US 20060233088A1

(19) **United States**
(12) **Patent Application Publication**
(10) **Pub. No.: US 2006/0233088 A1**
(43) **Pub. Date: Oct. 19, 2006**

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(54) **METHOD AND APPARATUS FOR CREATING A MULTI-DIMENSIONAL DATA SIGNAL**

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(21) Appl. No.: **11/402,291**

(22) Filed: **Apr. 10, 2006**

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/731,784, filed on Dec. 9, 2003, now Pat. No. 7,092,344.

(60) Provisional application No. 60/463,744, filed on Apr. 18, 2003.

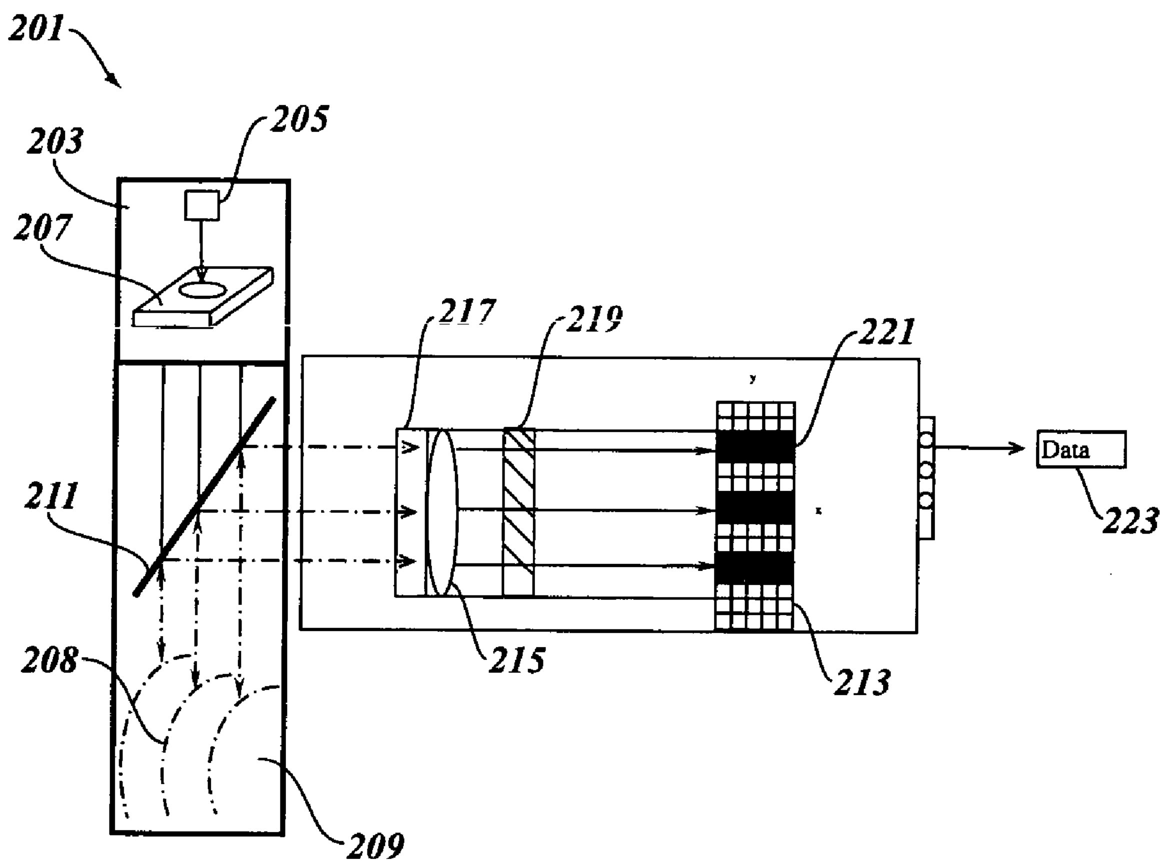
Publication Classification

(51) **Int. Cl.**
G11B 7/00 (2006.01)

(52) **U.S. Cl.** **369/103**

(57) **ABSTRACT**

An optical disk drive (101) is disclosed which has essentially no seek time. The drive utilizes a Virtual Head (VH) (**103**) which is capable of accessing any and/or all tracks in an optical disc (**111**) at any time. The drive utilizes a procedure by which all of the tracks (**208**) in an optical disc are continuously mapped to a detector (**121**) space at all times, thus making data stored on the disk drive available almost instantaneously. The mapping of the optical disc tracks to the sensor space is direct in that it is predetermined and is an integral part of the driver software. The direct mapping makes it possible to use the least amount of computation time required to access any track. The technique is enabled by using a combination of a holographic lens element (**125**) with the detector. The technique and the components used in this device open the possibility for rapid data transfers using multidimensional data access.



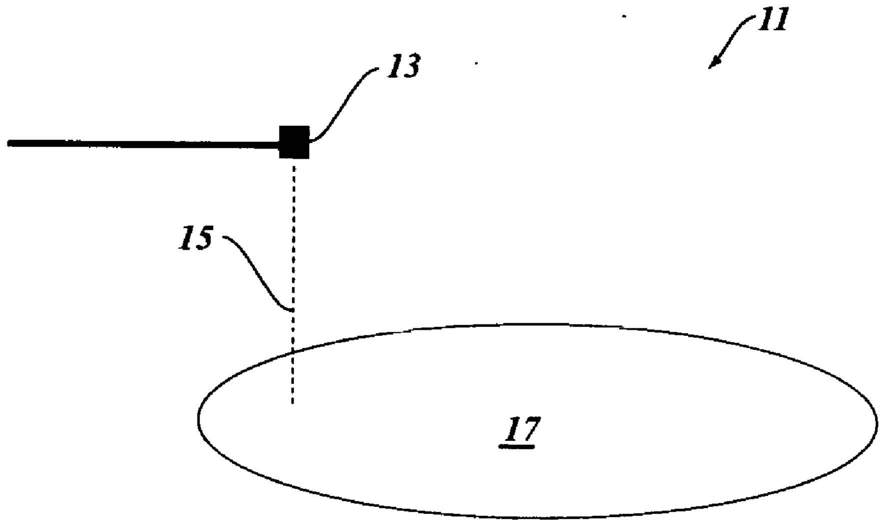


FIG. 1

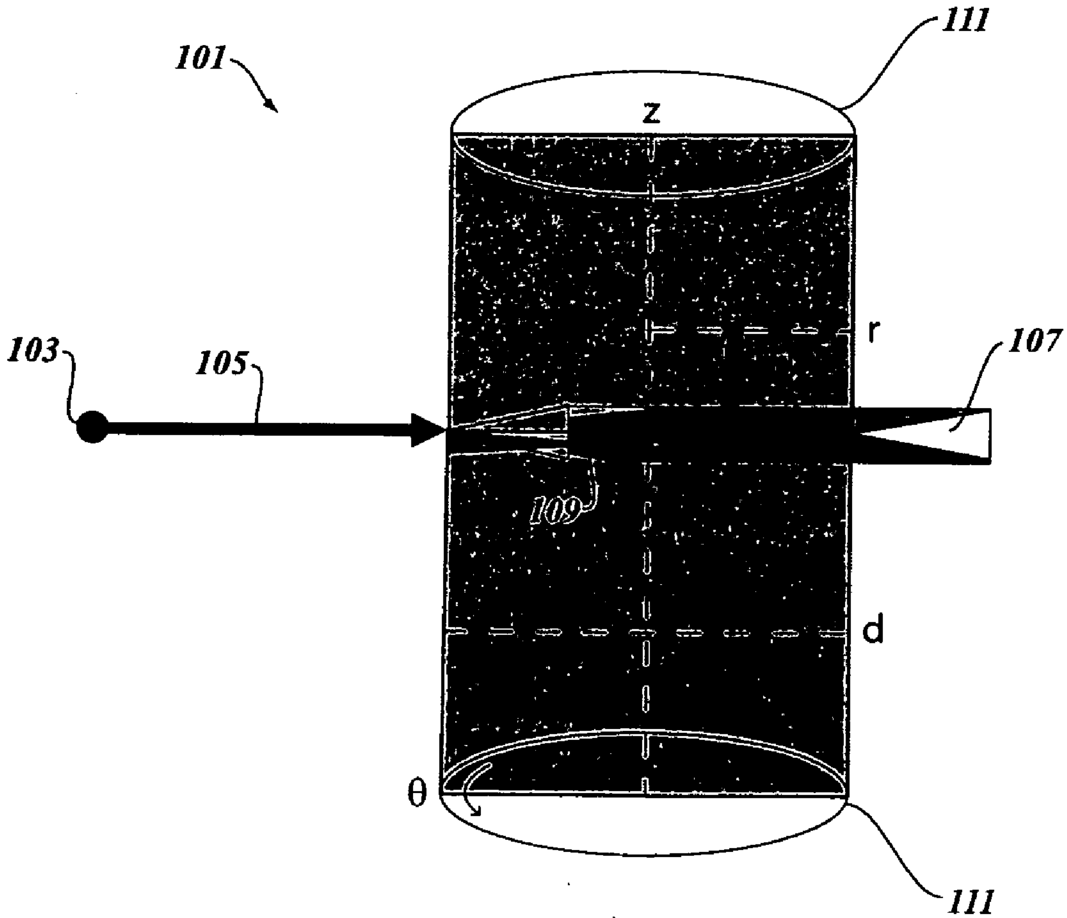


FIG. 2

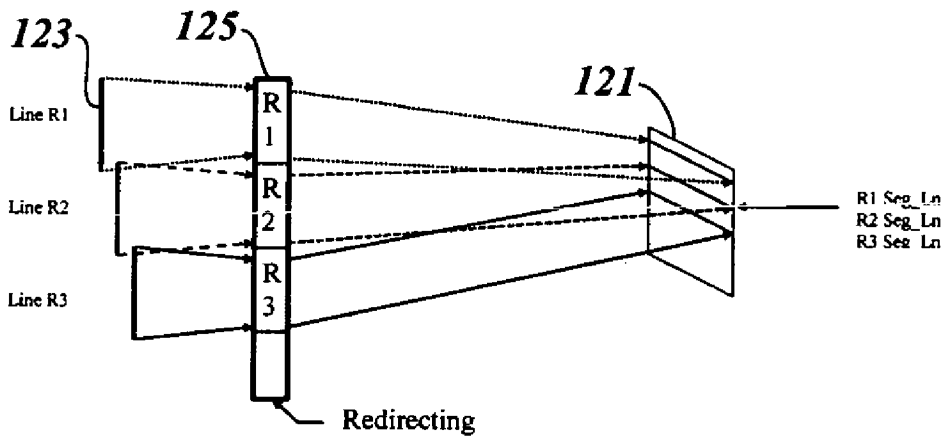

123
125
121
Line R1
Line R2
Line R3
R
1
R
2
R
3
R1 Seg_Ln
R2 Seg_Ln
R3 Seg_Ln
Redirecting

FIG. 3

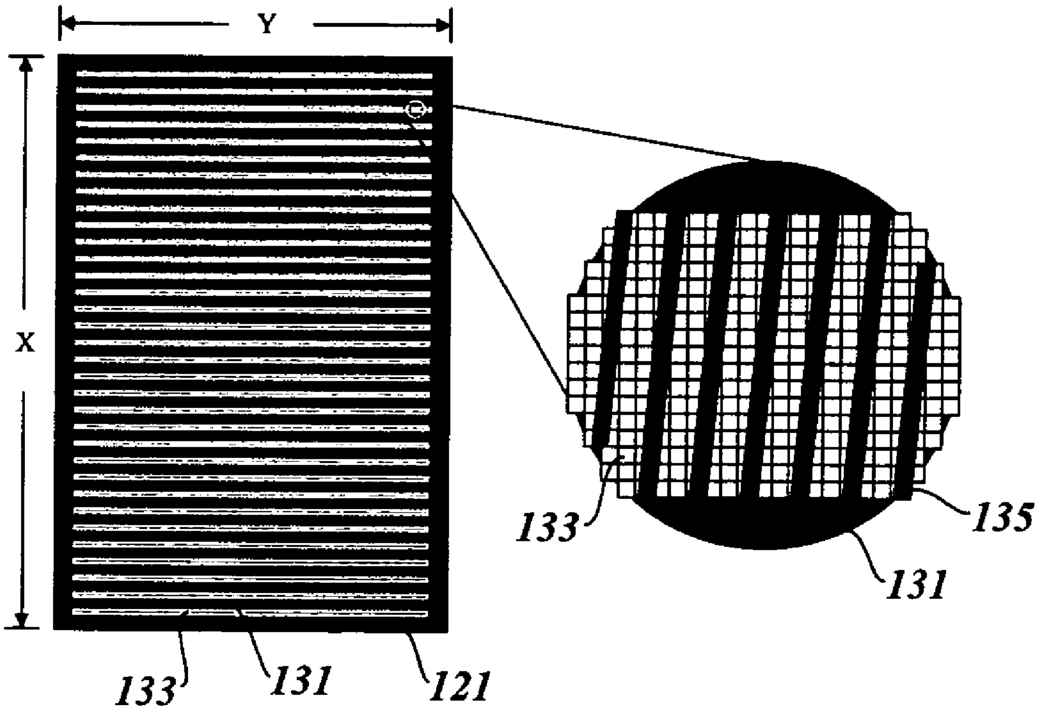

Y
X
133
131
121
133
135
131

FIG. 4

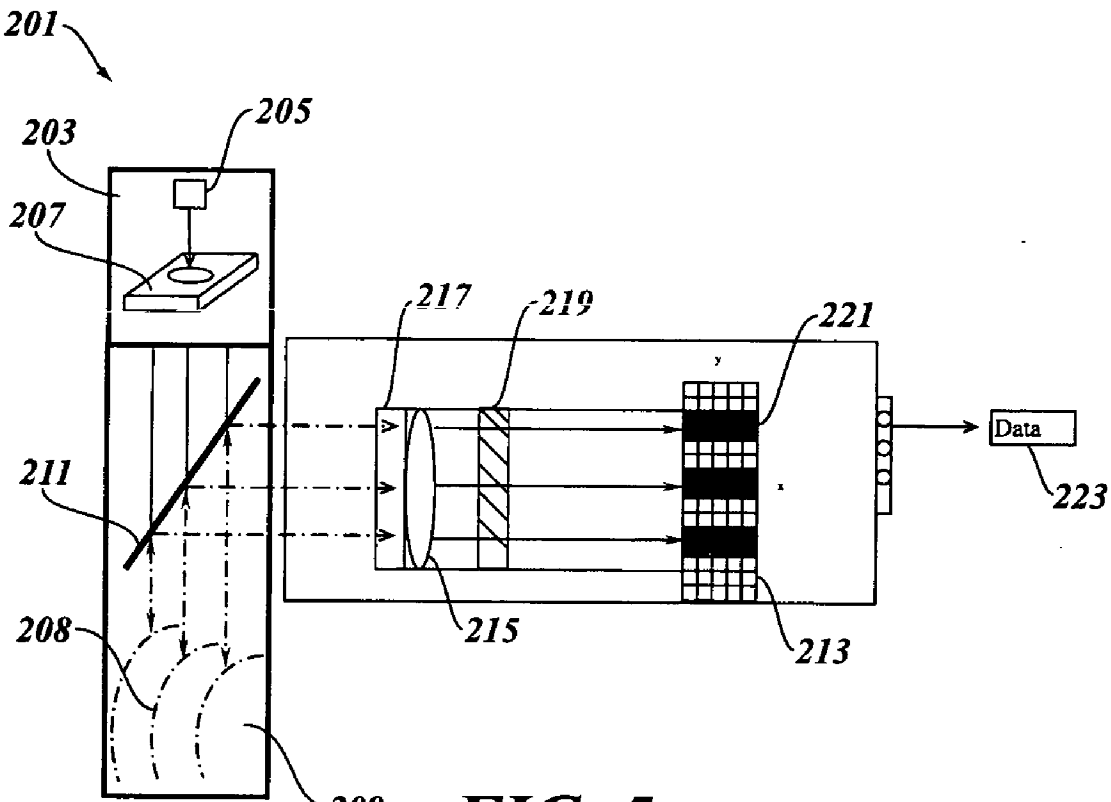

201
203
205
207
211
208
209
217
219
221
Data
223
215
213
y
x

FIG. 5

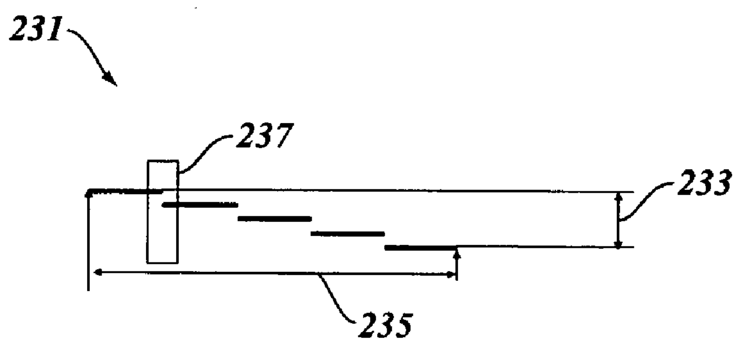

231
237
233
235

FIG. 6

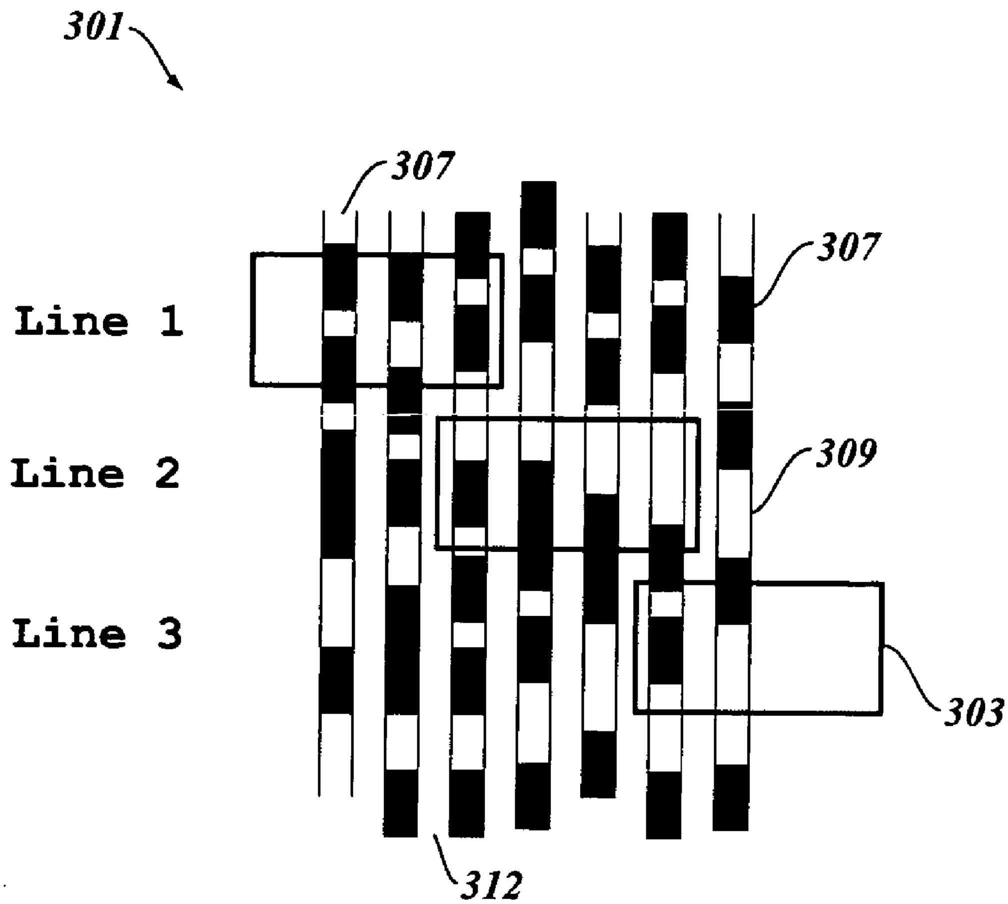

301
307
307
Line 1
Line 2
309
Line 3
303
312

FIG. 7

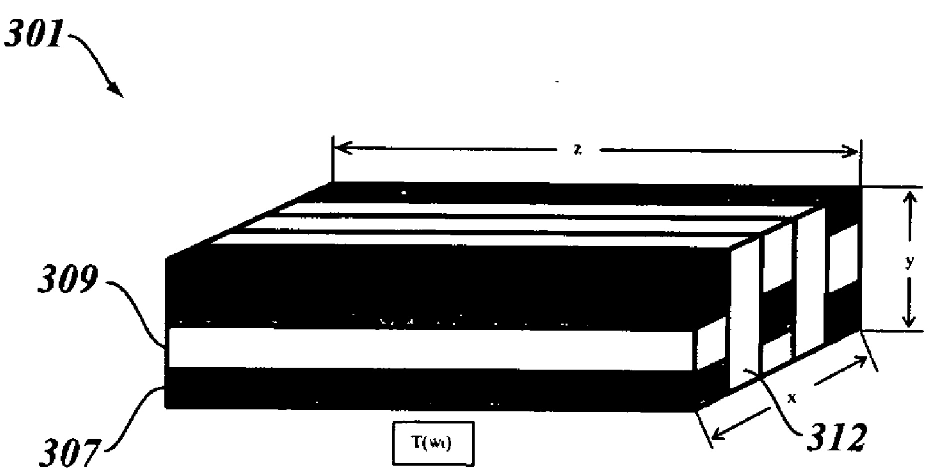

301
z
y
309
x
307
T(wt)
312

FIG. 8

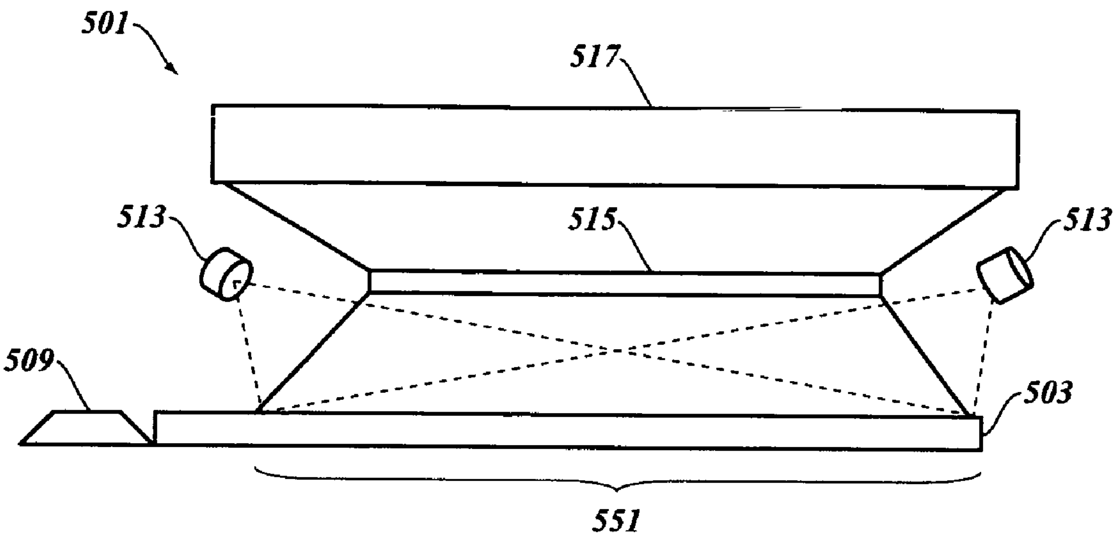


FIG. 9

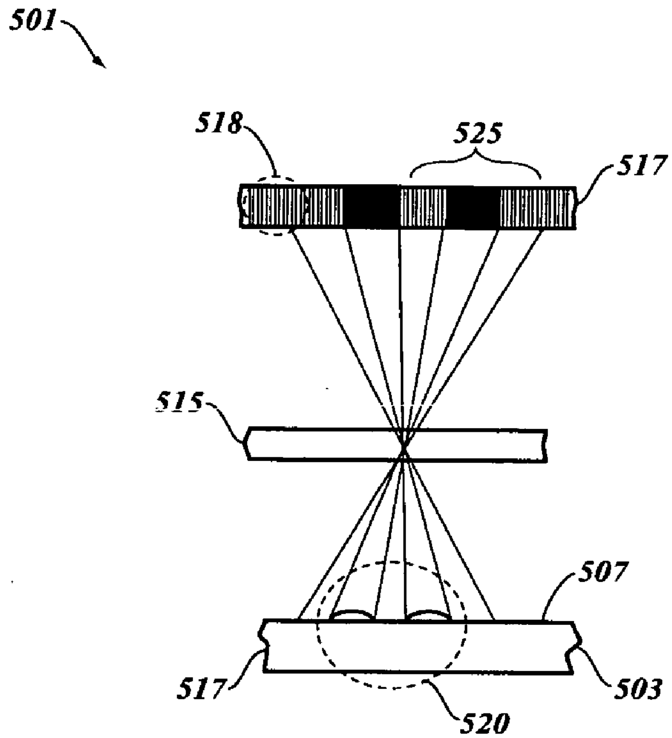


FIG. 10

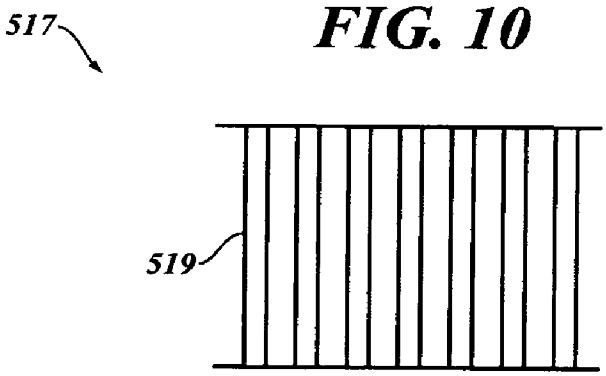


FIG. 11

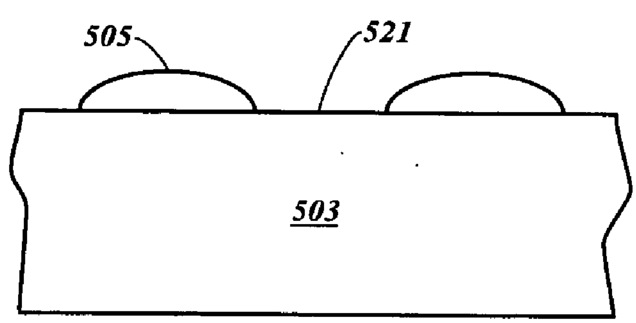


FIG. 12

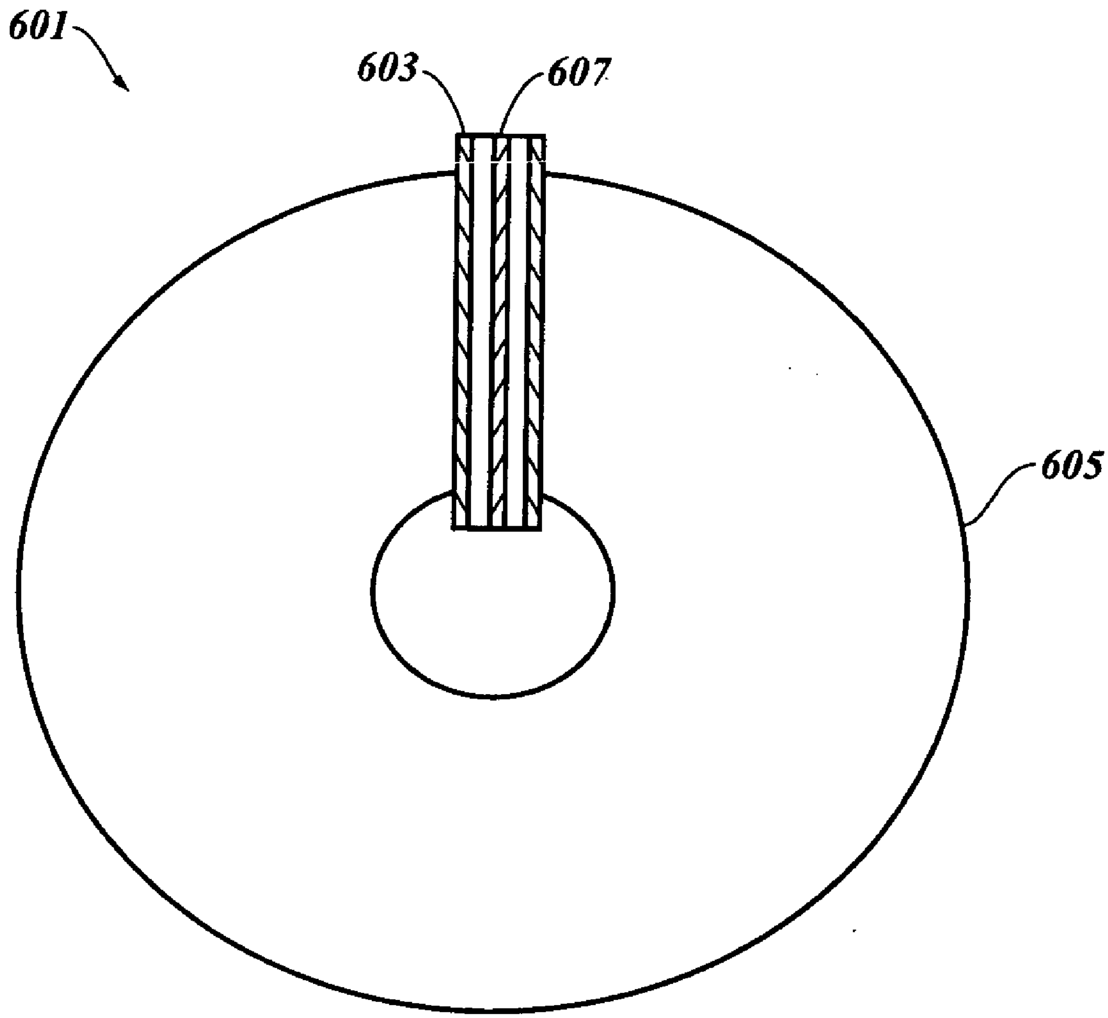


FIG. 13

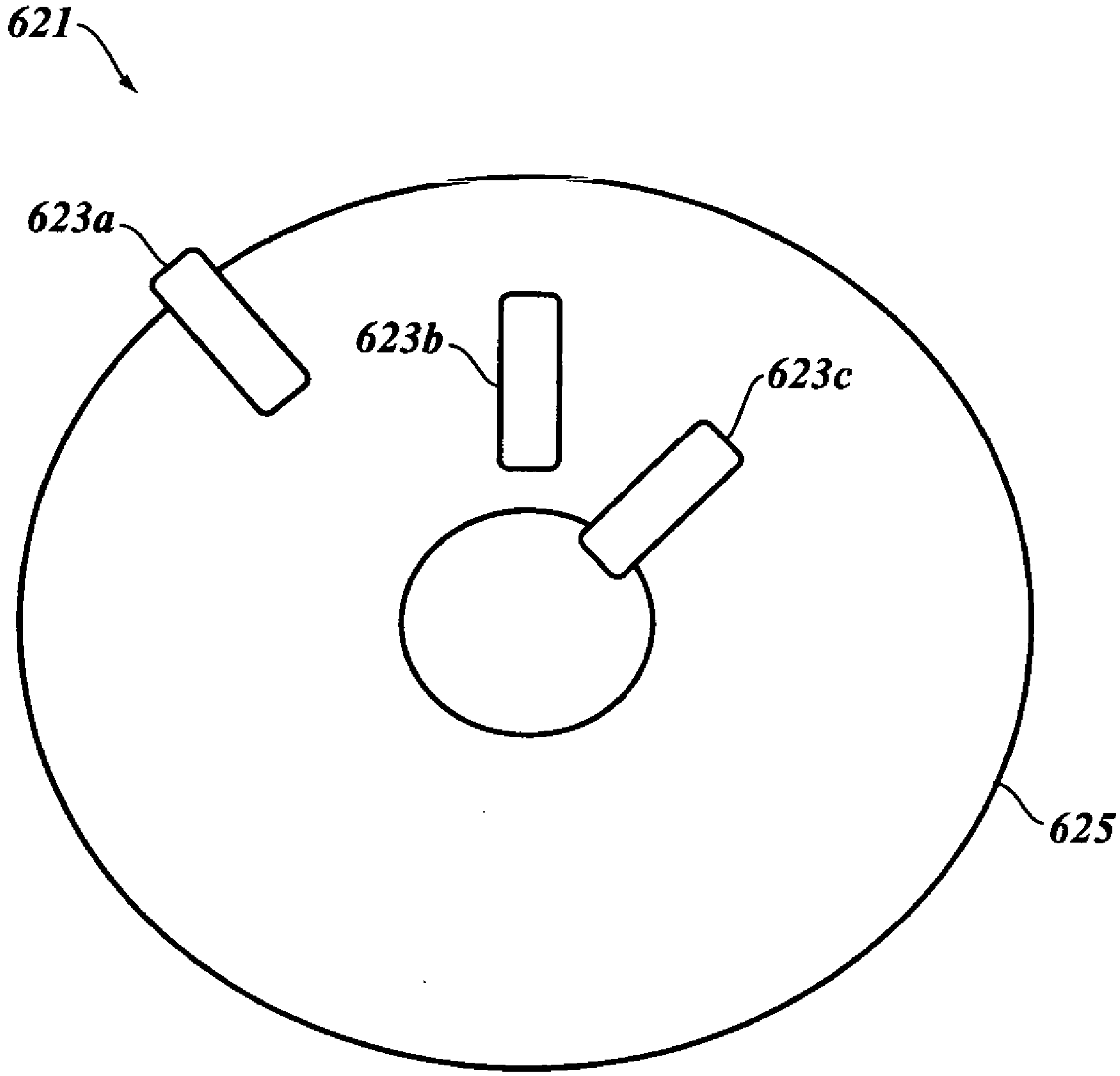


FIG. 14

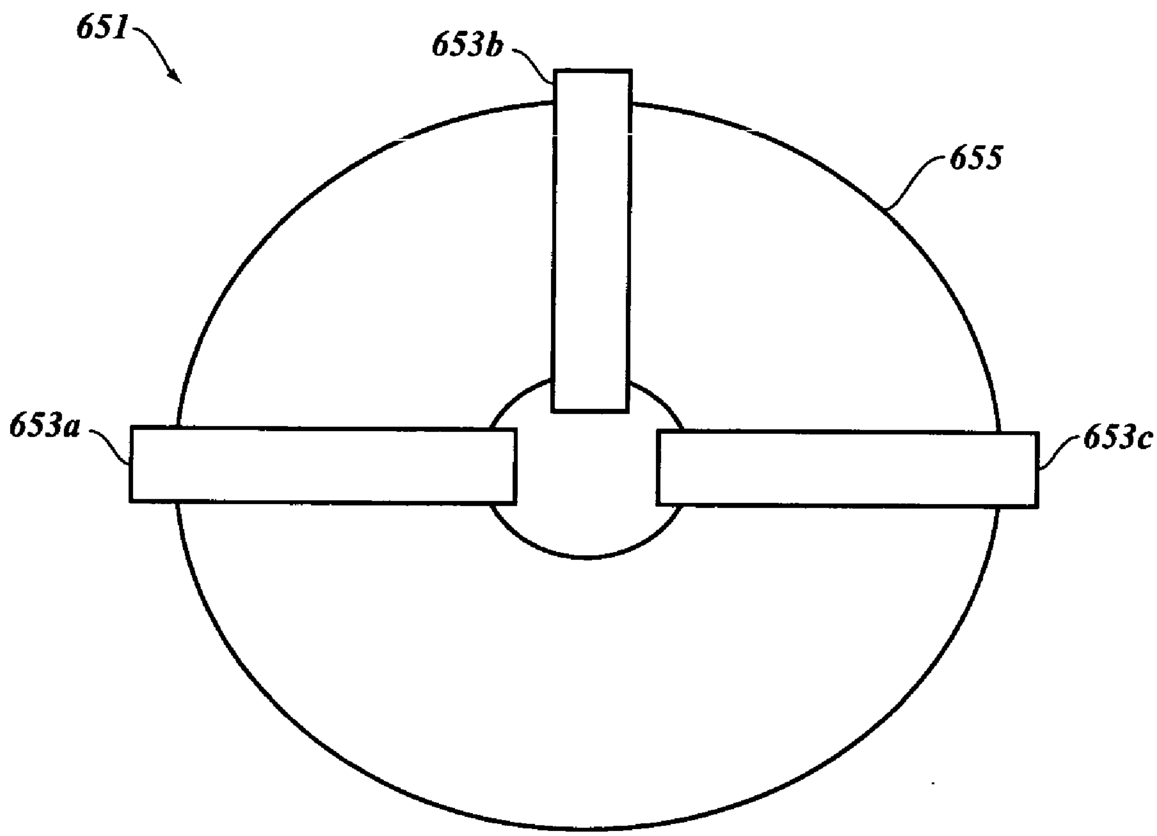


FIG. 15

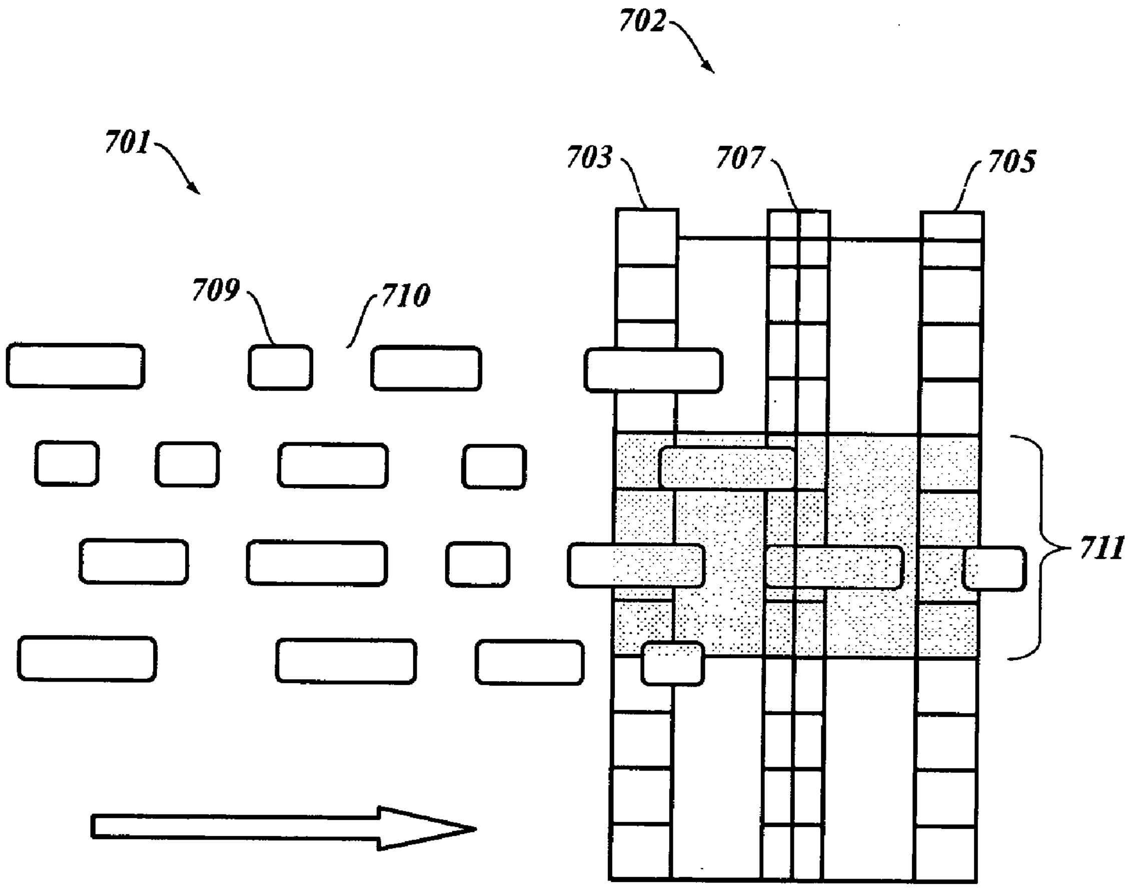


FIG. 16

METHOD AND APPARATUS FOR CREATING A MULTI-DIMENSIONAL DATA SIGNAL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Ser. No. 60/463,744, filed Apr. 18, 2003, entitled "Apparatus for Generating a Multi-Dimensional Binary Data Signal," having the same inventors, and incorporated herein by reference in its entirety; to U.S. Ser. No. 10/731,784, filed Dec. 9, 2003, entitled "Apparatus for Generating a Multi-Dimensional Data Signal," having the same inventors, and incorporated herein by reference in its entirety; and to U.S. Ser. No. 11/057,553, filed Feb. 14, 2005, entitled "Multi-Dimensional Data Signal and System for Manipulating the Same," having the same inventors, and incorporated herein by reference in its entirety.

TECHNICAL FIELD OF THE INVENTION

[0002] The teachings disclosed herein relate generally to data storage devices and methodologies, and more particularly to devices and methodologies for generating, storing, retrieving, and manipulating multi-dimensional data signals.

BACKGROUND OF THE INVENTION

[0003] Data storage devices are an essential element of any computer system. These devices have evolved to the point where enormous amounts of data may be stored on these devices and retrieved as needed.

[0004] **FIG. 1** depicts the functional configuration of a conventional static storage device. The device **11** employs a mechanical head **13** that uses monochromatic radiation **15** to transfer static information from or to a location on a storage medium **17**. To gain access to any given data, this mechanical head must traverse along a path defined with respect to the radius and length of the surface of the medium, seeking out the location of the recorded information desired. The time required for this mechanical device to traverse from one location on the storage medium to the next is referred to as "seek time".

[0005] A signal is generated from static data off the surface of the storage medium **17** in linear, sequential fashion with the aid of the mechanical head **13**. This signal is then transmitted for the purpose of being acted upon, manipulated by some means, or held in volatile memory.

[0006] Information is typically stored in data storage media as binary data. Binary data is typically represented by either a zero or a one, and is known as a bit. Data of this type may be either static or dynamic. Data which resides in a volatile state and which is being processed, transmitted, or otherwise acted upon, such as the data residing in Random Access Memory (RAM), is often referred to as dynamic data. By contrast, data which resides in a non-volatile state, such as the data residing on certain types of magnetic tape, magnetic discs, optical discs, is often referred to as static data.

[0007] Structured data, or information, is transmitted from one point to another as data signals. These binary data signals, which typically take the form of energy pulses, are generated for the purpose of storing, retrieving, processing, and transmitting information in the form of bits, bytes, words, packets, and the like. These signals (also called bit streams) are bit patterns that are structured sequentially, that is, structured linearly in one dimension. Hence, an energy pulse may be used to represent a bit of data within a bit stream that can be interpreted as logical lexicons such as "on or off", "yes or no", "0 or 1", "true or false", or any other type of discreet Boolean expression. Parallel bit streams are multiple sequential bit patterns that require independent channeling per bit stream. Nonetheless, the signal generated is structured linearly and in one dimension. For example, an eight-bit word is based on two discreet binary states to the power of 8, minus 1 (i.e., 2^8-1). The binary structures in such a word would be represented as some combination of these binary states in sequence (e.g., as 10110011). A simple method to represent this value would be to generate eight energy pulses with this sequence in a specified time. The signal is represented dimensionally as two to the power of 8, minus 1, as this energy pulse is in either of two discrete Boolean states as noted above.

[0008] Conventional CD discs of the type presently available have about 3.5 inches (36 mm)of active area. In this area, there are about 22 thousand concentric circular tracks (about 16000 tracks per inch, or 1556 tracks per mm). The tracks in a conventional optical disc are similar to the grooves in a vinyl record in that a single long line contains all of the active information. The track pitch is about 1.6 microns. Data from the spiral track is in the form of depressions, called "pits", and flat areas, called "lands". To extract information from an optical disc, a laser is focused through a set of optics onto the tracks. The light reflected from the track will determine if the incident light has landed on a pit or a land. In particular, a pit will disperse the incident light almost completely, while a land will reflect light back. The incident light is passed through a one way mirror disposed at an angle to the incident beam so that light reflected from the track surface will be redirected towards a set of photodiodes for sensing and tracking.

[0009] Binary data passing within the area illuminated by the laser is accessed sequentially as the medium rotates, and a signal is subsequently generated which comprises logical, sequential bits that are to be interpreted. This reflected signal, containing the desired binary information, is collected linearly (that is, in one dimension). An electro-optic device mounted on the mechanical mechanism follows this track until the task of accessing the end of the desired recorded information is achieved, a process which can take several rotations of the medium to complete. Once the correct information has been located from the medium, conventional optical devices increase the rotational speed of the medium in order to access the data faster.

[0010] The time it takes to acquire the recorded static information from the surface of the medium is referred to as "access time", and is a function of the rotational speed of the medium and of the electro-optics employed. When multiple requests to the same device occur, the time required for one process to complete before the next request can commence is known as the "lag time".

[0011] Presently, the primary limitation in information retrieval speeds of conventional optical disk drives is seek time. This limitation is the principle reason why data transfer rates do not increase linearly as a function of disc rotation speed. In fact, tests have shown that a 24× optical disc exhibits an improvement in operating performance of only about 20% when compared to 12× optical discs, rather than the approximately 100% improvement that might be expected if seek time were not a factor. The primary reason for slow seek times arises from conventional optical disc drive technology. While current optical disk drives are simple in design and construction, their performance is severely limited by the spatial distance the drive head has to cover, using a motor and gear mechanism, in order to access data located over several different tracks.

[0012] Another factor that reduces data retrieval speeds arises when multiple requests for data are sent to a single device. The submission of multiple requests has the effect of increasing the lag time and creating a bottleneck. Unfortunately, any decrease in data retrieval speeds can result in significant performance degradation in equipment which relies for its operation on the data retrieved from the data storage device. Typically, increasing the rotational speed of the data storage medium will not, by itself, compensate for increases in seek times and lag times.

[0013] Some attempts have been made to improve information retrieval speeds by constructing optical disk drives which utilize multiple mechanical devices or electro-optic heads to access multiple recorded informational areas. However, the additional cost in parts and electronic overhead makes this approach cost prohibitive for most applications. Other devices are provided with "look-ahead" algorithms to achieve some level of parallel accessing. However, the performance increases achievable with these devices are only incremental, and therefore do not adequately address the above noted problems.

[0014] There is thus a need in the art for methodologies for maximizing the performance and minimizing the seek time, access time, and lag time of optical disk drives and other memory devices. There is also a need in the art for memory devices which utilize such methodologies. These and other needs are met by the methodologies and devices disclosed herein and hereinafter described.

SUMMARY OF THE INVENTION

[0015] In one aspect, a method for accessing data from a data storage device is provided. The method comprises the steps of directing electromagnetic radiation onto the surface of the data storage medium/media, and receiving, as a multi-dimensional data stream, reflections of the electromagnetic radiation from the storage medium/media.

[0016] In some embodiments, prior to being directed onto the surface of the data storage device, the electromagnetic radiation is transformed into a hologram comprising a series of patterns. This hologram may encompass, but is not limited to, lines, dots, or combinations thereof. This transformation may be achieved, for example, by a holographic lens element, and the reflection of the hologram may be captured by a CMOS or CCD photo diode array or by other suitable detectors. However, one skilled in the art will appreciate that other linear detector arrays or ensuing technologies may also be used for this purpose, and there use is contemplated herein.

[0017] In other embodiments, the reflected electromagnetic radiation is transformed into a hologram comprising a series of line patterns after being directed onto the surface of the data storage device, after which the reflection of the hologram may be captured by a CMOS or CCD photo diode array.

[0018] The multidimensional data stream preferably comprises binary data. In some embodiments, the data storage device, which is preferably a static storage device, may comprise at least first and second data storage media, and a plurality of bits and/or data tracks may be accessed on the first and/or second storage media simultaneously and in parallel.

[0019] In another aspect, a method for generating a multidimensional data signal is provided. The method comprises the steps of generating a first signal from an electromagnetic radiation source, directing the first signal onto the surface of a data storage device, and receiving a second, multi-dimensional signal from the data storage device. The data captured is preferably binary data.

[0020] The method may further comprise the step of manipulating the second signal into at least two combinations of measurable parameters selected from the group consisting of, but not limited to, length, width, height, radius, angle, spatial dimensions, and time. The method may also comprise the step of measuring the second signal. The data storage device preferably comprises at least one static storage medium, and the first signal preferably bisects the at least one static storage medium. The at least one static storage medium may comprise first and second static storage media, and the method may further comprise the step of accessing multiple bits and/or data tracks on the first and/or second storage media simultaneously and in parallel.

[0021] In yet another aspect, a data retrieval system is provided which comprises a data storage medium, a sensor array, a mirror, and a holographic lens element adapted to cooperate with said mirror so as to generate a hologram in the form of multiple data patterns that are focused upon said sensor and/or sensor array.

[0022] In some embodiments, the holographic lens element is adapted to receive electromagnetic radiation reflected from said data storage medium or media and is further adapted to generate, from the reflected electromagnetic radiation, a hologram in the form of multiple data patterns that are focused upon said sensor array.

[0023] In other embodiments, the system further comprises a source of electromagnetic radiation, such as a monochromatic or polychromatic laser source, and the holographic lens element is adapted to receive electromagnetic radiation from said source and is further adapted to generate, from the electromagnetic radiation, a hologram in the form of multiple data patterns that are focused upon said data storage medium. Preferably, the data patterns are line patterns, the data storage medium comprises a plurality of tracks, and each of the data patterns corresponds to electromagnetic radiation reflected from one of said plurality of tracks. In some embodiments, the bit patterns on the surface of the disc or storage medium may be multidimensional bit patterns. The storage medium may be preformatted to utilize a multidimensional format (the header files may also be in this format). Either or both of the input and output signals in the system may also be multidimensional.

[0024] The data retrieval system may further comprise a source of coherent electromagnetic radiation, and a beam splitter which is adapted to receive electromagnetic radiation from the source and is further adapted to split the electromagnetic radiation into a plurality of multiple beams. The data storage medium may comprise a plurality of optical discs, and the data retrieval system may be constructed such that each of the plurality of beams impinges upon one of the plurality of optical discs.

[0025] In still another aspect, a device is provided which comprises a source of an electromagnetic radiation signal, a reflective element adapted to direct the electromagnetic radiation signal onto the surface of a data storage device, a second element adapted to capture binary data in multiple dimensions from the data storage device, medium, or media, transporting means for transporting data in multiple dimensions, manipulating means for manipulating said electromagnetic radiation into any given minimum two combinations of measurable dimensions relating to length, width, height, radius, angle, spatial dimensions, and/or time, and measuring means for measuring said electromagnetic energy. The data storage device may comprise a static or dynamic storage medium or media. In some embodiments, the data storage device can be adapted to simultaneously read to and write from the data storage medium or media.

[0026] In another aspect, a device for generating a multidimensional signal is provided. The device comprises a source of electromagnetic radiation, capturing means for capturing binary data in multiple dimensions from a static storage device, medium, or media, transporting means for transporting data in multiple dimensions, manipulating means for manipulating said electromagnetic radiation into any given minimum two combinations of measurable dimensions relating to length, width, height, time, radius, and/or angle, and measuring means for measuring said electro-magnetic energy. The signal is preferably convertible to a static state and a dynamic state, anu can preferably be measured dimensionally by a function of binary data, by some function of binary bit(s) in relation to time, or by some function of binary bit(s) in relation to space or any combination thereof The signal may also comprise and be measured by any given number of bits of information in relation to combinations of space and time, or may be manipulated or processed mathematically with linear or non-linear, parallel, or multidimensional algorithms.

[0027] One skilled in the art will appreciate that the storing, retrieving, processing, and transmitting of a multidimensional data signal has substantial benefits and enhancements and can offer significant performance improvements in devices that access data from data storage media. Accordingly, the present disclosure provides a means of increasing data at any given time, lowering costs in generating information, decreasing or eliminating input and/or output bottlenecks, improving static and dynamic data functionality in performance (typically by orders of magnitude), providing a greater level of security for information, and providing a greater degree of data integrity. Still further advantages of the devices and methodologies disclosed herein will become apparent from a consideration of the ensuing description and accompanying drawings.

[0028] One skilled in the art will appreciate that the various aspects of the present disclosure may be used in various combinations and sub-combinations, and each of those combinations and sub-combinations is to be treated as if specifically set forth herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which like reference numerals indicate like features and wherein:

[0030] **FIG. 1** is an illustration of a conventional data storage device;

[0031] **FIG. 2** is a ray tracing showing a generated source of coherent electromagnetic radiated energy interacting with a mirror component (the mirror component inverts the electromagnetic raddied energy) and bisecting perpendicularly two optical discs;

[0032] **FIG. 3** is an illustration depicting the reflected energy source of **FIG. 2** from a multifaceted mirror component or passing through a Holographic Optical Element (HOE) and striking a detector with the data pattern captured from the media in a recognizable pattern;

[0033] **FIG. 4** is an illustration showing the illumination of multiple data tracks on a storage medium upon an imager;

[0034] **FIG. 5** is an illustration of one specific embodiment of a data retrieval system made in accordance with the teachings herein;

[0035] **FIG. 6** is an illustration of a line pattern generated by a line generating holographic element or detector;

[0036] **FIG. 7** is an illustration of multidimensional incidence on an optical disc;

[0037] **FIG. 8** is a 3D cross section of a generic multidimensional binary data signal;

[0038] **FIG. 9** is an illustration of one particular embodiment of a data retrieval device made in accordance with the teachings herein;

[0039] **FIG. 10** is an illustration depicting in greater detail the means by which data is retrieved in the device of **FIG. 9**;

[0040] **FIG. 11** is a magnified view of REGION **518** in **FIG. 10**;

[0041] **FIG. 12** is a magnified view of REGION **520** in **FIG. 10**;

[0042] **FIG. 13** is an illustration of a particular embodiment of a data retrieval device in accordance with the teachings herein in which the data retrieval device comprises a unitary data access head;

[0043] **FIG. 14** is an illustration of a particular embodiment of a data retrieval device in accordance with the teachings herein in which the data retrieval device comprises multiple data access heads;

[0044] **FIG. 15** is an illustration of a particular embodiment of a data retrieval device in accordance with the teachings herein in which the data retrieval device comprises multiple lower resolution data access heads; and

[0045] **FIG. 16** is an illustration depicting the use of a data access device of the type shown in **FIG. 13** in retrieving data from a data storage medium.

DETAILED DESCRIPTION OF THE INVENTION

A. Overview

[0046] In accordance with the teachings herein, methodologies and devices are provided that enhance and/or maximize the performance and/or minimize the seek time, access time, and lag time of optical disk drives and other memory devices. In particular, a novel disk drive design is provided herein which eliminates moving parts from the drive head and which increases data transfer rates by at least an order of magnitude. Various methods which utilize, or which may be implemented by or used in conjunction with, this disk drive design are also disclosed.

[0047] In some embodiments of the disk drive design disclosed herein, the drive accesses data simultaneously from several tracks or several locations on one or more optical discs or other optical data storage medium, thus eliminating or greatly reducing seek times. This design enables multidimensional data access, wherein burst reads can make data transfers within a single signal from several tracks individually, simultaneously, and/or in parallel, wherein single and/or multiple bits per track can be illuminated with the read head, and wherein the principle limitation in data access rates is the processing electronics. The methodologies and devices disclosed herein maximize the performance of data storage units and the devices that utilize them, and may be used to minimize or eliminate seek time, access time, and lag time in such devices.

[0048] Methodologies and devices are also disclosed herein which utilize multidimensional signals to store, retrieve, process, and transmit information and its components. By contrast, conventional telecommunications, network infrastructures, and digital environments typically store, transfer, and manipulate bits of information in one dimensional, linear terms.

[0049] The devices and methodologies disclosed herein allow data to be available instantaneously or simultaneously from static storage media. Consequently, seek time and lag time are essentially eliminated, while access speeds are limited only by the latency (that is, the time it takes for a specific block of data on a data track to rotate around to the read/write head) of the media. The resultant signal that is generated from the modified device is multidimensional and hence has a more complex structure than the signals generated in conventional data storage technologies. This multidimensional signal may be transmitted and/or manipulated in a variety of ways. Furthermore, a signal of this type enables the use of multidimensional formats, algorithms, media or matrices for storing, retrieving, processing, and transmitting data relative to a given task and state of the data.

[0050] The above noted means for accessing any and/or all tracks of the medium at any given time preferably includes a signal source referred to herein as a Virtual Head (VH). When the signal source is a source of electromagnetic radiation, the VH may be referred to as a "Virtual Optical Head" (VOH). It will be appreciated, of course, that various signal sources can be used in the devices and methodologies described herein, including, but not limited to, acoustic, microwave, short or long wavelength radio, or x-ray signal sources.

[0051] In the case of a standard optical disc, in order to generate the complex signal, the VH bisects the diagonal or radius of the data storage media at some given distance perpendicular, or near perpendicular, to the media surface, thus allowing all data to be accessed in one half to one rotation of the media. The return signal is a multidimensional signal comprising binary data that can boost system performance by an order of magnitude or more compared to conventional data storage devices.

[0052] When the virtual head is applied to a single medium, the format is commonly a two dimensional signal generated over time, but the signal could also have 3 or more dimensions. If N multiple media are utilized, a signal having N or greater dimensions can be generated over time. The mathematical difference between the information conveyable using conventional one-dimensional technology, and that conveyable using a multi-dimensional approach of the type disclosed herein, can be appreciated with reference to TABLE 1, which shows a comparison of the possible unique permutations for an n-dimensional eight-bit data array or "word" based on 2 discreet binary states, wherein all dimensions have a maximum equivalent value and time t is constant:

TABLE 1

Possible Permutations in n-Dimensional Words

Dimensions	Permutations
1	256
2	65536
3	16777216

[0053] The details of some aspects of the devices and methodologies used to implement this approach are described in greater detail below and with respect to the specific, non-limiting embodiments depicted in the figures.

[0054] **FIG. 2** illustrates one particular embodiment of a data storage device made in accordance with the teachings herein. The data storage device **101** comprises a source **103** of electromagnetic radiation **105**. As noted above, the source may be a component of the virtual optical head. The electromagnetic radiation generated by this source may be referred to as the transmission signal, and can be characterized by various quantitative features, such as, for example, wavelength, frequency, power, harmonic or geometrical spatial distribution.

[0055] The electromagnetic radiation from the source is shown interacting with a mirror component **107**. The ray tracing shows the direction of the initial transmitting signal inverted vertically in the z direction, with width x of the original signal divided over a given length xy **109**. Since the width of the original generated signal is now the length of xy, the electromagnetic radiation bisects perpendicularly the diagonal (equal to d or xy) of the static storage media **111** which, in the particular embodiment depicted, comprises two optical discs.

[0056] The mirror component is preferably adapted to reflect the electromagnetic radiation at two times the angle of incidence, and to elongate the electromagnetic radiation by some given length xy. The length xy is preferably a minimum of the radius or diagonal of the optical disc or other storage media. In some embodiments, positive and negative vertical values may be created simultaneously with this component.

[0057] As previously noted, the electromagnetic radiation strikes and illuminates the optical discs **111** (which contain static data) perpendicularly or near perpendicularly, bisecting the radius/radii or diagonal/diagonals over given special domains measured in two/three dimensions, respectably. This illuminated space of coherent, electromagnetic energy captures data stored on the surface of the optical media and reflects it back according to the angle of incidence. This multidimensional, reflected signal passes through a hologram for the purpose of segmenting the signal. This segmented, multidimensional, coherent electromagnetic energy may be imaged on a detector **121** or sensor as shown in **FIG. 3**. The detector may be, for example, a CCD or CMOS detector. Other components may be employed for optimal focusing, alignment, and other purposes.

[0058] **FIG. 3** shows the return signal (second signal) reflected from the optical disc by way of mirror component **107** of **FIG. 2**. The reflected signal is now a Multidimensional Data Signal (MDS) **123** which passes through a Holographic Optical Element (HOE) or multifaceted, segmented mirror component **125** or any other device prior to striking the detector **121**. The second signal is now segmented and aligned upon a sensor array. When the MDS impinges upon the detector, it is encoded with the multidimensional data pattern captured from the data storage media **111** (see **FIG. 2**) in some recognizable pattern.

[0059] **FIG. 4** is an illustration of a magnified perspective of the reflected signal imaged upon the detector **121**. The segmented reflected radiation (second signal) is measured dimensionally by the Cartesian coordinates (xy). The radiation illuminates the static data stored on the surface of the data storage media and captures simultaneously multiple data tracks, and can capture single or multiple binary bits of data. The amount of data captured may be measured in terms of the number of bits of data within the mathematical domain $\{x, y; r, \theta\}$. As illustrated in **FIG. 4**, MDS light areas **133** represent the reflected signal segmented upon the imager, while the dark areas **131** represent separations between segmentations of the second signal. In a magnified perspective **139** shown to the right, each of the light areas **133** contain multiple data tracks **135** while the dark areas **137** indicate the adjacent lines or dead space" between tracks. When multiple discs are illuminated, the amount of data captured may be represented mathematically, in some instances, by the three-dimensional domain $\{x, y, z; z, r, \theta\}$.

[0060] In the preferred embodiment, a source of electromagnetic radiation, which may be a laser, is used to generate the transmitting signal that perpendicularly bisects the optical discs or other static data storage media, thereby resulting in multiple data tracks being accessed simultaneously, at the speed of light, and in parallel. This aspect of multidimensional signal generation can be achieved either through holographic means or by way of a properly designed mirror or EM component. This transmitting signal source of electromagnetic radiation captures binary data in multiple dimensions from the surface of the medium (media) and returns this pattern by reflection. The reflected MDS can be transmitted through space and/or inverted to accommodate transmission via optical fiber, by microwave transmission, through acoustic transmission, or through other suitable means, and can be captured on a Charged Couple Device (CCD), a CMOS detector array, or by other suitable means.

[0061] The signal which bisects the optical disc(s) or other static data storage media can be of a variety of geometrical patterns and can be of variable width, height, length, and intensity. The signal can be pulsed, quasi-pulsed, modulated or continuous, and be generated in any frequency of the electromagnetic spectrum. The return, reflected, multidimensional binary signal will vary with binary data as the media rotates over time. The static medium or media can be horizontal, vertical, or any degree off axis and can rotate at a set, variable or any combination of speeds. The data on the static media can be stored in a linear or multidimensional format. The MDS can be processed or manipulated linearly or multi-dimensionally with the appropriate algorithms. Notably, the MDS can be treated with current, linear means resulting in linear computations.

B. Novel Disk Drive Design

[0062] 1. Overview

[0063] **FIG. 5** illustrates another embodiment of a disk drive of the type disclosed herein. The disk drive **201** comprises a holographic line generating unit **203** that comprises a monochromatic or polychromatic laser source **205** and a holographic optical element **207**. The holographic optical element **207** transforms the radiation from the laser source into a hologram in the form of multiple line patterns that impinge upon the data tracks **208** of the optical data storage medium **209**. A one-way mirror component **211** is provided that redirects reflections from the optical data storage medium through a set off focusing optics **215**, **217** and a redirecting mirror **219** and onto a detector array **213**. The reflections **221** of the data tracks **208** from the optical storage media **209** are thus read by the detector.

[0064] The holographic lens element is preferably a sinusoidal line generating and/or binary phase beam splitting, diffraction grating holographic lens element. Such lens elements are available commercially from a variety of merchants. The hologram generated by these devices is a predefined image that has specific dimensions given as coordinates (x,y) which can be measured and quantified.

[0065] The disk drives disclosed herein may have one of at least two possible designs. In the first design, the line pattern or "beam" passes along an optical path including a one-way mirror before reaching the optical medium or media. Then, the holographic pattern is generated after reflecting off of the surface of the optical medium or media.

[0066] In some embodiments, a first set of focusing optics is provided to shape and size the line pattern as required by the geometry of the optical medium or media or detector. After incidence on the optical medium or media, the beam reflects and travels back the same path, or off axis a degree or so, towards a one-way mirror and passes through a holographic optical element, which segments the single line into multiple lines. The one-way mirror redirects the returning reflected signal that comes from the optical medium to a detector. A second set of focusing optics along with a redirecting mirror serve the function of spreading the beam over the sensor space of the detector as required by the sensor geometry and in such a way that the reflections of the data tracks from the data storage media are impinged upon the detector. The detector may be a CMOS or CCD detector array or the like and is preferably capable of random pixel selection with on board A-D conversion and onboard clocking.

[0067] 2. Holographic Line Generating Element

[0068] The holographic line-generating element **207** is an important component of many of the disk drives and other data storage and retrieval systems disclosed herein. Line generating devices that are currently commercially available generate up to 99 lines. These translucent lenses, for the purpose of discussion relative to this subject matter, create either 1-D linear incident patterns, or a 2-D plane of equidistant incident holographic pattern, which can then be focused down to a focal plane. If the incident beam is elliptical (as with diode lasers), elliptical patterns will emerge.

[0069] Dynamically, the reflected or incident beam of the laser emerges from the HOE as a hologram divided and diverging at consistent degrees of uniformity. This holographic pattern, when focused on the surface of an optical disc or detector, provides a homogenous environment for bit pattern recognition along the disc's radius. When the data storage media comprises a plurality of stacked optical discs and this hologram is utilized, the distances between the stacked discs can be very small (e.g., on the order of 1 to 3 mm), thereby simplifying complex alignments between different optical constituents. The length of the line, the pattern required, and the number of lines is determined by the geometry of the optical disc(s) and the sensor array. Some possible line patterns that can be used are shown in **FIGS. 3 and 6**.

[0070] With reference specifically to **FIG. 6**, the line pattern **231** shown therein comprises a series of lines **232** having an overall beam width **233** and an overall beam length

[0071] The overall beam length, width and height are variable but the beam length is preferably equal to at least the radius or diagonal of the optical disc(s). With respect to the sensor array, the length of the line may be dependent on the sensor geometry, and this factor will determine the total number of lines needed. Preferably, two adjacent areas of illumination should overlap each other (the area **237** marked X) to obtain coverage of all the lines in the optical disc(s) and to provide redundancy for error correction.

[0072] The reason for this type of pattern can be appreciated with respect to **FIGS. 7 and 8**. **FIG. 7** depicts one of many line patterns **301** incidence on an optical disc. The rectangles **303** represent segments that perpendicularly bisects the radius of the optical disc(s) and intersects its tracks. Each track **305** comprises a plurality of dark boxes **307** and white boxes **309**. The dark boxes **307** indicate pits in the tracks of the optical disc(s), while the white boxes **309** represent lands. The spaces **312** between adjacent lines correspond to spaces between the tracks in the optical disc. Since the recorded area has finite dimension, multiple pits and lands are captured. The recognized bit pattern is the result of flux intensities reflected from the disc surface(s) captured within this focal plane or volume which then will be imaged and resolved on the sensor array. Since a pit disperses the incident light and the land reflects it back completely, the reflected beam is a two dimensional image of the area of incidence **303**. **FIG. 8** is a 3D cross section of Line **1** of **FIG. 7** at incidence $T(w_t)$, where T is a function of the energy (E) delivered from the multidimensional illuminated area measured in Watts over a given time "t" typically measured in micro to nano seconds.

[0073] 3. Distribution of Power & Loss with Signal to Noise Ratio

[0074] The signal by definition will lose power at each interface within the system, including the interfaces at such components as the hologram, the mirror or lens components, and the disc(s) surface. Theoretically, considering power distribution over a given area will give a general understanding of the signal and its loss function ξ(x,y,z). In a typical, non-limiting set-up, the loss function is given by the integral:

$$\xi(x, y, z) = \left[P - \int\int\int H dx dy dz - \int\int\int L dx dy dz - \int\int\int D(R\sin\theta) d\theta dx dy\right] \quad \text{[EQUATION I]}$$

wherein

[0075] ξ=loss;

[0076] P=initial laser power;

[0077] H=reflection loss at hologram;

[0078] L=scattering loss at any lens element;

[0079] D=scattering loss at the disc(s); and

[0080] R sin θ=area covered by the focal plane.

It is important to note that this system is dealing with a volume of light (and hence the 3 dimensional integrals) until it strikes the disc(s). At that point, the dependence is brought down to an area with changing dθ.

[0081] The Signal to Noise Ratio (SNR) of a theoretical system is given by EQUATION 2 (representative, non-limiting values for some of the parameters in EQUATION 2 and in the succeeding equations and calculations have been provided for purposes of illustration):

$$SNR=AER \quad \text{[EQUATION 2]}$$

wherein

[0082] A=the area of the focus plane=65(0.9 μm×1600 μm);

[0083] $E=T(w_t)$=(laser power in Watts)(time)=Joules

[0084] R=sensor array response.

[0085] 4. Magnifying Optics

[0086] The reflected plane is a representation of the cross section of the optical disc(s). Each pit or land is captured as an image within the reflected plane. This beam will be magnified naturally as a result of the hologram before it impinges on the sensor array. The magnification of the reflected beam, which is accomplished by the nature of the hologram's creation, may be understood in reference to the following non-limiting example.

[0087] The track pitch in some currently available CD ROMs is 1.6 microns. The track width itself is only about 0.6 micron. Using 0.35 micron technology, the smallest pixel size that is currently available in the CMOS or CCD detectors is about 8-9 microns. However, the image size of a pit or a land on an optical disc is typically much smaller.

This means an image of many lands and pits will be smaller than the sensor pixel size, thus necessitating magnification of the return beam.

[0088] 5. Redirecting Optics

[0089] The purpose of the redirecting optics is to align and focus all the returning lines onto a given CMOS or CCD array geometry. The length of the returning beam is equal to the radius of the optical disc(s). Unfortunately, most sensor arrays cannot cover this area. However, since the returning beam is split into many lines, it is only necessary to have a CMOS or CCD array that is as wide as the length of a hologram. All the adjacent lines can then be redirected below this line on the CMOS or CCD array.

[0090] The redirecting optics can be accomplished either by utilizing another HOE, or by utilizing a mirror component with varying reflective indices (e.g., $R_1<R_2<R_3<R_4>R_5>R_6$, etc.). Due to these varying refractive indices, adjacent lines get focused below each other within the geometry of the CMOS or CCD. Thus, even though the angle of incidence for all the lines on the redirecting mirror is the same, due to the varying reflective indices, the angle of reflection changes. This change takes place where one track ends and the other track begins, as illustrated in **FIG. 4**.

[0091] 6. Sensor Array

[0092] Another important element in some of the devices made in accordance with the teachings herein is the CMOS or CCD sensor array. The ability of the CMOS or CCD sensor array to pick any pixel in the sensor space within the response time of the detector is critical to the operation of optical drives made in accordance with the teachings herein. Currently, this response time is on the order of microseconds. Since accessing pixels is equivalent to accessing different tracks, optical drives made in accordance with the teachings herein will be able to switch from one track to another at the response time of the CMOS or CCD detector once the driver software has calculated which track to access. It should also be clear that multiple outputs are achievable.

[0093] The geometry of the CMOS or CCD will typically drive the other physical design considerations of optical drives made in accordance with the teachings herein. TABLE 2 shows how the array size of the detector determines the number of lines needed from the line generator. Assuming that x represents that longest dimension of the CMOS or CCD detector and that the total number of tracks is 65,000 (this corresponds to the number of tracks on a conventional DVD), the number of pixels required per track in the x direction is 1 pixel. Therefore total number of pixels needed in the x direction for all 65,000 tracks is 65,000×3=195,000 pixels, and more preferably 65,000×5=325,000 pixels.

TABLE 2

Number of Lines Needed From Line Generator as a Function of Array Size

No.	No. of Pixels in the X direction	No. Of lines needed
1	1024	195
2	1050	190
3	2000	100
4	2050	97
5	3000	66
6	3050	65
7	4000	50
8	4050	49

[0094] TABLE 2 shows that an optimum pixel size would be 3000 or 4000 pixels in the x direction. The choice of array for a particular application would depend upon such factors as the response time, signal processing capabilities, and geometry of the array. The values set forth in TABLE 2, and the subsequent calculations based on these values, are for illustrative purposes only and assume a 10 micron technology. One skilled in the art will appreciate that these numbers may change as the detector array technology evolves.

[0095] For the y direction, the number of pixels needed can be calculated as follows:

[0096] required magnification=45x

[0097] line width=microns

[0098] number of lines=65 for 3000 pixels in the x direction

[0099] number of lines=50 for 4000 pixels in the y direction.

Therefore, total width=20 (width)*(66 or 50) lines*45 (mag.)=59,400 microns or 45,000 microns, Assuming a pixel size of 10 microns and an inter pixel distance of 5 microns, the number of pixels in the x direction is

59,400/15 or 45/000/15=4400 pixels or 3000 pixels.

Hence, the array dimensions are 3000×44000 or 4000×3000.

[0100] 7. Signal Processing

[0101] From a processing standpoint, if all spatial domains of the tracks map to a specific pixel space and do not change over time, the mapping of the particular track in the optical disc(s) to a specific pixel space can be predetermined. Once this relationship is known, the mapping can be made an integral part of the software driver.

[0102] For purposes of data access, it is only necessary to monitor the pixel that corresponds to the line to be accessed. For accessing data from any track, consider a virtual read head having a 1×2 pixel window. As the optical disc(s) spins, the virtual head remains stationary while accessing, at the speed of light, virtually any or all tracks and/or bit(s) simultaneously and/or in parallel. This is accomplished by slowly incrementing the x-access line of the detector, while keeping the y access line constant until the 1×2 head reaches the edge of the detector. The 1×2 head moves along one of the line images on the CMOS or CCD array. Once the edge of the detector is reached, the y access line is incremented by a known amount to next line image on the CMOS or CCD detector which corresponds to the continuation of a track in the optical disc(s). This is equivalent to the stylus of a record player moving closer to the center of the disc(s) as the disc(s) spins. A similar effect is accomplished here using a Virtual Read Head (VRH).

[0103] One significant difference between optical drives made in accordance with the teachings herein and conventional optical disc(s) manifests itself when the drive has to access data from another line many tracks away from the current line. As noted above, a conventional drive would have to calculate the spatial distance to move the head, and then use a gear mechanism to get to that location. In optical drives made in accordance with the teachings herein, the same effect is obtained simply by applying different coordinates to the x and y by the driver software to access lines in the CMOS or CCD detector.

[0104] Since the driver software will have the mapping information for all the tracks, the only thing needed is to feed the x and y access lines with the appropriate coordinates for any given track. This makes it possible to start supplying the data almost immediately. The time required to accomplish this task is estimated to be significantly less, or at worst equal, to the time taken by current drives to compute the distance to move the read head. However, in conventional drives, the read has to then move to its required location. Since optical drives made in accordance with the teachings herein can use a VRH, this operation is eliminated.

[0105] 8. Other Applications

[0106] a. Parallel Reads

[0107] The novel optical drives disclosed herein enable a variety of other performance boosting mechanisms. For example, using a multi-tap CMOS or CCD detector, it is possible to do data look ahead on several tracks basically "on-iine", that is, accessed concurrently or simultaneously instantaneously, prior to the VRH actually accessing that track. This facilitates burst reads as data from several tracks can be simultaneously fetched and processed in the same time it takes to process one track. The cost of processing many parallel tracks is in the processing electronics, and not in the drive heads themselves.

[0108] b. Multiple VRHs

[0109] Another function possible with optical drives made in accordance with the teachings herein is multiple, concurrent reads. The optical drives disclosed herein offer the possibility of simultaneous reads at different locations on the optical disc(s). This is equivalent to two users using the same optical disc(s) but accessing different tracks from that optical disc(s), a feat unimaginable with conventional drive technology. The real world advantage is that data requests to the drive from multiple users, to two or more different locations, need not be serialized. Rather, both the requests can be handled simultaneously.

[0110] 9. Description of Dynamic Optical Pickup for a Zero Seek Time Optical Media Reader

[0111] a. Overview

[0112] The concept for a zero seek time optical drive relies on a VH or optical pickup unit that may be implemented in a variety of ways. For example, the optical pickup unit may be implemented as a single unit that spans the maximum dimension of the optical media, or as a series of smaller, overlapping units that together span the maximum dimension of the optical media. Unlike existing optical pickups that must be physically moved to the vicinity of the track to be read, this optical pickup unit is of a size and radial orientation such that, on each revolution of the media, every data track or other progression of data encoded in the optical medium passes by the optical pickup unit.

[0113] The optical pickup unit preferably consists of a means to illuminate or direct radiation onto the portion or portions of the optical medium that contain encoded data, a means to magnify and focus onto an array of detectors the image of the disc features (e.g., pits and lands, or regions defined by light-adsorbing molecules) that are used to encode the data in the medium, and a detector array capable of distinguishing and/or reporting the transitions between disc features.

[0114] In many embodiments, the means to magnify and focus the image will be an optical lens. Such a lens may be mounted on the detector, mounted onto or integrated into the optical media itself, or may be placed or mounted elsewhere along the desired optical path. Moreover, the lens may include a plurality of lenses (e.g., it may be a lens array) or stacked lens.

[0115] An access operation (which may include a read operation, a write operation or both) is initiated by the selection of the proper track on which the data being sought lies. The selection operation results in the encoded signal from the selected track being read or accessed from the optical media by a dynamically assigned region of the detector. The values streamed are directed to a decoder that extracts track and sector position, data, and error detection and correction information from the encoded signal. Track selection and switching from one track to another in response to process requests is accomplished at electronic switching speeds, and hence may be on the order of nanoseconds.

[0116] The optical media that is read or accessed is assumed to belong to the family of physical encoding techniques represented by CDROMs, DVDROMs, and later generations of optical media such as HD-DVD and Blu-Ray™ optical disc formats. All encode data as a series of physical (geometric) changes in the media's data surface (often referred to in the art as "pits and lands") that are inscribed on the media in the form of a long spiral path of pitland transitions. Additional decode logic turns the progression of pitland transitions into a recovered data stream corresponding to the original data.

[0117] A moving optical disc is a dynamic target. The spiral data recording pattern means that, on each revolution, the consecutive data bits are subtly shifted radially by the distance represented by the track pitch. For example, the track pitch of a typical data CD is 1.6 microns (μm). Thus, a contiguous read of one circumference of the media will begin at radius X mm and end at a radius of X mm+1.6 μm. In addition, because optical media is not permanently mounted in the reader, the tolerances of the mating of the media to the rotating spindle, as well as the original manufacturing tolerances of the media, result in a some degree of run-out whose linear value may exceed the track pitch by as much as a factor of ten.

[0118] Existing optical pickups address the dynamic nature of the rotating media by means of corresponding physical motion of the optical pickup. lnitially, the entire optical pickup is moved to the vicinity of the track to be read. Next, the pickup centers itself on the pitland structures of a single track by means of comparing the amplitude of the signals returned by the data and the signal returned by the featureless areas between the tracks. A feedback mechanism constantly adjusts the tracking, by means of voice coils for small motions and the head positioning gear train for large motions. All of these motions are extremely slow when compared to the speed of electronics.

[0119] The preferred embodiment of the optical pick-up or access methodology described herein eliminates all speed-limiting physical motion in favor of optical tracking of the data track and electronic switching to the appropriate track. Detectors are not permanently assigned to any particular track, but rather, the signal rendered by the dynamic passage of the data features (e.g., pitslands) and the featureless inter-track areas are interpreted and the data is extracted from those detectors that have the most accurate "view" of the desired data. The selection of detector can be altered repeatedly or dynamically to maintain an undisturbed view of the data features as the data portion of the track "translates" radially beneath the detector in the course of a revolution. The run-out characteristic of a given readerdisc pair can be determined at startup and used as a predictive and corrective factor in the assignment of the detectors to data tracks.

[0120] In various embodiments, the optical pick-up devices utilized to implement the methodologies described herein may consist of:

[0121] (a) One or more sources of illumination arranged such that an entire radius of the data encoded portions of the media can be illuminated.

[0122] (b) One or more lenses that focus the reflected illumination from the optical media onto the detector array.

[0123] (c) One or more detectors consisting of at least 4 sensors elements (pixels) per track pair (data track plus adjacent unrecorded inter-track area).

[0124] (d) Selection electronics to determine which portion of the detector array should be used to sense the data on the desired track and to direct the state of those sensors to the track centering and data feature interpretation electronics.

[0125] The optical pick-up device may be implemented in various configurations. For example, the device may be implemented as a single, unified array of illumination, focusing, and/or detection elements, or as a series of radially arranged individual pickup or data access units that together provide access to the entire area of the data storage medium that contains encoded data. Multiple pickup units may be implemented, for example, in segmented or interlaced configurations. In the former, each pick-up unit spans a distance smaller than the radius of the media, but is capable of extracting the signal from every track that passes beneath the pickup. A series of these pickups thereby provides full coverage for the media's data array.

[0126] In the interlaced configuration, multiple pickup units span the entire radius, cross-section or maximum dimension of the data storage medium. The detector arrays of these pickup units may be less densely populated such that they are each capable of detecting and reading or accessing every Nth track beneath the detector array. In the aggregate, the N pickup units are capable of reading any of the tracks of the data storage media. The use of multiple detectors located a different angular positions can also be used to assist in predictive tracking corrections.

[0127] b. Logical Operation

[0128] Optical media of the type represented by CD ROMs and DVD ROMs divide the data recorded on their surface into various physical and logical features for the purpose of synchronization, positioning, and error detection and correction. Devices that incorporate optical pickups of the type described herein are capable of very high rates of response to random I/O requests. For this reason, the operating system logic that deals with such a device may treat it as a mounted file system analogous to a magnetic disk drive.

[0129] Requests for I/O initiated by a task are encoded by the operating system into a form that specifies the head or data pickup unit, the track and cylinder to be accessed, and the amount of data requested. The head/track/cylinder form is a holdover from older magnetic disc geometries and has almost no direct interpretation in terms of the disc geometry. The H/T/C formula is translated by the disk controller or drive into a logical block address that the drive electronics can interpret as a physical location to which to move the optical data pickup unit. A similar functional transformation will be employed to translate inputoutput (I/O) requests to the appropriate logical block address (LBA) for the optical media.

[0130] The optical pickup devices and methodologies described herein will permit analogous functions. When the optical media is mounted, the drive electronics will bring the media up to reading speed, during which the drive will detect the beginning and end of the data on the media surface, estimate the run-out of the mounted media (for use in adjusting the mapping of detectors to tracks) and establish the initial correspondence between detectors and tracks.

[0131] In operation, a request for a read is translated into a logical block address, and the estimated track is derived. A set of illuminators and detectors are activated that bracket the derived track position, and two search functions are commenced. First, the output of the detectors are compared in order to determine which detector(s) deliver the data signal and which detector(s) deliver the tracking (inter-track land) information. Then, as the data storage medium rotates or moves beneath the detectors, the reflected signal is streamed to the decode logic and a search for a synchronization pattern is initiated. Once synchronization is established, the internal address of the media data sector is compared to the one sought. This comparison holds until the desired sector rotates or moves under the data pickup unit. The sector contents are then delivered to the decode logic to be turned into the original data and delivered to the requesting task by way of buffering and bus control logic.

[0132] c. Specific Geometries for Optical Pickup Units

[0133] The foregoing principles may be further understood with reference to **FIGS. 9-12**, which illustrate a first specific, non-limiting embodiment of the means by which a read or data access operation may be implemented in accordance with the teachings herein. In the configuration **501** depicted therein, an optical medium **503** is provided which has a plurality of tracks **505** defined on a first surface

507 thereof (see **FIGS. 10 and 12**). The optical medium **503** is rotated about an axis by means of a spindle **509**. The tracks **505** (see **FIG. 12**) are illuminated by a suitable (preferably monochromatic) electromagnetic radiation source **513**.

[0134] The reflections of the tracks **505** are captured by a lens array **515** which focuses them onto a detector array **517** disposed in the optical pickup unit (not shown). The detector array **517** is populated with a series of photo detectors **519** (see **FIG. 10**) and is divided into regions such that, at a particular point in time, a given region R_N of the detector array **517** contains a plurality of photo detectors **519** that are dynamically assigned to track N of the optical medium **503**. Since the photo detectors **519** are dynamically assigned, any movements or fluctuations of the track during disc rotation that arise, for example, from disc aberrations or vibrations may be compensated for by dynamic reassignment of the photo detectors **519** within region R_N without requiring movement of the optical pickup unit.

[0135] The intervening regions **521** (see **FIG. 12**) between adjacent tracks (which are reflective and hence appear as bright regions to the detector array **517**) may be utilized in this process to identify the boundaries of track N, thus allowing the appropriate photo detectors within Region N of the detector array to be activated for image capture. The intervening regions **521** may be mapped during initial spin-up of the optical medium to provide some measure of predictability to this process.

[0136] **FIG. 13** illustrates a first particular, non-limiting configuration of an optical pickup device **601** which may be utilized in the devices and methodologies described herein. In the particular device **601** depicted, a single optical pickup unit **603** is provided which extends over the entire radius of the optical medium **605**. The optical pickup unit **603** contains a lens array and detector array as shown in **FIGS. 9-10**, and is equipped with a suitable number of photo detectors to read all of the tracks of the optical medium **605**.

[0137] **FIG. 14** illustrates a second particular, non-limiting embodiment of an optical pickup device **621** in accordance with the teachings herein. The optical pickup device **621** shown therein comprises multiple optical pickup units **623***a*, **623***b* and **623***c* which are allocated to reading multiple tracks across designated regions of the optical medium **625**. In this particular configuration, optical pickup unit **623***a* is disposed at a suitable angle to optical pickup unit **623***b*, and optical pickup unit **623***b* is disposed at a suitable angle to optical pickup unit **623***c*, it being understood that other angles, dispositions and arrangements are possible. Preferably, the regions assigned to optical pickup units **623***a*, **623***b* and **623***c* overlap by about 20 to about 25 tracks. Optical pickup units **623***a*, **623***b* and **623***c* typically contain about 4 pixels or detectors per track.

[0138] **FIG. 15** illustrates another possible, non-limiting embodiment of an optical pickup device **651** in accordance with the teachings herein. In some applications, especially those involving some of the new, extremely dense optical media being developed, it may not be possible or desirable to utilize a detector whose individual pixels are sufficiently dense to detect all of the tracks at one time. In such applications, effective reading of the optical media may nonetheless be accomplished using an optical pickup device **651** of the type depicted in **FIG. 15**. In the particular optical pickup device **651** shown therein, first **653***a*, second **653***b* and third **653***c* lower density optical pickup units are provided which are disposed over the optical medium **655**, though in other configurations, a larger number of optical pickup units may be provided. Preferably, although the first **653***a*, second **653***b* and third **653***c* optical pickup units are lower density optical pickup units, in the aggregate, they contain a sufficient number of pixels per track to allow the tracks in the optical medium **655** to be read. The desired image is then obtained by integrating or multiplexing over two or more of the detectors. In so doing, various algorithms may be employed to account for lag time and other such factors, and to effectively integrate the signals obtained at the individual optical pickup units.

[0139] **FIG. 16** illustrates one possible, non-limiting use of the data access device of the type depicted in **FIG. 13** in retrieving data from a data storage medium. In the configuration **701** depicted therein, the data access unit **702** comprises first **703** and second **705** detectors which are used to detect the outer portions of a track **711** in a data storage medium (and hence deal with wobble and runout), and a data detector **707** which is adapted to retrieve data **709** encoded in the track **711** itself in the form of a series of pits **709** and lands **710**.

[0140] Methodologies and devices have been disclosed herein that eliminate or reduce seek time, lower the overall costs of production and maintenance, and structure data in a real world, three dimensional matrix that results in the ability to perform complex mathematical computations that are impossible with today's one dimensional technology. The time to retrieve any amount of data is irrelevant to the amount of data to be retrieved. Moreover, these methodologies and devices provide superior parallel performance, superior data management systems and software performance, greater bandwidth, higher data transfer rates, and elimination or near elimination of inputoutput bottlenecks.

[0141] Although the description above contains specific details of some possible embodiments of the devices and methodologies disclosed herein, these should not be construed as limiting the scope of the invention, but as merely providing illustrations of some of the presently preferred embodiments of this invention. Various other embodiments and ramifications are possible within the scope of the present disclosure.

[0142] For example, the superior and more efficient means provided herein for storing, retrieving, processing and transmitting data will result in advances in medicine, scientific research and engineering. It is also evident that the devices and methodologies disclosed herein can result in substantial increases in performance in the storage, retrieval, processing and transmission of data, while also reducing long term overall costs, thus resulting in overall increases in bandwidth and lower costs. Consequently, it will be appreciated that the devices and methodologies disclosed herein will result in substantial improvements in telecommunications and networking functionality, encryption and data processing, etc.

[0143] It will also be appreciated that, while the devices and methodologies disclosed herein have frequently been described with reference to specific components (e.g., linear detector arrays, such as CMOS or CCD photo diode arrays), these components may be replaced by other components of like functionality that are presently available or that become available in the future.

What is claimed is:

1. A method for accessing data from a data storage medium, comprising the steps of:

directing electromagnetic radiation onto the surface of the data storage medium; and

receiving a multi-dimensional data signal from the data storage medium.

2. The method of claim 1 wherein, prior to being directed onto the surface of the data storage medium, the electromagnetic radiation is transformed into a holographic pattern.

3. The method of claim 2, wherein the electromagnetic radiation is transformed into a hologram by way of a holographic lens element.

4. The method of claim 2, wherein the reflection of the hologram is captured by a detector.

5. The method of claim 1, wherein the multidimensional signal is transformed into a hologram.

6. The method of claim 5, wherein the hologram is captured by a detector.

7. The method of claim 1, wherein the data signal comprises binary data.

8. The method of claim 1, wherein the storage device is a static storage device.

9. The method of claim 1, wherein the multidimensional data signal comprises reflections of the electromagnetic radiation from the data storage medium.

10. The method of claim 1, wherein the multidimensional data signal comprises transmissions of the electromagnetic radiation through the data storage medium.

11. The method of claim 1, wherein the electromagnetic radiation is emitted by a diffuse light source.

12. The method of claim 1, wherein the electromagnetic radiation is emitted by multiple light sources.

13. A method for generating a multi-dimensional data signal, comprising the steps of:

generating a first signal from an electromagnetic radiation source;

directing the first signal onto the surface of a data storage medium; and

receiving a second, multi-dimensional signal from the data storage medium.

14. The method of claim 13, wherein the data captured is binary data.

15. The method of claim 13, further comprising the step of manipulating the second signal into at least two combinations of measurable parameters selected from the group consisting of length, width, height, radius, angle, frequency and time.

16. The method of claim 13, wherein said data storage device comprises at least one static storage medium.

17. The method of claim 16, wherein the first signal bisects the at least one static storage medium.

18. The method of claim 13, further comprising the step of accessing multiple data tracks on the data storage medium simultaneously and in parallel.

19. The method of claim 13, further comprising the step of accessing multiple data bits on the data storage medium simultaneously and in parallel.

20. A data retrieval system, comprising:

a data storage medium;

a sensor array;

a mirror; and

a holographic lens element adapted to cooperate with said mirror so as to generate a hologram in the form of multiple data patterns that are focused upon said sensor array.

21. The data retrieval system of claim 20, wherein the holographic lens element is adapted to receive electromagnetic radiation reflected from said data storage medium and is further adapted to generate, from the reflected electromagnetic radiation, a hologram in the form of multiple data patterns that are focused upon said sensor array.

22. The data retrieval system of claim 20, further comprising a source of electromagnetic radiation.

23. The data retrieval system of claim 22, wherein said source of electromagnetic radiation is a laser source.

24. The data retrieval system of claim 22, wherein the holographic lens element is adapted to receive electromagnetic radiation from said source and is further adapted to generate, from the electromagnetic radiation, a hologram in the form of multiple data patterns that are focused upon said data storage medium.

25. The data retrieval system of claim 20, wherein said data patterns are line patterns.

26. The data retrieval system of claim 20, wherein said data storage medium comprises a plurality of tracks, and wherein each of said data patterns corresponds to electromagnetic radiation reflected from one of said plurality of tracks.

27. The data retrieval system of claim 26, wherein said data storage medium is an optical disc.

28. The data retrieval system of claim 20, further comprising:

a source of electromagnetic radiation; and

a beam splitter adapted to receive electromagnetic radiation from said source and to split the electromagnetic radiation into a plurality of multiple beams;

wherein said data storage medium comprises a plurality of optical discs, and wherein each of said plurality of beams impinges upon one of said plurality of optical discs.

29. A device, comprising:

a source of an electromagnetic radiation signal;

a reflective element adapted to direct the electromagnetic radiation signal onto the surface of a data storage medium;

a second element adapted to capture binary data in multiple dimensions from the data storage medium;

transporting means for transporting data in multiple dimensions;

manipulating means for manipulating said electromagnetic radiation into any given minimum two combinations of measurable dimensions relating to length, width, height, radius, or angle; and

measuring means for measuring said electro-magnetic energy.

30. The device of claim 29, wherein the data storage device comprises a static storage medium.

31. A device for generating a multidimensional signal, comprising:

a source of electromagnetic radiation;

capturing means for capturing binary data in multiple dimensions from a static storage device, medium, or media;

transporting means for transporting data in multiple dimensions;

manipulating means for manipulating said electromagnetic radiation into any given minimum two combinations of measurable dimensions relating to length, width, height, radius, or angle; and

measuring means for measuring said electromagnetic energy.

32. The device of claim 31, wherein said signal can be converted to a static state.

33. The device of claim 31, wherein said signal can be converted to a dynamic state.

34. The device of claim 31, wherein said signal can be measured dimensionally by a function of binary data.

35. The device of claim 31, wherein said signal can be measured dimensionally by a function of binary bits and time.

36. The device of claim 31, wherein said signal can comprise and be measured by some function of binary bits and space.

37. The device of claim 31, wherein said signal can comprise and be measured by any given number of bits of information in relation to combinations of space and time.

38. The device of claim 31, wherein said signal can be manipulated or processed mathematically with linear or non-linear, parallel, or multidimensional algorithms.

39. A data retrieval system, comprising:

a data storage medium;

a source of electromagnetic radiation; and

a plurality of data retrieval devices adapted to retrieve data from said data storage medium;

wherein each of said plurality of data retrieval devices comprises a plurality of photodetectors adapted to capture electromagnetic radiation from said light source after it has interacted with the data storage medium.

40. The data retrieval system of claim 39, wherein said plurality of photodetectors are adapted to capture reflections of electromagnetic radiation from said data storage medium.

41. The data retrieval system of claim 39, wherein said plurality of photodetectors are adapted to capture electromagnetic radiation which has been transmitted through said data storage medium.

42. The data retrieval system of claim 39, wherein said plurality of photodetectors are adapted to capture electromagnetic radiation which has been emitted from said data storage medium.

43. The data retrieval system of claim 39, wherein said plurality of photodetectors are dynamically assigned to capture electromagnetic radiation from said electromagnetic radiation source after it has interacted with specific data tracks defined in said data storage medium.

44. A data retrieval system, comprising:

a data storage medium; and

a fixed head adapted to retrieve data from said data storage medium.

45. The data retrieval system of claim 44, wherein said fixed head comprises a sensor array.

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