffraction onto the reference grating formed at the detector. In one embodiment, the illumination arrangement uses an extended area light-emitting diode source with appropriate optics to form therefrom a line grating whose multiple beams self image the disk grating on the detector grating constructively. Alternatively, a laser diode or other type of light-emitting diodes may be used as the light source.

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

FIG. 1 shows in simplified form the basic elements of a head carriage assembly with a disk inserted therein in accordance with an illustrative embodiment of the invention;

FIG. 2 shows in simplified form the same elements shown in FIG.1 with the carriage config-

ured for disk insertion and withdrawal;

FIG. 3 shows in cross section a double sided magnetic disk including an optical grating for use in the assembly shown in FIG. 1;

FIG. 4 shows the layout of the various photosensitive elements of a sensor that also serve as a reference grating at the detector for cooperation with the optical grating in the disk, in an assembly of the kind shown in FIG.'s 1 and 2;

FIG. 5 shows a plan view of silicon device that forms a sensor of the kind included in FIG. 4;

FIG. 6 shows schematically a quadrature detector circuit using the sensor of FIG. 4 to provide a servo signal from the light incident on the sensor;

FIG. 7 shows a novel form of illumination source suitable for use in the assembly shown in FIG.'s 1 and 2;

FIG. 8 shows in functional block diagram form a data storage apparatus embodying the present invention;

FIG. 9 is a perspective view of an integrated head stucture in accordance with the present invention;

FIG. 10a is a plan view of a diffraction lens used for collimating purposes in an a head embodying the present invention; and

FIG. 10b is a schematic representation of the cross-section of the lens of FIG. 10a.

It is to be understood that the various figures are not to scale unless indicated.

Detailed Description

Referring now to FIG. 1, there is shown schematically the basic elements of a head carriage assembly 100, in accordance with an illustrative embodiment of the invention, operatively positioned with respect to a double sided magnetic disk 12 rotatably supported on a drive spindle 13. The details of disk 12 are shown in FIG. 3. Head carriage assembly 100 and spindle 13 form part of a magnetic data storage apparatus or flexible magnetic disk drive embodying the present invention. Assembly 100 is also shown in FIG. 2 in its inoperative disk insertion or withdrawal position with the magnetic disk 12 removed.

As shown in FIG. 3, the disk 12 comprises a base 20, formed by a support member 21 chosen to be transparent to the radiation of the light or illumination source to be used for tracking control and an optical grating 22 formed on or in member 21 by relatively opaque concentric rings 22A, alternating with relatively transparent gaps or rings 22B, with respect to the radiation to be used for tracking control. These rings also serve as optical tracks to define the position of tracks in which information is to be stored in magnetic data recording or storage layers 24 and 25 which are located on opposite surfaces of the base member 20. These layers 24 and 25 are very thin compared to the thickness of base 20 so as to substantially transparent, or at least highly transmissive, with respect to the radiation used for tracking control.

While the inventive concepts of this invention may be used to advantage in storage apparatus or disk drives using different types of storage media, e.g. magnetic (flexible or rigid), optical or magneto-optical, the illustrated embodiment is directed to a flexible magnetic disk drive as will become more apparent. In this case disk 20 is a flexible or floppy, high density magnetic recording disk contained in a cassette housing or jacket (not shown) and having a plastic (e.g. Mylar) support 21 on which the optical grating pattern 22 is photographically or otherwise formed. Typically, support member 21 is about .003 inches (0.08 mm) thick and the thin magnetic recording layers 24 and 25 have a thickness of about 1 micron (0.001 mm).

The composition of layers 24 and 25 typically includes gamma ferric oxide or barium ferrite particles dispersed in a polymeric binder with the latter particle being preferred for higher density data storage. While this type of disk is transmissive to visible light for head position control purposes , it is even more transmissive to light in the infra-red portion of the spectrum and therefore the use of infra-red light is preferable.

With reference again to FIG.'s 1 and 2, the head carriage assembly 100 includes in operative relationship with the disk 12, a radially movable head support 14 comprising support members 14A and 14B which supports a pair of complementary integrated magnetic and optical heads 0 and 1, respectively, on opposite sides of the disk in spaced operative alignment with each other. Each of the heads 0 and 1 includes a body portion 10, suggested by the dotted lines for visual clarity, which supports and positions the elements of the head including a magnetic read/ write transducer 15; a light source 16 and an aligned collimating lens 17; and a light detector 18. It should be understood that the inclusion of collimating lens 17 is preferable for both improving collimation and concentrating light flux, but its use in the integrated head is not absolutely necessary.

Each transducer 15 includes a body portion 15a mounting a ferrite core 15b having a flux gap therein at the face of the head confronting the respective adjacent magnetic layer on the disk. The head is adapted to fly over the recording surface in air bearing relation thereto and the body 15a typically includes a slot 15c in the face for selectively reducing pressure in the air bearing for flying height control as is well known in the art. The complimentary arrangement of the transducers 15

in the opposed heads 0 and 1 provides a radial offset of the respective cores 15b which is desirable to prevent data print-through of the opposite recording surface as is known in the art.

The detector 18 is preferably located on one side of the transducer 15 and the light source 16 and associated lens 17 (if used) are located on the other side, although both of these element could be grouped together on one or the other side. Also it is preferable for tracking purposes to position the detector on the side of the transducer body where it is closest to the core 15b so that the detector "looks at " a portion of the disk that is as close a possible to the magnetic flux gap. While it would be ideal for the detector to look at exactly the same portion of the disk as the transducer gap, physically these two elements cannot occupy the same space and thus are radially offset as shown. However, by locating the detector 18 as close to the transducer core 15b as practical, this offset is minimized.

The arrangement of the detectors 18 and the light sources 16 on the opposed heads 0 and 1 is complimentary so that the light source 16 on head 0 is positioned to direct light output therefrom through the disk 12, for modulation by grating pattern 22, onto the aligned detector 18 of head 1. Similarly the light source 16 on head 1 directs its light output through the disk onto the aligned detector 18 on head 0.

The details of the light sources and the detectors will be discussed in detail hereinafter.

Support member 14A is shown schematically to be pivotally coupled to support member 14B at hinge point 19. This allows support member 14A to rotate to the raised inoperative position shown in FIG. 2 where heads 0 and 1 are spaced further apart to facilitate disk insertion and withdrawal. As a disk 12 is inserted into the drive and is seated on spindle 13, support member 14A automatically returns to the position shown in FIG. 1. As a disk 12 is removed, support member 14A automatically returns to the position shown in FIG. 2.

Support members 14A and 14B need not be coupled together, but it is desirable that one of same should be designed to capable of being moved relative to the other so as to facilitate easy and safe removal and insertion of a disk 12. Mechanisms for effecting such movement of the head carriage supports are well known in the art and need not be discussed further herein.

Because the illustrated head carriage assembly 100 is adapted for use with a flexible disk 12, the upper head 1 is preferably suspended from a gimbal arrangement 26 mounted on the underside of pivoting support 14a which allows head 1 to pivot somewhat about its pitch and roll axis to maintain its face to face alignment with head 1 in the presence of a portion of the spinning flexible disk 12 therebetween that may assume a slight curved shape depending on head penetration and loading. Also, the gimbal mounting is provided to compensate for transient distortions of the flexible disk 12 resulting from disk vibration in response to rotation. Such gimbal arrangements are well known in the art and need not be discussed further herein.

In the U.S. application Serial No. 898,527, optical servo head position control for double sided recording is accomplished with a single optical system comprising a light source on one side of the disk and a detector incorporating the reference grating on the opposite side of the disk. While this system is workable, it presents a difficult and costly manufacturing problem relating to the very tight mechanical tolerances required for mounting the two magnetic transducers and the single detector on the carriage so the detector is in a non-varying predetermined radially spaced relation with respect to each of the magnetic transducers on opposite sides if the disk. The tolerance problem is even more sever in the case of a flexible disk drive because one transducer must be gimbal mounted on the arm of the carriage that pivots or moves relative to the other thus providing two additional tolerance factors to overcome. But, the more important concern is that the gimbal mounted transducer moves in response varying disk dynamics at the head medium interface so its radial spacing from the fixedly mounted detector will vary and result in incorrect position error signals.

As will become apparent, by using two separate optical servo systems and incorporating the optical and magnetic transducer components into an integrated head structure, these types of problems are minimized.

Because it is important that the spacing between the detector and the active transducer not vary, and given the movable nature of the gimbaled head 1, it is desirable to have the tracking control detector 18 on the same side of the disk as the active transducer 15 doing the reading or writing. This can be satisfied only if a separate detector 18 is adapted to be associated with each side of the disk. This necessitates the inclusion of two separate optical systems, one for each head.

Accordingly, in the head carriage assembly 100 shown in FIG. 1, detector 18 on head 1 is used to control the tracking alignment on the magnetic layer 24 on the upper surface of the disk 12 and detector 18 on head 0 is used to control the tracking alignment on the magnetic layer 25 on the lower surface of the disk 12.

The drive of which the head carriage assembly 100 and spindle 13 are part also includes means for moving the support 14 radially with respect to the disk, and in the cross-track direction with re-

spect to the disk grating 22, so that the head being activated for reading/writing is aligned with the single track being addressed. Such means are under servo control of the head position error information provided by the two optical systems formed respectively by the light sources 16 and detectors 18 on the opposed heads 0 and 1. Additionally, the drive includes means for rotating the disk in operative relation to the disk. These drive components and the operation of head position control system will be described later herein with reference to Fig. 8.

It will be useful to discuss at this point the detection process of the tracking control signals.

The small scale of the optical tracks defined by the opaque rings 22A formed on the disk 12 (shown in FIG. 3) makes it likely that their edge profile will not be ideal but rather will include roughness that may produce additional noise in the servo signals. As an example of the scale, in a 3.5 inch flexible disk format, a high density barium ferrite disk of 20 Mb capacity (10 Mb per side) would require a track density of about 540 TPI.

It is known that the signal-to-noise ratio in a periodic optical system may be improved by spatial filtering, e.i. weighted integration over periodic portions of space. Each detector 18 in its optical sensor used in the preferred embodiment of the invention uses spatial filtering to improve the signal-to-noise ratio of the detection process.

Additionally, it is to be noted that not only is it important for the detection system to detect any misalignment between the active head, i.e. the particular head being aligned, and the desired optical track, but it is also important to ascertain the appropriate direction of radial movement to correct the alignment.

To this end, it has been found advantageous to use an optical grating in the disk in which the width of the opaque lines 22A is essentially equal to the width of the transparent gaps 22B in combination with a detector whose sensor portion includes a first periodic set of viewing apertures spaced by optical stops to form a reference grating, the width of the apertures (the cross track dimension) matching the width of the opaque lines of the optical grating in the disk.

As the reference grating of a detector on a head is moved radially with respect to the disk grating, they act in combination to modulate the intensity of light that reaches the photosensitive portion of the detector behind the reference grating that provides the position error signal. When the two gratings are in phase with their respective opaque and transparent portions in alignment, the amount of light reaching the photosensitive element is at a maximum. When the two gratings are offset by one half track pitch, or are 180 degrees out of phase, the opaque portions of one grating block the transparent portions of the other grating so that the intensity of light that is incident upon the photosensitive element is at a minimum. Advantageously, with this arrangement of equal pitch gratings, the variation of light intensity is essentially linear between the maximum and minimum offset positions of the gratings providing a linear control range for determining position error of the transducer relative to a selected track. Thus, the maximum linear control range is obtained by making aperture width exactly half the track pitch. Each of the periodic apertures is designed to essentially overlie the transition between transparent space and an opaque line of the disk grating so that movement to reduce the amount of light intercepted will tend to center the aperture properly over the transition being tracked.

Moreover, to insure that minor irregularities in edge smoothness of the opaque lines have a relatively small effect, it is desirable to have an aperture whose length along the track is relatively long. That is, because it is desirable to follow a smooth track, the effect of irregularities may be lessened by averaging along the track. Thus the length of the aperture along the track should be sufficient so the minor irregularities have a much smaller percentage effect on the amount of light falling on the photosensitive portion of the detector.

However, because the opaque lines of the disk grating are curved, and because the viewing apertures are linear, as is desirable for ease of fabrication, an aperture that is too long may have portions that overlie the opposite transition. To get an effective longer length, the detector is designed also to include a second set of periodic apertures that essentially tracks the opposite transition (opaque to transparent) of the disk grating, i.e., a set like the first set but directly out of phase with it.

In particular, an ideal detector for generating servo signals would comprise a pair of photodiodes each viewing the same area of the disk through matched spatial filters that lead and lag the magnetic track by ninety degrees of pitch, respectively.

The geometry for such a generator can be realized with a custom photodetector array consisting of two independent active areas, each with a periodic set of fingers whose width matches the width of the lines and gaps to be detected, with the two sets interleaved to form an interdigitated two channel detector whose separate outputs would be supplied to different inputs of a differential amplifier for subtraction.

There is an additional complication in that disks typically are intended to be interchangeable between drives which have the same phasing. While precise manufacturing is one way of ensuring the same phasing, this results in an increase in produc-

tion costs. An alternative is to permit individual drives to be adjusted at time of use to achieve the desired phasing. Although mechanical adjustment of the individual drives is possible, electrical adjustment typically is more attractive and precise.

Referring now to FIG. 4, there is shown the layout of the photosensitive sensor portion 500 of a quadrature detector 18 for use in the present invention and designed additionally to facilitate calibration of each detector 18 to the particular disk used. This sensor comprises a uniformly spaced array of sixteen parallel, rectangular, photosensitive elements 50 interconnected in groups of four to form four photocells. In particular, as depicted, each element labelled A is connected to a common lead 51 and forms part of photocell A, each C element is connected to common lead 52 and forms part of photocell C, each B element is connected to common lead 53 and forms part of photocell B and finally each D element is connected to common lead 54 and forms part of photocell D. It will be convenient to describe the interleaving of elements of four photocells in this fashion as "periodic" interleaving of the elements of the four photocells. Between each element 50 is a non- photosensitive or "dead" space 55 which serves as an optical stop to minimize cross-talk between elements 50.

The array of sixteen elements 50 corresponds essentially to a square aperture desired for the sensor to intercept the infra-red radiation that passes through the disk and is modulated by the disk grating 22.

There is also shown included on the right side of FIG. 4, the opaque lines 22A spaced by gaps 22B forming the optical grating 22 included on the disk. The relative position of the elements 50 of the sensor array to the optical grating 22 corresponds to that when the array is in the alignment corresponding to that desired for stable tracking, with essentially no servo current being generated. It will be noted that the height of the sixteen elements 50 correspond to twelve opaque lines 22A and intervening transparent gaps 22b of the disk grating 22. To this end, each finger element 50 has a width equal to the average width of an opaque (or transparent) grating line 22A and , when active, serves as a half track pitch aperture. Each optical stop 55 has a width of one-half the width of a finger element 50. The uppermost, or first opaque line 22a, has its bottom edge aligned with the top edge of the uppermost or first C finger element. The second opaque line 22a has its top edge aligned with the bottom edge of the first C finger element 50. The third opaque line 22a is aligned with the first D element 50 and the fourth opaque line 22a, like the first, has its bottom edge aligned with the top edge of the next or second C element 50 and the pattern is repeated.

The result is that all four of the finger elements 50 of an individual photocell have the same spatial phase relation with the optical grating 22. It can be seen that the horizontal center lines of elements 50 of photocells A are spaced one and one-half pitch distance of the optical grating 22 from the horizontal centerlines of the elements 50 of photocell B, and the horizontal centerlines of elements 50 of photocell C are similarly spaced from the elements 50 of photocell D. Moreover, the horizontal centerlines of the elements 50 of photocell A are spaced three quarters of the pitch distance of optical grating 22 from the horizontal centerlines of elements 50 of photocell C, as are the elements 50 of photocell B from the elements 50 of photocell D.

Referring now to FIG. 5, there is shown a four channel sensor of this kind. It comprises a silicon chip 600, the back surface (not shown) of which includes an N-type region covered with a large area electrode (not shown), the front surface of which includes an array of sixteen elongated P-type regions 60, corresponding to the sixteen elements 50 shown in FIG. 4. Generally, there is included an intermediate intrinsic layer (not shown) between the P-type and N-type region to form sixteen PIN structures (not shown) that are photosensitive. The spacing of the sixteen elements is as previously described and each group of every fourth element is connected to a different one of four output electrodes 61, 62, 63, and 64 corresponding respectively to leads 51, 52, 53 and 54 of FIG. 4. Large area conductive pads labelled 66A, 66B, 66C and 66D, respectively, are provided as output terminals of the four photocells A, B, C and D. The electrode (not shown) on the back surface (not shown) serves as a common electrode for the four photocells A,B,C, and D. Aluminum strips 65, opaque to the illumination, serve as optical stops to isolate individual P-type regions from their neighboring P-type regions.

Referring now to FIG. 6, there is shown how the four photocells A, B, C and D are interconnected to form a quadrature detector 70. A common electrode of each is a.c. grounded. Output electrodes (terminals) of cell A and cell B are connected to the inverting and non-inverting input ports, respectively, of a differential amplifier 71 and output electrodes (terminals) of cells C and D are connected to the inverting and non-inverting input ports, respectively, of a differential amplifier 72. An output terminal of amplifier 71 is supplied directly to one position of a switch 73, and by way of an inverter circuit 74, to the other position of switch 73. Similarly, an output terminal of amplifier 72 is supplied directly to one position of a switch 75 and indirectly, by way of an inverter circuit 76, to the other position of switch 76. Respective output terminals of switches 73 and 75 are connected to

opposite ends of a potentiometer 77, whose adjustable center tap 78 supplies an output terminal 79 of the detector. The settings of switches 73 and 75 and of the center tap 78 are adjusted typically during a calibration phase, when a disk 12 is first inserted in the drive, so that when a read/write transduce core 15b is properly aligned with a reference track provided on the disk 12 ,a null is measured at the output terminal 79, corresponding to an absence of servo signal for providing any adjusting movement of the head carriage 14. It will usually be desirable to include a reference track (not shown) on the disk together with appropriate control circuitry (not shown) to set the switches and the potentiometer tap electronically. It should be also understood that the switches 73 and 75 and the potentiometer 77 are electronic components well known for such roles.

It can also be appreciated that this circuit can act to correct for offsets between the center of the magnetic track and the center of the optical track.

It can be shown that by making the width of each finger element 60 of the sensor equal to one-half the pitch distance of the disk grating 22, the range of linear control is maximized, and by dividing this pitch distance equally between the opaque line and the transparent gap in the disk grating 22, the chances for a jump between tracks when there is a drift from alignment is minimized.

Additionally, by using four photosensitive finger elements 60 in each photocell spaced apart by an integral number of pitch distances (three pitches in the illustrated embodiment) , there is effectively enlarged the size of the detector for higher sensitivity which results in better averaging out noise arising from the various sources. These sources of noise typically include irregular spacing and ragged edges of the grating lines, the viewing of optical patterns through grainy magnetic coatings 24 and 25 , and , also, non-uniformities in the disk 12 such as elliptical track distortion caused by anisotropy of a disk's base material 21. It should be understood that an integral multiple of four can be used for the total number of elements 60 to be used for division between the four photocells A,B,C, and D, the larger the number the greater the averaging effect.

Moreover, by using a pair of photocells such as photocells A and B, viewing essentially the same area that lead and lag the magnetic tracks, respectively, by one-quarter the pitch distance, one for tracking the upper illustrated edge of an opaque disk grating line 22a and the other for tracking the lower edge of grating of the next adjacent line 22a, there is effectively canceled out common mode noise which may be caused , for example, by variation of the intensity of the illumination source or variations in the optical transmission characteristics of the magnetic coatings 24 and 25.

Finally, a quadrature detector formed by interleaving two sets of pairs of photocells, shifted in phase in the manner described, there is added an extra degree of freedom for electrical adjustment to compensate both for minor deviations from uniformity because of imprecision of manufacture of different transducers and for offsets between the centers of the magnetic and optical tracks.

In the illustrated embodiment, the sensor 600 utilizes the geometry of the individual photosensitive elements 60 and their relative spacing in the array to form a photosensitive electronic reference grating, thus combining the function of light modulation and detection into a single structural element. In this sensor, each of the elements 60 functions as an aperture for its corresponding photocell and the aluminum stripes 65 serve as optical stops. However, each element 60, while serving as an aperture for its own photocell, also effectively serves as an optical stop for the other photocells. For example, with regard to photocell A, the intervening elements 60 of cells C,B, and D do not provide signals to the A channel even though light passing through the disk 12 is incident thereupon, so effectively these elements are inactive as far as photocell A is concerned and thereby function as optical stops.

To maximize the effectiveness of the tracking technique, various other considerations are also important.

First, it is desirable to maximize the degree of modulation and the triangular waveform of the servo-signal provided by the sensor while minimizing the distortion arising from separation of a detector 18, formed by sensor 600 from the optical grating 22 on the disk. This distortion is caused by diffraction blur and can be minimized ideally by locating the detector 18 in close proximity to the disk 12. However, this is not always easy to do because there are usually wire leads bonded to the top surfaces of the conductive pads 66 of the photocells and these tend to limit how close the detector 18 on an integrated head 0 or 1 may be positioned to the disk. Nevertheless, in some instances it has been the practice to position the detector 18 as close to the disk as such obstructions permit, tolerating some degradation of the disk grating modulated light pattern received.

One such integrated head structure is shown in Fig. 9 wherein integrated head 90 comprises a body portion or collar 92 adapted to receive and support a magnetic transducer 15 as shown. Adjacent the ferrite core 15b, collar 92 mounts the sensor 600, which is the equivalent of the detector 18 in Fig. 1, in fixed radial spaced relation to the flux gap of core 15b. On the opposite side of transducer 15, the collar mounts a lens 17 for directing the light output from a light source 16

therebehind (not shown) through the disk 12.

The collar 92 supports the sensor 600 as close as possible to as the plane of the flux gap while permitting space for the wire bonded leads 94a-d connected to the corresponding pads 66a-b. Although not shown in the drawings, thin transparent covers may be provided over the sensor 600 and lens 17 to provide the head 80 with a smoother face that is adapted to confront the disk surface.

Alternatively, it is also possible to include an optical element such as a gradient-index rod in the head body adjacent to the disk facing surface to image the optical grating 22 of the disk onto the reference grating of the detector 18, but this structure tend to be difficult and costly to package and manufacture.

A more promising approach includes the use of highly collimated light from a quasi-point or line source for the illumination so that the disk grating 22 self images on the reference grating of the detector 18 by diffraction. This can make for easier packaging, less expensive optics, and reduced optical noise resulting from dirt, scratches and edge roughness in the media.

One technique to achieve collimation and therefore to form a diffraction image is to use a laser diode light source 16, as a quasi point source or line source at the infinity focal plane of a lens, such as a gradient index rod, a plastic aspheric collimating lens, or a holographic collimating lens, to supply a collimated beam of light. This light is transmitted through the optical grating 22 of the disk to self image optical grating 22 onto the surface of the detector 18 incorporating the reference grating therein. . The detector 18 is placed at a distance D from the disk grating 22 as given by the relation $D = P^2/L$, where P is the pitch of the disk grating 22 and L is the wavelength of the light. Alternatively, it may be preferable from a cost and packaging view to substitute an edge light-emitting diode or area light-emitting diode, wherein the emitting area is less than 5 microns in one dimension, as a quasi-point or line source for the diode laser light source 16, thereby also avoiding objectionable interference patterns that may arise because of the temporal coherence of a laser. When line sources are used, they should be aligned to be parallel to the disk and detector gratings.

An alternative that permits use of a relatively large or extended area light source 16 is shown in FIG. 7. It includes a surface area light-emitting diode 81, illuminating the rear surface of optical element 82. This rear surface includes an entrance surface 83 that is shaped to form a linear grating and coincides with the infinity focal plane of optical element 82. In particular, the surface 83 includes flat portions where light enters for passage to the exit surface 84, alternating with rearwardly extending V shaped faceted portions where incident light is scattered and does not effectively pass through to the exit surface. The exit light surface 84 is aspheric so that element 82 serves as a collimating lens. Because of the geometry of element 82, the extended area light emitting diode 81 simulates an array of line sources. As a result, there exits from exit surface 84 a set of angularly spaced collimated beams, one for each of the flat portions of the entrance surface 83, that are spatially coherent. In the interest of simplicity, only three of the beams are shown in FIG. 7. These beams are then passed through the optical grating 22 in the disk 12 to self image the disk grating 22 on the detector reference grating, as previously indicated to be desirable. The linear grating formed at the entrance surface 83 is designed to have a periodicity that causes the corresponding multiple self images to superimpose constructively.

It is possible, if desired, to position the reference grating on the detector 18 further from the disk grating 22 at the focus of a higher order diffraction self image.

Another type of optical element 17 that may be used in the integrated head structure is a diffraction lens, or zone plate, that is a circular diffraction grating which focuses light not by refraction like a standard lens, but by diffraction. In an integrated head it would serve as a collimator lens for a quasi-point source LED.

The diffraction lens comprises alternating opaque and transparent zones 9 concentric circles), each zone having the same area, but the pitch of each zone decreases from the center to the outer edge. Such a diffraction lens 96 is shown in Fig. 10a. The cross section of lens 96 is shown schematically in Fig. 10b. The amplitude of each diffraction element peak is equal, but the frequency of circlular elements increase toward the outer edge. The grating is symmetrical, so light is diverted into the zero order and equally into the positive and negative first orders of diffraction. Weaker focal points occur at each positive and negative odd order of diffraction (i.e.,3,5,7... etc).

Alternatively, light may be diverted preferentially into a selected order by including appropiate asymmetry in the grating of the diffraction lens.

The aforementioned methods in addition tend to improve the modulation of the detected signal.

A data storage apparatus or flexible magnetic disk drive 110 embodying the present invention is shown in functional block diagram form in Fig. 8. The apparatus 110 operates under the control of a controller circuit 112 having read/ write control and servo circuits sections that are operated in a coordinated manner under the administration of a microprocessor based control logic circuit section. The controller 112 also is provided with an inter-

face section for operatively connection the drive 110 to a host computer (not shown).

The head carriage assembly 14 is connected to a head position actuator 114 responsive to head position signals provided by an actuator control circuit 116 for moving the head carriage assembly 14 radially with respect to the disk 12 for track seek, read/write and position error adjustment operations. The actuator 114 preferably is of the fast response, precise positioning type and may be selected from a variety of such actuators recognized in the art as being suitable for high data density applications.

The apparatus 110 also includes means for moving the storage medium past the read/write transducers and, in the illustrated embodiment, such means take the form of a spindle motor assembly 118 for effecting rotation of the disk 12. The spindle motor assembly 118 is operated by the actuator control circuit 116 which receives index signals from the motor assembly 118 and provides drives signals thereto in a well known manner. The actuator control circuit 116 in turn operates in response to input signals received from the read/write control and servo circuits of the controller 112.

To effect servo controlled head tracking, both of the integrated heads 0 and 1 are operative, but the head that is enabled for read or write operations with respect to its adjacent facing side of the disk 12 is designated as the "active head". The non-active head on the opposite side of the disk 12 is operative in that its light source 16 is turned on to direct light through the disk, for modulation by the optical pattern or grating 22, and onto the reference grating of the detector 18 on the active head adjacent its enabled corresponding read/write transducer 15.

Upon receipt of the active head designation signals from the host computer, the controller 112,through its control logic section, directs the read/write control circuit to send head selection signals to two head select switching circuits, 120 and 122, which configure the heads for the designated selection. The first head select switch circuit 120 is connected between the read/write control circuit if the controller 112 and the read/write transducers 15 and light sources 16 of heads 0 and 1. The second head select circuit 122 likewise connected between the controller 112 and the detectors 18 of heads 0 and 1 and is operative to direct the position error signal output from the detector 18 on the active head to the servo circuit which in response provides corrective position signals to the actuator control circuit 116 to effect alignment of the active head transducer with the selected track .

Data to be recorded on the disk 12 is fed from the read/write section through a write channel circuit 124 connected to the first head select switch 120 while data that is to be read from the disk is routed through a read channel circuit 126 connected between the first head select switch 122 and the read/write control circuit.

If data is to be written on or read from the 0 side of the disk (the underside as viewed in Fig. 8), head 0 is designated as the active head. In this mode, the read/write control circuit directs the head select switch 120 to assume a configuration whereby the read/write transducer 15 on head 0 is connected to the appropriate one of the read and write channels 126 and 124 (and the transducer on head 1 is disconnected therefrom) and the light source 16 on head 1 is energized to direct its light output through the disk 12 and onto the reference grating of the detector 18 on head 0 which the second head select circuit 120 has connected to the servo circuit in response to the active head designation provided by the read write control circuit. While the head 1 light source 16 is energized, the first head select circuit 120 maintains the head 0 light source 16 in a de-energized state and the second head select switch 122 blocks signals from the detector 18 on head 1 from being transmitted to the servo circuit.

In the opposite mode for writing data onto or reading it from side 1, the head select switches are reversed to connect the transducer on head 1 to the appropriate one of read and write channels 162 and 124 , to energize the light source 16 on head 0 and direct the position error signal output from the "active" detector 18 on head 1 to the servo circuit.

With the disk 12 mounted on the spindle 13, the position of its grating 22 is relatively fixed and the reference gratings on the heads 0 and 1 primarily move relative thereto for modulating the light intensity sensed by the detector 18. In effect the two gratings act as a comb type shutter so that when the detector apertures are aligned with the light transmissive gaps of the disk grating 22, maximum light intensity is sensed and when the apertures are in the opposite phase relation to the gaps , minimum light intensity is sensed. Between these two conditions sensed light intensity varies linearly and thereby provides proportionate head position error information.

In the case of a flexible disk, a previously recorded circular magnetic track may assume an elliptical shape due to anisotropic expansion of the disk base material, so in effect the rings of the disk grating 22 have moved or shifted relative to the reference grating which causes a change in the intensity of light at the quadrature detector 18. In response, detector 18 provides the appropriate error position signal to the servo circuit to effect

movement of the head carriage 14 for aligning the active head with the selected track.

The illumination used in the illustrative system, typically infra-red in a band centered at about 890 nanometers, is readily available from GaAlAs light-emitting diodes or GaAlAs diode lasers. Silicon photocells are convenient to use at such wavelengths. Moreover, light at this wavelength is compatible with the typical materials used for the magnetic disk and can readily be arranged to be absorbed by the opaque portions of the optical grating 22. Of course, other wavelengths can be used that satisfy the various requirements that must be met if the illumination is to function in the role desired.

While the invention has been described with reference to the use of disks, either floppy or rigid, as the storage medium, it should be obvious that the invention is applicable with obvious modifications to other forms, such as tape, where the information is stored in linear tracks and there is a need for accurate alignment of a read/write head with the particular track being addressed.

The quadrature detector may be omitted and a simpler form of detector substituted. Such a simpler form might be a large area photosensitive cell whose surface has been suitably masked to form a linear reference grating thereof for cooperation with the optical grating in the disk. Alternately, there may be employed simply a pair of photocells each including an array of spaced strip elements, the two arrays being interleaved in a fashion to form a linear reference ngrating at the detector for cooperation with the optical grating in the disk.

Claims

1. A data storage apparatus for use with a double sided data storage medium (12) of the type including a transparent support (21), a light transmissive data storage layer (24,25 on each of respective opposite sides of the support (21), and an optical grating (22) formed on the support (21) between the storage layers (24,25) for defining the location of data storage tracks in the storage layers (24,25), said apparatus comprising :

means (13) for supporting and moving such a medium (12) for data read and/or write operations;

first and second heads (0,1), each including a data recording and/or reading transducer (15);

a light source (16), and

a detector (18), including a reference grating (50), responsive to light transmitted through the medium (12) for modulation by the medium grating (22) and thereafter incident upon said reference grating (50) for providing position error signals indicative of the position of said transducer relative to a selected track;

a head carriage (100) configured for cross track movement relative to the medium (12) and mounting said first and second heads (0, 1) thereon in complementary alignment on opposite sides of the medium (12);

means responsive to said position error signals for moving said head carriage assembly to maintain a selected one of said transducers (15) in aligned relation to a selected track,

characterized in that said

head carriage assembly (100) includes support members (14A) and (14B) which supports said heads as a pair of complementary integrated magnetic and optical heads (0) and (1) respectively, on opposite sides of said medium in spaced operative alignment with each other, that each of the heads (0) and (1) includes a body portion (10), which supports and positions the elements of the head including a magnetic read/ write transducer (15) a light source (16) and a light detector (18), such that said transducers (15) are each in recording and/or reading relation to a respective adjacent one of the storage layers (24,25) said light source (16) on said first head (0) is positioned to direct its light output through the medium (12) and onto said reference grating (50) of said detector (18) on said second head (1), and said light source (16) on said second head (1) is positioned to direct its light output through the medium (12) and onto said reference grating (50) said detector (18) on said first head (0) for providing said position error signals.

2. The magnetic data storage apparatus of claim 1 wherein each of said detectors (18) comprises a photosensitive sensor (50) which is configured to serve as reference grating as well as providing said position error signals.

3. The magnetic data storage apparatus of claim 2 wherein the magnetic storage medium is a flexible magnetic recording disk and said head carriage includes first and second head supports, mounted for movement between a first position wherein said first and second heads are in operative relation to the disk and a second position wherein said first and second heads are spaced further apart than when in said first position to facilitate disk insertion and removal.

movement of the head carriage 14 for aligning the active head with the selected track.

The illumination used in the illustrative system, typically infra-red in a band centered at about 890 nanometers, is readily available from GaAlAs light-emitting diodes or GaAlAs diode lasers. Silicon photocells are convenient to use at such wavelengths. Moreover, light at this wavelength is compatible with the typical materials used for the magnetic disk and can readily be arranged to be absorbed by the opaque portions of the optical grating 22. Of course, other wavelengths can be used that satisfy the various requirements that must be met if the illumination is to function in the role desired.

While the invention has been described with reference to the use of disks, either floppy or rigid, as the storage medium, it should be obvious that the invention is applicable with obvious modifications to other forms, such as tape, where the information is stored in linear tracks and there is a need for accurate alignment of a read/write head with the particular track being addressed.

The quadrature detector may be omitted and a simpler form of detector substituted. Such a simpler form might be a large area photosensitive cell whose surface has been suitably masked to form a linear reference grating thereof for cooperation with the optical grating in the disk. Alternately, there may be employed simply a pair of photocells each including an array of spaced strip elements, the two arrays being interleaved in a fashion to form a linear reference ngrating at the detector for cooperation with the optical grating in the disk.

Claims

1. A data storage apparatus for use with a double sided data storage medium (12) of the type including a transparent support (21), a light transmissive data storage layer (24,25 on each of respective opposite sides of the support (21), and an optical grating (22) formed on the support (21) between the storage layers (24,25) for defining the location of data storage tracks in the storage layers (24,25), said apparatus comprising :

means (13) for supporting and moving such a medium (12) for data read and/or write operations;

first and second heads (0,1), each including a data recording and/or reading transducer (15);

a light source (16), and

a detector (18), including a reference grating (50), responsive to light transmitted through the medium (12) for modulation by the medium grating (22) and thereafter incident upon said reference grating (50) for providing position error signals indicative of the position of said transducer relative to a selected track;

a head carriage (100) configured for cross track movement relative to the medium (12) and mounting said first and second heads (0, 1) thereon in complementary alignment on opposite sides of the medium (12);

means responsive to said position error signals for moving said head carriage assembly to maintain a selected one of said transducers (15) in aligned relation to a selected track,

characterized in that said

head carriage assembly (100) includes support members (14A) and (14B) which supports said heads as a pair of complementary integrated magnetic and optical heads (0) and (1) respectively, on opposite sides of said medium in spaced operative alignment with each other, that each of the heads (0) and (1) includes a body portion (10), which supports and positions the elements of the head including a magnetic read/ write transducer (15) a light source (16) and a light detector (18), such that said transducers (15) are each in recording and/or reading relation to a respective adjacent one of the storage layers (24,25) said light source (16) on said first head (0) is positioned to direct its light output through the medium (12) and onto said reference grating (50) of said detector (18) on said second head (1), and said light source (16) on said second head (1) is positioned to direct its light output through the medium (12) and onto said reference grating (50) said detector (18) on said first head (0) for providing said position error signals.

2. The magnetic data storage apparatus of claim 1 wherein each of said detectors (18) comprises a photosensitive sensor (50) which is configured to serve as reference grating as well as providing said position error signals.

3. The magnetic data storage apparatus of claim 2 wherein the magnetic storage medium is a flexible magnetic recording disk and said head carriage includes first and second head supports, mounted for movement between a first position wherein said first and second heads are in operative relation to the disk and a second position wherein said first and second heads are spaced further apart than when in said first position to facilitate disk insertion and removal.

4. The magnetic data storage apparatus of claim 3 wherein said first head is gimbal mounted on said first support.

5. The magnetic data storage apparatus of claim 2 where on each of said first and second heads, said light source and said detector are disposed on opposite sides of said magnetic transducer.

6. The magnetic data storage apparatus of claim 5 wherein said transducer includes a magnetic core, having a flux gap, mounted near one side of a transducer body and said detector is located adjacent said one side to position said detector in close relation to said core.

7. The magnetic data storage apparatus of claim 2 wherein each of said detectors comprises a photosensitive sensor which is configured to serve as reference grating as well as providing said position error signals.

8. The magnetic data storage apparatus of claim 2 wherein the magnetic storage medium is a flexible magnetic recording disk having a grating therein formed by concentric opaque rings separated by transparent rings to define the location of concentric circular data tracks in magnetic recording layers on opposite sides of the disk, and in which each detector includes a sensor comprising a plurality of uniform parallel photosensitive elements spaced apart to define said reference grating for cooperating with the disk grating.

9. The magnetic data storage apparatus of claim 8 in which each sensor comprises four separate photocells, each photocell including a plurality of said photosensitive elements, said photosensitive elements of said four photocells being periodically interleaved and spaced apart for defining said reference grating.

10. The magnetic data storage apparatus of claim 9 in which the disk grating transparent rings are of a width equal to the width of the opaque rings and in which the width of said photosensitive elements of the detector is equal to that of each of said opaque and transparent rings and in which said photosensitive elements are spaced apart by a distance equal to one-half the width of said photosensitive elements.

11. The magnetic data storage apparatus of claim 10 in which said means responsive to the position error signals includes a circuit which is supplied with the outputs of the four photocells for deriving a position error signal as a measure of any misalignment between a head and a selected track.

12. The magnetic data storage apparatus of claim 11 in which said circuit includes a first differential amplifier whose two inputs are supplied with the outputs of two of the photocells and a second differential amplifier whose two inputs are supplied with the output of the others of the photocells, and the outputs of the two differential amplifiers are supplied to opposite ends of an impedance means that includes a variable terminal where a position error signal is available.

13. The magnetic data storage apparatus of claim 2 further including means for imaging a respective aligned portion of the storage medium grating onto said reference grating of each said detector.

14. The magnetic data storage apparatus of claim 13 in which said imaging means includes means for self imaging by diffraction said respective aligned portion of the medium grating onto each said reference gratings.

15. The magnetic data storage apparatus of claim 2 in which said light source comprises an area-emitting diode and said apparatus further includes optical means for forming incident illumination provided by said diode into a plurality of collimated angularly spaced beams of light that are spatially coherent.

16. The magnetic data storage apparatus of claim 15 in which said optical means includes means for providing that multiple self images associated with the plurality of collimated beams image the medium grating on the reference grating of the detector constructively.

17. The magnetic data storage apparatus of claim 16 in which said optical means includes an optical element that includes an entrance surface that includes an array of flat surfaces spaced by faceted surfaces and an exit surface that is aspheric for forming the incident illumination into the plurality of angularly-spaced collimated beams of light.

18. The magnetic data storage apparatus of claim 2 in which each of said light sources comprises a quasi-point or line source and each head further includes a collimating optical element positioned such the said light source is at the infinity focus of said collimating optical

element and parallel to said medium grating.

19. The magnetic data storage apparatus of claim 18 in which said collimating optical element is a plastic aspherical lens.

20. The magnetic data storage apparatus of claim 18 in which said collimating optic is a diffraction lens.

21. The magnetic data storage apparatus of claim 18 in which said collimating optic is a gradient index lens.

22. The magnetic data storage apparatus of claim 18 in which said quasi point line source is an edge emitting light emitting diode.

23. The magnetic data storage apparatus of claim 18 in which said quasi point line source is a laser diode.

24. The magnetic data storage apparatus of claim 18 in which said quasi-point line source is an area emitting light emitting diode with its area of emission approximating a quasi-point or line source.

25. The magnetic storage apparatus of claim 2 wherein said light sources are infra-red light sources.

26. The magnetic storage apparatus of claim 25 wherein said light sources emit infra-red light in a band centered about 890 nanometers.

Patentansprüche

1. Datenspeichergerät zur Benutzung in Verbindung mit einem doppelseitigen Datenspeichermedium (12), welches einen transparenten Träger (21), eine lichtdurchlässige Datenspeicherschicht (24,25) auf den jeweils gegenüberliegenden Seiten des Trägers (21) und ein optisches Gitter (22) aufweist, das auf dem Träger (21) zwischen den Speicherschichten (24,25) angeordnet ist, um die Lage der Datenspeicherspuren in den Speicherschichten (24,25) zu definieren, wobei das Gerät folgende Merkmale umfaßt:

Mittel (13) zur Halterung und zur Bewegung eines solchen Datenspeichermediums (12) zum Lesen und/oder Einschreiben von Daten;

erste und zweite Köpfe (0,1), von denen jeder einen Datenaufzeichnungs- und/oder Datenlesewandler (15) aufweist;

eine Lichtquelle (16) und einen Detektor (18) mit einem Bezugsgitter (50), der auf Licht anspricht, das über das Medium (12) übertragen wurde, um durch das Gitter (22) des Mediums moduliert zu werden und das danach auf das Bezugsgitter (50) auftrifft, um Lagefehlersignale zu erzeugen, die die Lage des Wandlers relativ zu einer gewählten Spur anzeigen;

einen Kopfschlitten (100), der quer zu den Spuren relativ zum Medium (12) beweglich ist und den erstem und zweiten Kopf (0,1) in komplementärer Ausrichtung auf gegenüberliegenden Seiten des Mediums (12) lagert;

Mittel, die auf die Lagefehlersignale ansprechen, um den Kopfschlitten so zu bewegen, daß ein ausgewählter Wandler (15) auf einer gewählten Spur ausgerichtet bleibt;

dadurch gekennzeichnet, daß

der Kopfschlitten (100) Träger (14A) und (14B) aufweist, die die Köpfe als Paar komplementärer, integrierter Magnet- und Optikköpfe (0) bezw. (1) auf gegenüberliegenden Seiten des Mediums im Abstand ausgerichtet aufeinander tragen, daß jeder der Köpfe (0) und (1) einen Aufbau (10) aufweist, der die Elemente des Kopfes einschließlich dem magnetischen Lese/Schreibwandler (15), einer Lichtquelle (16) und eines Lichtdetektors (18) derart trägt und positioniert, daß die Wandler (15) jeweils in Aufzeichnungs- und/oder Lesestellung gegenüber einer der Speicherschichten (24,25) angeordnet sind, wobei die Lichtquelle (16) auf dem ersten Kopf (0) so angeordnet ist, daß ihr Lichtausgang durch das Medium (12) und auf das Bezugsgitter (56) des Detektors (18) auf dem zweiten Kopf (1) gerichtet wird und die Lichtquelle (16) auf dem zweiten Kopf (1) so angeordnet ist, daß ihr Lichtausgang durch das Medium 12) und auf das Bezugsgitter (50) des Detektors (18) auf dem ersten Kopf (0) gerichtet wird, um die Lagefehlersignale zu erzeugen.

2. Magnetisches Datenspeichergerät nach Anspruch 1, bei welchem jeder der Detektoren (18) einen lichtempfindlichen Sensor (50) aufweist, der so ausgebildet ist, daß er als Bezugsgitter dient und außerdem die Lagefehlersignale liefert.

3. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem das magnetische Speichermedium eine flexible magnetische Aufzeichnungsdiskette ist und der Kopfschlitten erste und zweite Kopfträger aufweist, die zwischen einer ersten Stellung, in der erster und zweiter Kopf in Arbeitsstellung gegenüber der Diskette angeordnet sind, und einer zweiten

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Stellung beweglich sind, in der erster und zweiter Kopf weiter als in der ersten Stellung im Abstand zueinander liegen, um die Diskette einlegen und entnehmen zu können.

4. Magnetisches Datenspeichergerät nach Anspruch 3, bei welchem der erste Kopf auf dem ersten Träger kardanisch gelagert ist.

5. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem auf jedem von ersten und zweiten Kopf die Lichtquelle und der Detektor auf gegenüberliegenden Seiten des magnetischen Wandlers angeordnet sind.

6. Magnetisches Datenspeichergerät nach Anspruch 5, bei welchem der Wandler einen Magnetkern mit einem Flußspalt aufweist, der in der Nähe der einen Seite des Wandlerkörpers angeordnet ist und bei welchem der Detektor benachbart zu der einen Seite liegt, um den Detektor dicht benachbart zu dem Kern zu positionieren.

7. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem jeder der Detektoren einen lichtempfindlichen Sensor aufweist, der sowohl als Bezugsgitter dient als auch die Lagefehlersignale liefert.

8. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem das magnetische Speichermedium eine flexible, magnetische Aufzeichnungsdiskette ist, die ein Gitter aufweist, welches aus konzentrischen opaken Ringen besteht, die durch transparente Ringe getrennt sind, um die Lage konzentrischer, kreisförmiger Datenspuren in den magnetischen Aufzeichnungsschichten auf gegenüberliegenden Seiten der Diskette zu definieren und bei welchem jeder Detektor mehrere gleiche parallele lichtempfindliche Elemente aufweist, die im Abstand derart angeordnet sind, daß das Bezugsgitter definiert wird, welches mit dem Diskettengitter zusammnewirkt.

9. Magnetisches Datenspeichergerät nach Anspruch 8, bei welchem jeder Sensor vier getrennte Photozellen aufweist und jede Photozelle mehrere lichtempfindliche Elemente besitzt, wobei die lichtempfindlichen Elemente der vier Photozellen periodisch ineinandergeschachtelt sind und im Abstand zueinander liegen, um das Bezugsgitter zu definieren.

10. Magnetisches Datenspeichergerät nach Anspruch 9, bei welchem die transparenten Ringe des Diskettengitters eine Breite aufweisen, die gleich ist der Breite der opaken Ringe, bei bei welchem die Breite der lichtempfindlichen Elemente des gleich ist der Breite der opaken und der transparenten Ringe und bei welchem die lichtempfindlichen Elemente in einem Abstand zueinander liegen, der gleich ist der Hälfte der Breite der lichtempfindlichen Elemente.

11. Magnetisches Datenspeichergerät nach Anspruch 10, bei welchem die auf die Lagefehlersignale ansprechenden Mittel eine Schaltung aufweisen, die von den Ausgängen der vier Photozellen gespeist wird, um ein Lagefehlersignal als Maß irgendeiner Mißausrichtung zwischen dem Kopf und einer gewählten Spur zu liefern.

12. Magnetisches Datenspeichergerät nach Anspruch 11, bei welchem die Schaltung einen ersten Differentialverstärker aufweist, dessen zwei Eingänge von den Ausgängen zweier Photozellen gespeist werden und bei welchem die Schaltung einen zweiten Differentialverstärker aufweist, dessen zwei Eingänge von den Ausgängen der beiden anderen Photozellen gespeist werden, wobei die Ausgänge der beiden Differentialverstärker an entgegengesetzte Enden einer Impedanz angelegt sind, die einen variablen Anschluß aufweist, wo ein Lagefehlersignal zur Verfügung steht.

13. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem außerdem Mittel vorsehen sind, um einen jeweiligen ausgerichteten Abschnitt des Speichermediumgitters auf jedem Detektor abzubilden.

14. Magnetisches Datenspeichergerät nach Anspruch 13, bei welchem die Abbildungsmittel eine Einrichtung aufweisen, um eine Selbstabbildung durch Beugung des jeweils ausgerichteten Abschnitts des Mediumgitters auf dem Bezuggitter zu bewirken.

15. Magnetische Datenspeichergerät nach Anspruch 2, bei welchemdie Lichtquelle eine Flächenemissions-Diode ist und das Gerät außerdem optische Mittel aufweist, um die durch die Diode erzeugte Beleuchtung in mehrere im Winkelabstand zueinader angeordnete, parallelisierte Lichtstrahlen aufzuteilen, die räumlich koherent sind.

16. Magnetisches Datenspeichergerät nach Anspruch 15, bei welchem die optischen Mittel eine Einrichtung aufweisen, um die Mehrfachselbstabbildungen, die den parallelisierten Strahlen zugeordnet sind, das Mediumgitter

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auf dem Bezugsgitter des Detektors konstruktiv abzubilden.

17. Magnetisches Datenspeichergerät nach Anspruch 16, bei welchem die optischen Mittel ein optisches Element aufweisen, welches eine Eintrittsoberfläche aufweist, die ein Feld von flachen Oberflächen besitzt, die durch Facettenflächen distanziert sind und welches eine Austrittsoberfläche besitzt, die asphärisch ausgebildet ist, um die einfallende Beleuchtung in die im Winkelabstand zueinander angeordneten, parallelisierten Lichtstrahlen umzuformen.

18. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem die Lichtquellen eine Quasipunktlichtquelle oder eine Linienlichtquelle aufweisen und jeder Kopf ein optisches Kollimatorelement besitzt, welches so angeordnet ist, daß die Lichtquelle im Unendlichen des Kollimatorelementes und parallel zu dem Mediumgitter fokussiert ist.

19. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem das optische Kollimatorelement eine aus Plastikmateriel bestehende asphärische Linse ist.

20. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem die Kollimatoroptik eine Diffraktionslinse ist.

21. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem die Kollimatoroptik eine Gradientenlinse ist.

22. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem die Quasipunktlichtquelle eine Randemissions-Leuchtdiode ist.

23. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem die Quasipunktlichtquelle eine Laserdiode ist.

24. Magnetisches Datenspeichergerät nach Anspruch 18, bei welchem die Quasipunktlichtquelle Flächenemissions-Leuchtdiode ist, die einer Quasipunktlichtquelle oder einer Linienlichtquelle angenähert ist.

25. Magnetisches Datenspeichergerät nach Anspruch 2, bei welchem die Lichtquellen Infrarot-Lichtquellen sind.

26. Magnetisches Datenspeichergerät nach Anspruch 25, bei welchem die Lichtquellen infrarotlich in einem Band abstrahlen, das um etwa 890 Nanometer zentriert ist.

Revendications

1. Appareil de mémorisation de données à utiliser avec un support (12) de mémorisation de données à double face du type qui comprend une base transparente (21), une couche (24, 25) de mémorisation de données transmettant la lumière et placée sur chacun des côtés opposés respectifs de la base (21) et un réseau de diffraction optique (22) formé sur la base (21) entre les couches de mémorisation (24, 25) pour définir l'emplacement de pistes de mémorisation de données dans les couches de mémorisation (24, 25), ledit appareil comprenant :
   - un moyen (13) pour soutenir et déplacer un tel support (12) en vue d'opérations de lecture et/ou écriture de données,
   - des première et seconde têtes (0, 1) comprenant chacune un transducteur (15) de lecture et/ou enregistrement de données,
   - une source lumineuse (16), et
   - un détecteur (18), contenant un réseau de diffraction de référence (50), qui répond à la lumière transmise à travers le support (12) en vue d'une modulation par ledit réseau de diffraction (22) du support et arrivant ensuite sur ledit réseau de diffraction (50) de référence pour donner des signaux d'erreur de position indiquant la position dudit transducteur par rapport à une piste sélectionnée,
   - un chariot (100) de têtes, configuré pour se déplacer transversalement par rapport au support (12) et soutenant lesdites première et seconde têtes (0, 1) en alignement complémentaire sur les côtés opposés du support (12),
   - un moyen répondant auxdits signaux d'erreur de position pour déplacer ledit ensemble formant chariot de têtes afin de maintenir l'un sélectionné desdits transducteurs (15) dans l'alignement d'une piste sélectionnée,

   caractérisé en ce que ledit ensemble formant chariot (100) de têtes comprend des organes de support (14A et 14B) qui supportent lesdites têtes comme une paire de têtes (0) et (1) optiques et magnétiques complémentairement intégrées, respectivement sur les côtés opposés dudit support en alignement de fonctionnement et espacées l'une par rapport à l'autre, en ce que chacune des têtes (0) et (1) comprend une partie formant corps (10) qui supporte et positionne les éléments de la tête incluant un

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transducteur magnétique (15) de lecture/écriture, une source lumineuse (16) et un détecteur de lumière (18), de telle sorte que lesdits transducteurs (15) soient chacun en relation d'enregistrement et/ou lecture par rapport à une couche de mémorisation (24, 25) adjacente et correspondante, que ladite source lumineuse (16) sur ladite première tête (0) soit positionnée pour diriger sa sortie lumineuse à travers le support (12) et sur ledit réseau de diffraction de référence (50) dudit détecteur (18) se trouvant sur ladite seconde tête (1), et que ladite source lumineuse (16) sur ladite seconde tête (1) soit positionnée pour diriger sa sortie lumineuse à travers le support (12) et sur ledit réseau de diffraction de référence (50) dudit détecteur (18) se trouvant sur ladite première tête (0) pour fournir lesdits signaux d'erreur de position.

2. Appareil magnétique de mémorisation de données selon la revendication 1, dans lequel chacun desdits détecteurs (18) comprend un capteur photosensible (50) qui est configuré pour servir comme réseau de diffraction de référence ainsi que pour fournir lesdits signaux d'erreur de position.

3. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel le support de mémorisation magnétique d'un disque souple d'enregistrement magnétique et ledit chariot de têtes comprend des premier et second supports de têtes montés en vue d'un déplacement entre une première position dans laquelle lesdites première et seconde têtes sont en relation opérationnelle par rapport au disque et une seconde position dans laquelle lesdites première et seconde têtes sont davantage espacées que quand elles se trouvent dans ladite première position pour faciliter l'insertion et le retrait du disque.

4. Appareil magnétique de mémorisation de données selon la revendication 3, dans lequel ladite première tête est montée sur cardan sur ledit premier support.

5. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel, sur chacune desdites première et seconde têtes, ladite source lumineuse et ledit détecteur sont disposés sur les côtés opposés dudit transducteur magnétique.

6. Appareil magnétique de mémorisation de données selon la revendication 5, dans lequel ledit transducteur comprend un noyau magnétique, avec un entrefer, monté près d'un côté d'un corps de transducteur et ledit détecteur est situé adjacent audit premier côté pour positionner ledit détecteur à proximité dudit noyau.

7. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel chacun desdits détecteurs comprend un capteur photosensible qui est configuré pour servir comme réseau de diffraction de référence ainsi que pour fournir lesdits signaux d'erreur de position.

8. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel le support magnétique de mémorisation est un disque souple d'enregistrement magnétique ayant un réseau de diffraction qui y est formé par des anneaux opaques concentriques séparés par des anneaux transparents pour définir l'emplacement de pistes de données circulaires et concentriques dans les couches d'enregistrement magnétique sur les côtés opposés du disque, et dans lequel chaque détecteur comprend un capteur contenant une pluralité d'éléments photosensibles parallèles et uniformes, espacés les uns des autres pour définir ledit réseau de diffraction de référence destiné à coopérer avec ledit réseau de diffraction du disque.

9. Appareil magnétique de mémorisation de données selon la revendication 8, dans lequel chaque capteur comprend quatre cellules photoélectriques séparées, chaque cellule photoélectrique comprenant une pluralité desdits éléments photosensibles, lesdits éléments photosensibles desdites quatre cellules photoélectriques étant périodiquement entrecroisés et espacés pour définir ledit réseau de diffraction de référence.

10. Appareil magnétique de mémorisation de données selon la revendication 9, dans lequel les anneaux transparents du réseau de diffraction du disque sont d'une largeur égale à la largeur des anneaux opaques, dans lequel la largeur desdits éléments photosensibles du détecteur est égale à celle de chacun desdits anneaux transparents et opaques et dans lequel lesdits éléments photosensibles sont espacés les uns des autres d'une distance égale à la moitié de la largeur desdits éléments photosensibles.

11. Appareil magnétique de mémorisation de données selon la revendication 10, dans lequel ledit moyen répondant aux signaux d'erreur de position comprend un circuit qui est alimenté avec les sorties des quatre cellules photoélectriques pour produire un signal d'erreur de position en tant que mesure du mauvais alignement entre une tête et une piste sélectionnée.

12. Appareil magnétique de mémorisation de données selon la revendication 11, dans lequel ledit circuit comprend un premier amplificateur différentiel dont les deux entrées sont alimentées avec les sorties de deux des cellules photoélectriques et un second amplificateur différentiel dont les deux entrées sont alimentées avec la sortie des autres cellules photoélectriques, et les sorties des deux amplificateurs différentiels sont envoyées aux extrémités opposées d'un moyen formant impédance qui contient une borne variable où est disponible un signal d'erreur de position.

13. Appareil magnétique de mémorisation de données selon la revendication 2, comprenant en outre un moyen pour former l'image d'une partie alignée respective du réseau de diffraction du support de mémorisation sur ledit réseau de diffraction de référence de chacun desdits détecteurs.

14. Appareil magnétique de mémorisation de données selon la revendication 13, dans lequel ledit moyen de formation d'image comprend un moyen pour former l'auto-image par diffraction de ladite partie alignée respective du réseau de diffraction du support sur chacun desdits réseaux de diffraction de référence.

15. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel ladite source lumineuse comprend une diode à émission large et ledit appareil comprend en outre un moyen optique pour transformer l'éclairage incident fourni par ladite diode en une pluralité de faisceaux lumineux espacés angulairement et collimatés qui sont spatialement cohérents.

16. Appareil magnétique de mémorisation de données selon la revendication 15, dans lequel ledit moyen optique inclut un moyen pour faire que des auto-images multiples associées à la pluralité de faisceaux collimatés forment l'image du réseau de diffraction du support sur le réseau de diffraction de référence du détecteur de façon constructive.

17. Appareil magnétique de mémoristion de données selon la revendication 16, dans lequel ledit moyen optique contient un élément optique qui comprend une surface d'entrée avec un réseau de surfaces plates espacées par des surfaces à facettes et une surface de sortie qui est asphérique pour transformer l'éclairage incident en la pluralité de faisceaux lumineux collimatés et espacés angulairement.

18. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel chaque source lumineuse comprend une source de raie ou quasi-ponctuelle et chaque tête contient en outre un élément optique de collimation placé de telle sorte que ladite source lumineuse soit dans le plan de mise au point à l'infini dudit élément optique de collimation et parallèle audit réseau de diffraction du support.

19. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ledit élément optique de collimation est une lentille asphérique en plastique.

20. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ladite optique de collimation est une lentille de diffraction.

21. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ladite optique de collimation est une lentille à gradient d'indice.

22. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ladite source de raie quasi-ponctuelle est une diode émettrice de lumière émettant par le bord.

23. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ladite source de raie quasi-ponctuelle est une diode laser.

24. Appareil magnétique de mémorisation de données selon la revendication 18, dans lequel ladite source de raie quasi-ponctuelle est une diode émettrice de lumière à émission large dont la surface d'émission approche une source de raie ou quasi-ponctuelle.

25. Appareil magnétique de mémorisation de données selon la revendication 2, dans lequel lesdites sources lumineuses sont des sources de lumière infrarouge.

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26. Appareil magnétique de mémorisation de données selon la revendication 25, dans lequel lesdites sources lumineuses émettent de la lumière infrarouge dans une bande de fréquences centrée autour de 890 nanomètres.