Optical disc and apparatus for scanning the optical disc.

The invention relates to an optical disc comprising a recording area for recording data at a substantially constant density, the recording area being subdivided in a plurality of coaxial annular zones comprising circular or spiral tracks, each track within one of the zones for storing a same predetermined amount of data at a track density, the average of the track densities within one zone being substantially equal to said constant density.

The invention further relates to a recording device for recording data at a substantially constant density on an optical disc comprising a recording area comprising circular or spiral tracks, which recording area is subdivided in a plurality of coaxial annular zones, which device comprises a recording head and recording control means.

The invention further relates to a read device for reading data from an optical disc recorded at a substantially constant density, the optical disc comprising a recording area comprising circular or spiral tracks, which recording area is subdivided in a plurality of coaxial annular zones, which device comprises a reading head and read control means.

Such a record carrier and apparatus are known from European Patent Application EP 0 587 019, document D1 in the list of related documents. The document discloses a record carrier in the form of an optical disc having a recording area comprising a pattern of grooves on a substrate, constituting a servopattern of circular or spiral tracks. The recording area is subdivided in coaxial annular zones, and within a zone each track comprises a same amount of data. Hence the density of data storage decreases when going radially outward, whereas at the start of the next zone the density is restored. The average density over the entire surface is substantially equal, usually called a CLV (Constant Linear Velocity) density, e.g. as used in the audio CD. However within a zone the amount of data in each turn of the track is constant, usually called a CAV density (Constant Angular Velocity). The disc comprises a number of radially aligned servo pits in each turn, constituting a so-called sampled servo pattern. The servo pattern comprising radially aligned elements is called Constant Angular Velocity (CAV) servo pattern, and is to be scanned by a servo system having a phase locked loop (PLL) to generate a servo frequency locked to the rotation frequency of the disc. The servo pits are dimensioned to be read clocked by said servo

rotation frequency of the disc. The servo pits are dimensioned to be read clocked by said servo frequency. Further a data phase locked loop is provided for generating a data clock locked to a speed of data read/write operations, which are performed at said substantially constant linear density. When jumping to a new radial position, the rotation frequency setting point or the data clock setting point are adjusted to the new position, but the servo phase locked loop remains locked to the CAV servo pattern. Hence the servo pits are always read at the servo frequency. The recording apparatus comprises an optical system for recording or reading information by generating a spot via a radiation beam on a track of the record carrier. The optical disc is rotated and the spot is positioned in radial direction on the centre of the track by servo means for scanning the track. During scanning the servo phase locked loop is locked to the rotation frequency of the disc for reading the CAV servo pattern. The data phase locked loop is locked to the CLV data speed. The known record carrier and apparatus have the problem, that for reliable operation a first phase locked loop must be locked to the CAV servo pattern, and a second phase locked loop must be locked to the CLV data density.

It is an object of the invention to provide an optical disc, a recording and a reading device arranged for a more reliable data recording and/or retrieval operation while data is recorded at a substantially constant density.

For this purpose an optical disc as described in the opening paragraph is characterized according to the invention in that the tracks comprise periodic characteristics which are radially aligned within each one of the zones, the periodicity being indicative of the track recording density for the track concerned. This has the effect, that the speed of data recording and reading can be directly locked to a signal generated by detecting the periodic characteristics. When jumping within a zone the speed is not changed, whereas when jumping to a different zone the speed changes by a known amount. There is no need for a second phase locked loop, only one phase locked loop locked to the data frequency is required. Hence, the recording is less complex and more reliable.

For the purpose mentioned above a recording device as described in the opening paragraph is characterized according to the invention in that, while the tracks comprise periodic characteristics which are radially aligned within each one of the zones and the periodicity being indicative of a track density for the track concerned, the average of the track densities within one zone being substantially equal to said constant density, the recording control means are arranged for detecting the periodic characteristics and for recording in dependence thereon a same

predetermined amount data in each track within one of the zones at said track density. A reading device as described in the opening paragraph is characterized according to the invention in that, while the tracks comprise periodic characteristics which are radially aligned within each one of the zones and the periodicity being indicative of a track density for the track concerned, the average of the track densities within one zone being substantially equal to said constant density, the read control means are arranged for detecting the periodic characteristics and for reading in dependence thereon a same predetermined amount data from each track within one of the zones at said track density. This has the effect, that data, although positioned corresponding to a CAV pattern within a zone, has on average substantially the CLV density, and can be recorded and read by means directly synchronized to a signal generated by detecting the periodic characteristics.

The invention is also based on the following recognition relating to the reliability of the detection of servo signals in high density optical recording. For achieving the high density the distance between tracks, the track pitch, is designed as small as possible for the available scanning system and scanning spot size. When servo elements, e.g. pits or other periodic track characteristics, are then scanned and a servo signal is generated, the servo elements of neighbouring tracks also influence the servo signal, which is called cross-talk. However for a CLV density the amount of data stored in a track must be increased radially. The inventors have seen that by aligning the periodic characteristics within a zone the cross-talk within the zone can be eliminated. At the start of the next zone the density is increased stepwise, so that on average the density is substantially equal to the CLV density. The cross-talk problem is now only present at the boundary track between two zones. The boundary track can be skipped, or special countermeasures can be taken to control the interference problems at the zone boundary.

An embodiment of the optical disc is characterized in that the size of zones is such that the difference in the number of periodic characteristics in a turn of the track at the boundaries of adjoining zones is relatively low in relation to the number of periodic characteristics in a turn of the track. A difference in periodicity causes an interference pattern including (partial) extinctions in a boundary signal generated from the periodic characteristics when scanning a track at the boundary of two zones. A low difference in relation to the periodicity results in the boundary signal having only a few extinctions, which can be positioned by selecting the phase difference of the periodic characteristics.

Further advantageous, preferred embodiments of the apparatus and detection unit according to the invention are given in the dependent claims.

These and other aspects of the invention will be apparent from and elucidated further with reference to the embodiments described by way of example in the following description and with reference to the accompanying drawings, in which

Figure 1 shows a record carrier,

Figure 2 shows a prior art optical disc with a CLV header pattern,

Figure 3 shows a zoned optical disc,

Figure 4 shows a header and sector layout,

Figure 5 shows an apparatus for reading a record carrier,

Figure 6 shows an apparatus for writing and reading a record carrier,

Figure 7 shows a land/groove servo pattern at a zone boundary,

Figure 8 shows an optical disc having a wobbled track, and

Figure 9 shows servo signals generated at a zone boundary.

Corresponding elements in different Figures have identical reference numerals.

Figure 1a shows a disc-shaped record carrier 1 having a track 9 intended for recording and a central hole 10. The track 9 is arranged in accordance with a pattern of turns constituting substantially parallel spiral tracks. The track 9 on the record carrier is indicated by a pre-embossed track structure provided during manufacture of the blank record carrier. The track structure is constituted, for example, by a pregroove 4 which enables a read/write head to follow the track 9 during scanning. The invention is applicable in a corresponding manner to other track patterns having substantially parallel tracks, in which the turns are concentric instead of spiral forming circular tracks.

Figure 1b is a cross-section taken along the line b-b of the record carrier 1, in which a transparent substrate 5 is provided with a recording layer 6 and a protective layer 7. The pregroove 4 may be implemented as an indentation or an elevation, or as a material property deviating from its surroundings. The recording layer 6 may be optically or magneto-optically (MO) writable by means of a device for writing information, for example as in the known CD-Recordable system. During writing, the recording layer is locally heated by a beam of electromagnetic radiation, such as laser light. The recording layer in a re-writable record carrier is constituted, for example, by a phase-change material which acquires an amorphous or crystallized state when it is heated to the correct extent.

Figure 1c shows an alternative track structure consisting of alternating elevated and deepened tracks, called lands 11 and grooves 12. It is to be noted, that both lands 11 and

grooves 12 serve as recording tracks. Each turn has at least one area interrupting the lands and grooves constituting a header area. For a spiral pattern the grooves may be continued as grooves once in each turn after the header area constituting a double spiral by the concatenated lands and the concatenated grooves. Alternatively at least once per turn a transition from land to groove or vice versa is established by switching to the other type after the header area.

According to the invention the tracks are subdivided in recordable track portions 3 by radially aligned headers 2. The track portions 3 are for reading or recording optical marks representing user information, and are preceded by the headers for individually accessing each track portion. The headers comprise position information indicative of the position of the header and the adjoining track portion relative to the beginning of the track or radial and angular parameters, e.g. address marks representing address information. Address marks on a recordable type of record carrier are usually embossed during manufacture to enable positioning of a read/write head anywhere on the still unrecorded record carrier. The headers are located at a few, i.c. four, angular positions in each turn of the track, which corresponds to the header locations used in the Constant Angular Velocity (CAV) system. However the position information in the headers at said CAV locations is written at CLV density, i.e. the marks are encoding the position information at a constant density. This is schematically indicated by the rectangular header areas 2 in Figure 1a. Due to the CAV location of the headers the track portions have a length proportional to the radial position, i.e. the distance to the middle of the central hole 10. The track portions are recorded at a constant density, and therefore the amount of data in a track portion is proportional to the radial position, called the CLV format. The data within the track portions and the position information in the adjoining header are recorded at the same density and can be read with the same reading means. Data to be recorded is subdivided in sectors of a fixed length, which are recorded from a first arbitrary angular and radial position to a second arbitrary position, said positions being in between headers. In the disc format according to the invention there is no requirement to have a number of sectors fitting exactly in a turn, which gives additional advantages in average data density, because no zoning or small zones can be used. Said arbitrary positions can be calculated according to a few formula's knowing the amounts of data recordable in each track portion. Hence a reduced header overhead is achieved using a few CAV aligned headers per turn and writing sectors at CLV data density, which sectors are not aligned to the headers.

Figure 2 shows a prior art optical disc 21, such as DVD-RAM, using a zoned CLV format (CLV = Constant Linear Velocity, i.e. constant recording density independent of the radial position). Headers 22,23,24 are provided for each sector, and the recording area of the disc is

subdivided in coaxial annular zones. Each track portion within one of the zones accommodates one sector, and the associated header comprises a physical address for that sector. Each zone has a fixed number of sectors in a turn, and the number of zones increases by one for each radially outward next zone. The headers 24 of the first sector in each turn are aligned radially. The further headers 22,23 are aligned within the zone, and within said zone the amount of data recorded in a turn remains constant according to the CAV system (Constant Angular Velocity). The format of this disc is called ZCLV (Zoned CLV). However the prior art ZCLV disc has a significant loss of data storage capacity due to the large amount of headers. This loss is referred to as overhead, which overhead is reduced by the invention.

Figure 3 shows a zoned optical disc according to the invention. The disc has a recording area 31 from an inner diameter 32 to an outer diameter 33. The recording are comprises circular or spiral tracks (as shown in Figure 1) and the tracks are interrupted by headers 34 forming track portions. The headers are radially aligned, in particular the beginning of the headers is aligned along straight radial lines 36. The recording area 31 of the disc is subdivided in coaxial annular zones, and within each zone the track portions are arranged for recording a same amount of data. Within a zone the density starts at a nominal level, say the CLV density, and decreases proportional to the radial position of the track portion concerned, and at the beginning of a next zone the density is set to the nominal level. Hence the density within each zone is according to the CAV system. The average density of the total recording area is a little below the nominal CLV level, such a zoning loss being dependent on the number of zones, e.g. larger with only a few large zones. Hence each track portion within one of the zones is arranged for recording a same predetermined amount of data at a track portion density, and the average of track portion densities within one zone is substantially equal to said CLV density. The headers are written at the data density, which decreases outwardly within a zone according to the CAV system, the ending portions 35 of the headers are aligned at radial line-pieces 35 at a different angle constituting a sawtooth like structure on each spoke. In an embodiment of the disc the track portions are provided with periodic characteristics indicative of the density for the respective track portion. During scanning in a reading device the periodic characteristics generate a periodic signal in a scanning unit, e.g. in the servo signals or the data reading signal. The periodic signals can be used to synchronize the data recording or reading, e.g. by a phase locked loop circuit locked to the periodic signal. The periodic characteristics may be a variation of the track position in a direction transverse to the track called a wobble, or other variations of width or depth of the track. A track wobble for a CLV disc without headers, e.g. a CD-R, is described in US 4,901,300 (D2). In an embodiment of the zoned disc according to the invention the track wobbles within a

zone are radially aligned. The number of wobbles within a track portion is constant, and a fixed amount of data corresponds to one wobble, e.g. one wobble is 324 channel bits, and a frame is 6 wobbles or 1944 channel bits or 155 data bytes for a given channel code.

Figure 4 shows a header and sector layout. Figure 4a shows a land/groove pattern interrupted by headers in an enlarged and schematic way. A first groove 41 is interrupted by a header area 40. A first land 42 radially adjoins the first groove 41, and further grooves and lands follow. The grooves are provided with a transversal variation of the location, the so-called wobble, which is aligned between grooves. The header area is subdivided in a first portion 43 used for groove headers and a second portion 44 for land headers. Hence the reading of address marks 45 representing the position information is not disturbed by interference from address marks in a radially neighbouring area.

Figure 4b shows a header and track portion layout indicating the logical assignment of information stored. The unit of length is the wobble period, which corresponds to a fixed amount of channel bits as explained above. First a header are 40 is given, subdivided in a groove header portion 43 and a land header portion 44. Thereafter a 5 wobble control portion 46 follows for controlling the reading of stored data. The control portion 46 is subdivided in a Gap (non written area directly adjoining the header area), a Guard area for starting the writing operation (some variation in the starting point allowed to prevent wear), a VFO area for locking a Variable Frequency Oscillator, and a SYNC pattern for logically synchronising the channel code. After the control portion 46 a DATA area 47 follows for storing the user data, which DATA area has a length in dependence on the radial position of the track portion. The last part 48 of the track portion before the next header area is subdivided in a PA, a Post Amble for closing the channel code encoding, a second Guard and Gap with similar function as Gap and Guard in the control portion 46.

Figure 4c shows the logical data format. User data is subdivided in sectors 142 of a fixed length of 2 kByte, which each for example require 98 wobbles when recorded. A number of sectors, e.g. 32, are joined together forming an ECC block, in which Error Correcting Codes are included for correcting errors anywhere in the ECC block. Such a long ECC block provides better protection against burst errors, and constitutes the minimum amount of data to be written. Also if only one sector must be changed, the full ECC block is to be rewritten including newly calculated error codes. A linking sector 141, which is only a few wobbles, is reserve as buffer in between ECC blocks to allow independent writing of such blocks. Usually the linking sector is written with dummy data to make sure that no intermediate blank areas remain. Obviously the ECC block does not fit in a track portion, the block may be larger or smaller then the DATA area

47 within a track portion. The actual start of an ECC block can be easily calculated from the length of the block, the block address and the size of the track portions, which varies in a predetermined way in dependence on the radial position. Said calculation gives a track number, a header number within the track and a distance from that header, e.g. expressed as a number of wobbles. In an embodiment of the optical disc the position information in the header comprises a track number indicative of the radial position of the track and header number indicative for the angular position of the header. It is to be noted that a specific header will always be within a block with a specific address and there will always be located a next block at a known distance from that header. In an embodiment of the optical disc the position information in a header comprises a block address indicative of the block locatable at the header and a next block indicator indicative of the distance from the header to the start of the next block. The block address may be the block starting before and including said header, or it may be the address of the next starting block.

Figures 5 and 6 show apparatuses according to the invention for scanning a record carrier 1. The apparatus of Figure 5 is arranged for reading the record carrier 1, which record carrier is identical to the record carriers shown in Figure 1 or Figure 3. The device is provided with a read head 52 for scanning the track on the record carrier and read control means comprising drive means 55 for rotating the record carrier 1, a reading unit 53 for example comprising a channel decoder and an error corrector, tracking means 51 and a system control unit 56. The read head comprises an optical system of a known type for generating a radiation spot 66 focused on a track of the recording layer of the record carrier via a radiation beam 65 guided through optical elements. The radiation beam 65 is generated by a radiation source, e.g. a laser diode. The read head further comprises a focusing actuator for focusing the radiation beam 65 on the recording layer and a tracking actuator 59 for fine positioning of the spot 66 in radial direction on the centre of the track. The tracking actuator 59 may comprise coils for radially moving an optical element or may be arranged for changing the angle of a reflecting element on a movable part of the read head or on a part on a fixed position in the case part of the optical system is mounted on a fixed position. The radiation reflected by the recording layer is detected by a detector of a usual type, e.g. a four-quadrant diode, for generating a detector signals 57 including a read signal, a tracking error and a focusing error signal. The apparatus is provided with tracking means 51 coupled to the read head for receiving the tracking error signal from the read head and controlling the tracking actuator 59. During reading, the read signal is converted into output information, indicated by arrow 64, in the reading unit 53. The apparatus is provided with an header detector 50 for detecting the header areas and retrieving address information from the

detector signals 57 when scanning the header areas of the tracks of the record carrier. The header detecting means are arranged for reading the position information from the headers substantially at the data density, which substantially corresponds to the constant density used in CLV. The apparatus has positioning means 54 for coarsely positioning the read head 52 in the radial direction on the track, the fine positioning being performed by the tracking means 59. The device is further provided with a system control unit 56 for receiving commands from a controlling computer system or from a user and for controlling the apparatus via control lines 58, e.g. a system bus connected to the drive means 55, the positioning means 54, the header detector 50, the tracking means 51 and the reading unit 53. To this end, the system control unit comprises control circuitry, for example a microprocessor, a program memory and control gates, for performing the procedures described below. The system control unit 56 may also be implemented as a state machine in logic circuits. It is to be noted, that the headers are located at CAV positions, and therefore the amount of data in the track portions is dependent on the radial position. The reading unit 53 are arranged for eliminating the headers from the data read, which eliminating may be controlled via the control lines 58 by the header detector 50. Alternatively the reading means are provided with deformatting means, which recognize and remove the headers and further control information from the data stream. In an embodiment the read device is arranged for reading a disc having continuous wobbled tracks, as described below with reference to Figure 8. The read control means are arranged for detecting the periodic characteristics and for reading in dependence thereon a same predetermined amount data from each track within one of the zones. A read clock is synchronized to the periodic characteristics and the reading unit 53 reads a fixed number of channel bits for each instance of the periodic characteristics. In an embodiment the read control means are arranged for retrieving the data from an area of the track following an unrecorded area. The read clock is synchronised to the periodic characteristics in the unrecorded area and hence the reading speed is adjusted during scanning the unrecorded area.

The system control unit 56 is arranged to perform the position information recovery and positioning procedure as follows. A desired block address is derived from a command received from the user or from a controlling computer. The position of the block expressed in a track number and header number and distance from said header is calculated based on the known amounts of data stored in each track portion. A table may be used for a zoned format, giving for each zone the first block address and the length of the track portions, which is fixed during a zone. The radial distance from the current position to the desired track number is determined and a control signal is generated for positioning means 54 to radially move the read head 52 to the desired track. When the radial movement is completed a header is read by the

header detector 50. The read signal of the header is processed to detect if the desired track is being read. If so, the system control unit waits until the arrival of the desired header. After this header any data before the calculated distance from the header is discarded, and data from the desired block is read from a linking position within the linking sector described with reference to Figure 4c. In practice all data starting at the header will be read, and any data before the start of the requested block will be discarded, and for reading the linking position is effectively equal to the start of the block.

Preferably the system control unit 56 is arranged for combining the first amount of data from a first track portion with at least one further amount of data read from a consecutive track portion, the at least one further amount of data comprising a final amount of data retrieved from a track portion up to a next linking position. Hence the total ECC block comprises a first amount from part of the first track portion read, a final amount from part of the last track portion read and as much intermediate amounts from track portions between the first and last track portion.

Figure 6 shows a device for writing information on a record carrier according to the invention of a type which is (re)writable in, for example a magneto-optical or optical manner (via phase change or dye) by means of a beam 65 of electromagnetic radiation. The device is also equipped for reading and comprises the same elements as the apparatus for reading described above with Figure 5, except that it has a write/read head 62 and recording control means which comprise drive means 55 for rotating the record carrier 1, a write unit 60, which comprises for example a formatter, an error coder and a channel coder, tracking means 51 and a system control unit 56. The write/read head 62 has the same function as the read head 52 together with a write function and is coupled to the write unit 60. The information presented to the input of the writing means 60 (indicated by the arrow 63) is distributed over logical and physical sectors according to formatting and encoding rules and converted into a write signal 61 for the write/read head 62. The system control unit 56 is arranged for controlling the writing means 60 and for performing the position information recovery and positioning procedure as described above for the reading apparatus. During the writing operation, marks representing the information are formed on the record carrier. Writing and reading of information for recording on optical discs and usable formatting, error correcting and channel coding rules, are well-known in the art, e.g. from the CD system. In particular the header detecting means 50 are arranged for reading the position information from the headers substantially at the data density, which substantially corresponds to the constant density used in CLV. In the recording device or the reading device the header detecting means are synchronized to a data clock, which clock is generated by clock generation

means. The data clock is also used to control the writing means 60 and/or the reading unit 53. The clock generation means can be controlled by the system control unit 56 based on the radial position, the zone and the rotation rate of the disc. In an embodiment of the device the clock generation means comprise a phase locked loop, for example accommodated in the header detection means, which phase locked loop is locked to the periodic characteristics of the track, such as the wobble, during scanning. After a jump of the head 52,62 to a new scanning location the clock generation means may be preset to the data clock value at the new location, or the bandwidth of said phase locked loop may be increased to lock quickly to the new wobble frequency. Hence the recording control means are arranged for detecting the periodic characteristics and for locking the phase locked loop to the periodicity thereof. A predetermined, fixed number of channel bits is recorded corresponding to each instance of the periodic characteristics, and as within a zone the number of periodic characteristics in a turn of the track is constant, a same predetermined amount data in each track within one of the zones.

Figure 7 shows a land/groove servo pattern at a zone boundary. The tracks marked L (land) and G (groove) are to be scanned from left to right and are connected via a spiral (not shown) to the left side of the Figure. The tracks are provided with wobbles or other preformed variations indicative of the track portion data storage density. A first groove track 71 is the last track of a first zone and has a wobble corresponding to the data density in that zone, the last part of said first groove track being shown on said left side of the Figure. After the interruption by header area 70 the first groove track 71 continues as second groove track 73 belonging to the next zone, which is provided with the wobble according to that next zone, and hence the intermediate land track 72 forms the zone boundary 74. From zone to zone the number of wobbles in a track portion may be increased, e.g. by 1 wobble or by a frame of 6 wobbles. In the land/groove format the wobble is implemented in the groove, and on the land the wobbles of both neighbouring grooves are added in the servo signal. On the land 72 between two zones there is in interference between the two wobbles of slightly different period, e.g. when the number of wobbles in a track portion is increased by one frame (6 wobbles) at a zone boundary, the servo signal will be extinct to zero six times. The advantage of having only one wobble increase per track portion at a zone boundary is, that only one extinction of the servo signal occurs. Having one or only a few extinctions in a boundary track portion gives a sufficiently long area before a header where the servo signal is present at a sufficient amplitude to keep said phase locked loop in lock. Hence reading of the header is possible also at the boundary track portions and even recording data in such track portions is possible. Alternatively said boundary track portions may be skipped, and even at least one header directly following a boundary turn. The servo signal of land track 72 has

an interference of the two different wobbles and is not easily usable for data storage. Additional measures may be taken in the recording and reading device to counter the effects of the interference, but in a practical embodiment the land track 72 is not used for data storage for a full turn, the unused turn forming the zone boundary 74. It is to be noted, that on the boundary 74 the first land header 76, the second land header 77, etc. up to the last land header 78 cannot be reliably read because of said interference. In an embodiment of the disc (for reliable operation) two additional headers are not used, resulting in 1,25 unused track at eight headers in a turn. In an embodiment of the disc (for symmetry reasons, i.e. the same total storage capacity for land and groove) the capacity of the groove tracks is limited also by skipping the same amount of groove tracks at each zone boundary, shown in Figure 7 as the groove track 73.

Figure 8 shows an optical disc 1 having a wobbled track. The recording area 81 is subdivided in three coaxial, annular zones 82, 83 and 84. Each zone is provided with wobbled, circular or spiral tracks 85. The inner zone 84 has for example n wobble periods, the middle zone 83 has n+8 periods and the outer zone n+16 periods. The numbers of wobbles and the increase are selected for drawing purposes only. The number of periodic characteristics at the start of a zone has to be proportional to the radial distance to the centre of the disc. By selecting the appropriate size of the zones the difference in the number of periodic characteristics from zone to zone may be selected to be low relative to total number of periodic characteristics in a turn. For example for a large number of zones (100) a difference of only a few wobble periods (1% for a radial range of diameter n to 2n) from zone to zone can be achieved. The resulting signal has the a strong component related to the periodicity (e.g. the wobble frequency), and is amplitude modulated with a relatively low frequency due to the cross-talk or summation of signals from neighbouring tracks. For practical reasons the difference in periodicity is selected to be even, e.g. 4, 6, 8, 16, 32, 48 or 64 whereas the number of wobbles is about 3200 at the innermost zone. By selecting such a low difference the interference signal can be controlled and the maximum interference can be located at predetermined positions. In an embodiment in the disc format with headers, which format is described above with reference to Figures 1a and 3, the maximum interference can be located relative to the headers. In particular the maximum interference is located as far as possible before the headers, so that the headers can be reliably detected, because the phase locked loop has ample signal to synchronize. Hence in an embodiment the disc has the land groove format and the phase difference of the wobbles confining a land between two adjoining zones is substantially zero near the headers. An advantageous choice is a difference of only one wobble in each track portion, so that the maximum interference can be located in the middle of the boundary track portion and the minimum at the header.

Figure 9 shows servo signals generated at a zone boundary. The first signal 91 has a number of periods n, and may be generated scanning the last track of a zone for a full turn. The third signal 93 is generated from the first track within the next zone, and has n + 4 periods. The second signal 92 is generated from the boundary track between two zones, and shows the interference from combining the servo signals of two different wobble frequencies. As the difference in the number of periods is 4, the signal shows an extinction 94 at 4 locations. The second signal 92 is generated when scanning an intermediate land between two zones having wobble grooves, so that the signal is the sum of two wobbles and complete extinctions occur. In a different embodiment the interference is caused by cross-talk of the neighbouring track, and partial extinctions (amplitude variations) instead of complete extinctions occur. The boundary tracks may be skipped when recording data, or a phase locked loop may be controlled to keep in lock when a (partial) extinction 94 occurs.

Although the invention has been explained by embodiments using four or eight headers in each turn, it will be clear that other numbers or a combination of numbers can be employed in the invention. For instance, a disc of a recordable type has been described, but the invention can be applied also to discs comprising recorded data, or discs of a read-only type. Further, the invention lies in each and every novel feature or combination of features.

List of related documents

(D1) EP-A 587 019 Optical disc system and information processing system

(D2) US 4,901,300 Wobbled CLV optical disc (PHN 12.398)

CLAIMS:

1. Optical disc comprising a recording area for recording data at a substantially constant density,
the recording area being subdivided in a plurality of coaxial annular zones comprising circular or spiral tracks, each track within one of the zones for storing a same predetermined amount of data at a track density, the average of the track densities within one zone being substantially equal to said constant density,
characterized in that the tracks comprise periodic characteristics which are radially aligned within each one of the zones, the periodicity being indicative of the track recording density for the track concerned.

2. Optical disc as claimed in claim 1, characterized in that the periodic characteristics comprise a radial track wobble.

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3. Optical disc as claimed in claim 1 or 2, characterized in that the size of zones is such that the difference in the number of periodic characteristics in a turn of the track at the boundaries of adjoining zones is relatively low in relation to the number of periodic characteristics in a turn of the track.

4. Optical disc as claimed in claim 3, characterized in that said difference is 1, 2, 4, 6, 8, 16, 32, 48 or 64.

5. Optical disc as claimed in claim 2, 3 or 4, characterized in that the recording area comprises grooves and lands both constituting said tracks, the grooves exhibiting said radial track wobble, and the wobble being aligned between grooves within each one of the zones.

6. Optical disc as claimed in claim 1, 2, 3, 4 or 5, characterized in that the servo pattern comprises headers alternating with track portions, and in that the phase difference of the periodic characteristics at the boundary of two adjoining zones is substantially zero near the headers.

7. Optical disc as claimed in claim 6, characterized in that said difference in periodicity between adjoining zones results in 1 or 2 extinctions within one track portion.

8. Optical disc as claimed in any one of the claims 1 to 7, characterized in that the recording area comprises recorded data.

9. Optical disc as claimed in claim 8, characterized in that the optical disc is of a read-only type.

10. Recording device for recording data at a substantially constant density on an optical disc comprising a recording area comprising circular or spiral tracks, which recording area is subdivided in a plurality of coaxial annular zones, which device comprises a recording head and recording control means,
characterized in that, while the tracks comprise periodic characteristics which are radially aligned within each one of the zones and the periodicity being indicative of a track density for the track concerned, the average of the track densities within one zone being substantially equal to said constant density, the recording control means are arranged for detecting the periodic characteristics and for recording in dependence thereon a same predetermined amount data in each track within one of the zones at said track density.

11. Recording device as claimed in claim 10, characterized in that the recording control means are arranged for recording a predetermined amount of channel bits for each instance of said periodic characteristics.

12. Recording device as claimed in claim 10 or 11, characterized in that the recording control means are arranged for controlling the speed of recording in dependence on the periodic characteristics.

13. Recording device as claimed in claim 10, characterized in that the recording control means are arranged for skipping a boundary land track turn at a zone boundary during recording.

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14. Recording device as claimed in claim 13, characterized in that the recording control means are arranged for also skipping a groove track turn adjacent to the boundary land track turn.

15. Read device for reading data from an optical disc recorded at a substantially constant density, the optical disc comprising a recording area comprising circular or spiral tracks, which recording area is subdivided in a plurality of coaxial annular zones, which device comprises a reading head and read control means,
characterized in that, while the tracks comprise periodic characteristics which are radially aligned within each one of the zones and the periodicity being indicative of a track density for the track concerned, the average of the track densities within one zone being substantially equal to said constant density, the read control means are arranged for detecting the periodic characteristics and for reading in dependence thereon a same predetermined amount data from each track within one of the zones at said track density.

16. Read device as claimed in claim 15, characterized in that the read control means are arranged for retrieving the data from an area of the track following an unrecorded area by adjusting the reading speed during scanning the unrecorded area in dependence on the periodic characteristics.

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