Optical record carrier and apparatus for scanning such a record carrier.

The invention relates to an optical record carrier comprising a recording layer having substantially parallel tracks for recording user information in a pattern of optically detectable marks, the tracks forming in a direction perpendicular to the track direction a repeated succession of a first servo track, a non-servo track, a second servo track and a non-servo track, the servo tracks having a track modulation different from the user information pattern, and the first and second servo tracks having a first and second modulation patterns representing first and different, second position information.

The invention also relates to a method of scanning such a record carrier, an apparatus for scanning it and an apparatus for manufacturing it.

In general, a track is a line on the record carrier to be followed by a scanning device and having a length of the order of a characteristic dimension of the record carrier. A track on a rectangular record carrier has a length substantially equal to the length or width of the record carrier. A track on a disc-shaped record carrier is a 360° turn of a continuous spiral line or a circular line on the disc. Modulation is the variation of a characteristic of a carrier, which variation represents information. When the carrier is an optical record carrier, the characteristic may be the local reflectivity of the carrier, the width of a groove in the carrier, or any characteristic the variation of which is optically detectable. Different modulations may be used to distinguish between different information patterns recorded with such modulations.

When writing user information on a record carrier by means of a scanning radiation spot, it is in general desirable to know the position of the radiation spot on the record carrier. Since user information is not available on a virgin recordable record carrier according to the preamble, the position may be determined by reading position information from the servo tracks of the record carrier.

A record carrier having information stored in servo tracks is known from the Japanese patent application no. 06338066. The record carrier described therein comprises alternating first and second servo tracks in the form of adjacent grooves in a substrate. The modulation of the servo tracks is a radial wobble of the centre line of the groove. The first servo tracks are frequency modulated at a relatively low frequency, the second servo tracks

are frequency modulated at a relatively high frequency. When scanning a servo track, the scanning spot is modulated only by the modulation of the servo track, and the scanning device can read the position information by choosing a low-frequency decoder for a first servo track and a high-frequency decoder for a second servo track. When scanning a track in between two servo tracks, the spot is modulated by the modulations of both neighbouring servo tracks. The scanning device can then discriminate between signals from the first and second servo tracks by switching between the low- and high-frequency decoder to read the position information of the neighbouring first and second servo track.

To achieve an accurate positioning of the scanning spot on the record carrier, the density of the position information in the servo tracks should be made as high as possible. However, the density is limited by crosstalk of the track modulation on the signal representing the user information. In the known record carrier the frequency of the second servo tracks may be chosen near the limit imposed by the crosstalk. The frequency of the first servo tracks must be substantially lower than the frequency of the first servo tracks to be able to separate the two frequencies in the scanning device and thereby create a low crosstalk between the servo tracks. The substantially lower frequency results in a lower information density. Hence, the first servo tracks have a relatively low position information density.

It is an object of the invention to provide a record carrier, scanning method and associated apparatuses having a high position information density of the servo tracks.

In accordance with an aspect of the invention, the record carrier as described in the opening paragraph is characterized in that the track modulations of the first and second servo track have a predetermined phase relation. The predetermined phase relation allows a scanning apparatus to discriminate between position information from first and second servo tracks when scanning a track in between the servo tracks. The scanning apparatus can select appropriate different first and second positions along a track to sample a detector signal representing the combined track modulations of both the first and second servo tracks. At the first positions, the modulation of the first servo track can be derived from the detector signal without interference from the modulation of the second servo track,

and at the second positions, the modulation of the second servo track can be derived without interference or with a known interference from the modulation of the first servo track.

The predetermined phase relation allows to choose different frequencies for the modulation of the first and second servo track. The frequencies are preferably in the ratio of two integer numbers. Both servo tracks are preferably modulated at the same frequency; when the frequency is chosen near the limit imposed by the crosstalk, both the first and second servo track will have a high position information density, allowing accurate positioning on the record carrier.

In a preferred embodiment of the record carrier the track modulation has a predetermined value at regular, predetermined positions along the servo track. A scanning device can make advantageous use of such predetermined values of the modulation when scanning a non-servo track. The samples of the detector signal at the first positions are then due to the modulations of both the neighbouring first and second servo track. Nevertheless, the device can retrieve from the detector signal the position information stored in the modulation of the first servo track if the modulation of the second servo track has a predetermined value at the first position. Likewise, when the modulation of the first servo track has a predetermined value at the second positions, this fact can be used in the scanning device to derive the modulation of the second servo track by sampling the detector signal at the second positions.

The servo tracks are preferably grooves in the information layer of the record carrier and the non-servo tracks lands in between the grooves. The track modulation has preferably a sinusoidal pattern. The pattern may be a sinusoidal variation of the transverse position of a servo track, of its width or depth or of a combination of them. These variations may be deviations from an average value of the position, width or depth. Since a non-zero value of the average of the variations along a track may cause an offset in the scanning of the record carrier, the average value is preferably equal to zero, independent of the position on the record carrier. The user information may be written in the grooves and/or on the lands.

The phase relation between the sinusoidal patterns in the first and second servo tracks is preferably a phase shift substantially equal to 90°. As a consequence, if the modulation of the first servo tracks is a sine wave, the modulation in the second servo tracks is a cosine wave. When a sample is taken during the scanning of a non-servo track at a first position of 90°, the value of the cosine modulation will be zero, and the detector signal directly indicates the value of the modulation of the first servo track. When, likewise, a

sample is taken at a second position of 0°, the sine modulation will be zero and the detector signal will indicate the value of the modulation of the second servo track.

In a preferred embodiment of the record carrier the position information is encoded in the servo track by 180° phase-shift keying. Since this type of encoding does not change the value of the modulation at the first and second positions, it can suitably be combined with the phase-shifted modulations of the invention.

A good definition of the first and second positions along a track for taking samples can be obtained when the servo tracks are provided with clock marks. The positions for sampling can then be defined with respect to the clock marks.

The track modulation may contain parts representing position information, such as address information, and parts not representing position information, such as clock marks. The clock marks may have fast rising and falling edges, used in the detection of the clock marks. The clock marks in adjacent servo tracks are preferably aligned in a direction transverse to the tracks. When adjacent clock marks also have the same phase, they can be read both when scanning the servo tracks and the non-servo tracks, and they will not interfere with the reading of user information.

In order to prevent that position information modulation is detected as a clock mark, the modulation representing position information has preferably a finite derivative with respect to the position along the track. When the track modulation is sinusoidal, this can be realized by using parts of a sine wave beginning or ending at 0° or 180° and parts of a cosine wave beginning or ending at 90° or 270°. If necessary, the modulation pattern may be completed to have a predetermined, fixed length by adding to the sinusoidal variation track parts having no variation.

In a accordance with a further aspect of the invention, a method of scanning a record carrier is provided as described in the claims.

In accordance with a still further aspect of the invention, an apparatus is provided for scanning an optical record carrier according to the invention as described in the claims.

In accordance with another aspect of the invention, an apparatus for manufacturing a record carrier according to the invention is provided as described in the claims.

The objects, advantages and features of the invention will be apparent

from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings, in which

Figure 1a through d show embodiments of the record carrier in accordance with the invention,

Figure 2 shows a perspective view of a record carrier,

Figure 3 shows the modulation of two adjacent servo tracks according to the invention,

Figure 4a-e show track modulations encoding information,

Figure 5 shows a track modulation with clock mark,

Figure 6 shows a scanning device according to the invention,

Figure 7 shows a signal processor for deriving position information from a detector signal, and

Figure 8 shows an apparatus for manufacturing record carriers.

Figure 1 shows embodiments of a record carrier 1, Figure 1a being a plan view, Figure 1b showing a small part in a sectional view taken on the line b-b, and Figure 1c and Figure 1d being plan views showing a portion 2 of a first and second embodiment of the record carrier 1 to a highly enlarged scale. The record carrier 1 comprises a series of servo tracks, each forming a 360° turn of a spiral line, of which some eight are shown in the Figure. The servo tracks are constituted, for example, by preformed grooves 4 or ridges. The bottom parts of the grooves 4 in the Figure are closer to the light-incident side of the record carrier than the lands between the grooves. In an alternative embodiment the lands are closer to the light-incident side than the bottom parts of the grooves. The servo tracks are intended for recording a position information signal. For the purpose of recording information the record carrier 1 comprises a recording layer 6, which is deposited on a transparent substrate 5 and which is covered by a protective coating 7. The recording layer is made of a radiation-sensitive material which, if exposed to suitable radiation, is subjected to an optically detectable change. Such a layer may be, for example, a thin layer of material such as tellurium, which changes reflection upon heating by a radiation beam. Alternatively, the layer may consist of magneto-optic or phase-change materials, which change direction of magnetization or crystalline structure, respectively, upon heating. When the tracks are scanned by a radiation beam whose intensity is modulated in conformity with the information to be recorded, an information pattern of optically detectable marks is obtained, which

pattern is representative of the information. In a non-user-recordable, read-only record carrier the layer 6 may be a reflective layer, for example made from a metal such as aluminum or silver. The information in such a record carrier is prerecorded in the record carrier during its manufacture, for example in the form of embossed pits.

In order to determine the position of the track portion being scanned relative to the beginning of a reference servo track, position information is recorded by means of a preformed track modulation, suitably in the form of a sinusoidal track-position wobble as shown in Figure 1c, in which the radial position of the track centre is wobbled. Since a track-position wobble is simple to realise during the manufacture of the record carrier, a track modulation in the form of a track-position wobble is to be preferred. However, other track modulations such as, for example track-width modulation (Figure 1d), or track-depth modulation are also suitable.

It is to be noted that in Figure 1 the track modulation has been exaggerated strongly. In reality, a wobble having an amplitude of approximately $20 \cdot 10^{-9}$ metre in the case of a track width of $600 \cdot 10^{-9}$ has been found to be adequate for a reliable detection of the radiation-beam modulation. A small amplitude of the wobble has the advantage that the distance between adjacent servo tracks can be small.

In a special embodiment of the record carrier, the position information stored in the servo tracks is divided into servo segments of 48 binary bits. The first bit of a servo segment represents a synchronisation pattern used for synchronisation of the position information. The next four bits represent the layer number of the record carrier. The number indicates the ordinal number of the recording layer in a record carrier having a plurality of superposed recording layers. The next three bits of the servo segment represent the segment number in a track. A servo track is divided into eight radially aligned servo segments. The next 16 bits represent the track number of the servo track. The inner-most servo track on the record carrier has track number 0. The last 24 bits of a servo segment represent three parity bytes used for error correction of the position information.

Figure 2 shows a perspective view of a cross-section of a record carrier 10 having servo tracks in the form of grooves and non-servo tracks in the form of land portions between the grooves. The record carrier has a plurality of groups of four tracks, of which two groups are shown. A group comprises a first servo track 11, a non-servo track 12, a second servo track 13 and a non-servo track 14. The tracks 15, 16, 17 and 18 form an adjacent group of similar tracks. Information patterns of recording marks have been indicated schematically in the tracks 11, 12 and 13. The servo tracks 11 and 13 have been provided

with position information by modulating the position of the sidewalls of the groove. A scanning device suitable for scanning such a record carrier is able to guide a radiation spot both along the centre of a groove and along the centre of a land in between two grooves. The device may write, read and/or erase information in the groove and on the land. When scanning along a servo track, i.e. a groove in Figure 2, the scanning device can obtain position information from the groove wobble. The groove wobble may be read by means of a method usually called the push-pull method, known from *inter alia* the American patent no. US 4,057,833. When scanning along a non-servo track, i.e. a land in Figure 2, the push-pull method gives a signal the magnitude of which is the result of the groove wobbles of both adjacent grooves, which have different information content. When the modulation according to the invention is used, the position information stored in both servo tracks can be retrieved.

Figure 3 shows schematically a first servo track 20, a second servo track 21 and a non-servo track 22 in between the two servo tracks. If the servo tracks are numbered, the first and second servo tracks may be servo tracks having even and odd ordinal numbers respectively. The position along a track is indicated by degrees, where 360° is one period of the sinusoidal pattern with which the position of the servo tracks, i.e. the centre line of the groove in Figure 3, has been modulated. Servo track 20 has a sinewave variation, whereas servo track 21 has a cosine variation of the position. The right half of the Figure shows three signals 23, 24 and 25 from a push-pull detector, obtained when the spot of the scanning device follows servo tracks 20, 21 and non-servo track 22 respectively. The left and right half of the Figure indicate the same position in degrees along the track. When the spot follows a servo track, the amplitude of the detector signal follows the track modulation, as indicated by signals 23 and 24. Hence, detector signals 23 and 24 are phase shifted by 90°.

When following non-servo track 22, push-pull signal 25 is a linear combination of signals 23 and 24. It will be clear from the Figure that at the 90° position the amplitude of signal 25 is determined by the modulation of servo track 20, whereas at the 0° position the amplitude of signal 25 is determined by the modulation of servo track 21. Hence, the position information stored in servo tracks 20 and 21 can be retrieved when following non-servo track 22 by sampling the push-pull signal at the 90° and 0° positions along the track.

Figure 4 shows a possible way of coding information in the sinusoidal track modulation. A bit of position information is stored in a 810° section of a servo track. Consecutive bits are stored in consecutive sections. Figure 4a shows a synchronization pattern. The unique pattern of two consecutive 0° to 180° sections of a sinewave, a 90°

section having zero track deviation and two consecutive 180° to 360° sections of a sinewave does not occur in parts of the servo tracks other than those representing a synchronization pattern.

Figure 4b shows the modulation pattern of a first servo track representing a logical one. The pattern comprises two complete sinewaves followed by a 90° section having zero track deviation. Figure 4c shows the modulation pattern of a first servo track representing a logical zero. The pattern comprises two complete inverted sinewaves followed by a 90° section having zero track deviation. Figure 4d shows the modulation pattern of a second servo track representing a logical one. The pattern comprises a 90° section having zero track deviation followed by two complete sinewaves. Figure 4e shows the modulation pattern of a second servo track representing a logical zero. The pattern comprises a 90° section having zero track deviation followed by two complete inverted sinewaves. The sinusoidal patterns always start and end on a zero value and not on a maximum or minimum value, in order to avoid sharp transitions in the modulation pattern. Such transitions could otherwise interfere with clock marks embedded in the modulation pattern.

The invention is not limited to the modulation patterns shown in Figure 4. The patterns may comprise only one instead of two complete sinewaves. The average value of each pattern or of a series of patterns is preferably zero in order to avoid offsets in the tracking. Instead of the sinusoidal pattern, other patterns may be used, such as a triangular pattern or sinc-function pattern.

Figure 5 shows an example of a clock mark 30 embedded in a modulation pattern of a logical zero and one. The clock marks is a relatively fast modulation of the servo track from zero to a maximum track deviation, to a minimum track deviation and back to a zero track deviation. The relatively fast modulation of the clock marks allows extraction of the clock marks from the detector signal by frequency selection. The clock marks are preferably arranged at 0° positions along the servo tracks. A satisfactory clock extraction has been achieved when there are 128 clock marks on a servo track, i.e. on one revolution of a disc-shaped record carrier.

Figure 6 shows an apparatus for scanning a record carrier as shown in Figure 3. The apparatus comprises an optical system 31 for optically scanning tracks in record carrier 10. Optical system 31 comprises a radiation source 32, for example a semiconductor laser. Radiation source 32 emits a radiation beam 33, which is reflected by a beam splitter 34 and converged by an objective lens 35 to a radiation spot 36 on the tracks in an information layer of record carrier 10. Radiation reflected from the record carrier is

guided to a detector through objective lens 35 and beam splitter 34 to a detector 37. The detector is a split-detector having a dividing line between the two halves of the detector running parallel to the direction of the tracks being scanned. The sum signal of the two halves, usually called the central aperture signal, represents the information recorded in the tracks and is output as signal S_i. The difference signal of the two halves, usually called the push-pull signal, represents position information and servo information recorded in the tracks, and is output as signal S_p. The low-frequency content of the signal S_p represents the servo information, indicating the position of the radiation spot 36 with respect to the centre-line of the track being scanned. The signal S_p is used as input for a servo circuit 38, possible after a low-pass filter which passes the servo information but blocks the position information. The servo circuit controls the position of the radiation spot in a direction perpendicular to the direction of the track by controlling the position of optical system 31 and/or the position of objective lens 35 within the optical system.

The signal S_p is also fed into a signal processor 39, which extracts the position information from the signal S_p. The position-information signal output from signal processor 39 is fed into a micro-processor 40, as shown in Figure 6. The micro-processor can derive, for example, the current position of radiation spot 36 on record carrier 10 from the position-information signal. During reading, erasing or writing, the micro-processor can compare the current position with a desired position and determine the parameters for a jump of the optical system to the required position. The parameters for the jump are fed into servo circuit 38. The information signal S_i is fed into the micro-processor, enabling it to derive for instance directory information from the signal, which may be used for controlling the position of the radiation spot. The information signal is provided as output signal 41 of micro-processor 40.

When writing user information on a record carrier having prerecorded servo tracks comprising position information, the user information to be recorded is fed into micro-processor 40 by a signal 42. The scanning device reads the position information from the servo tracks. Micro-processor 40 synchronizes the information to be written with the position information and generates a control signal which is connected to a source control unit 43. Source control unit 43 controls the optical power of the radiation beam emitted by radiation source 32, thereby controlling the formation of marks in record carrier 10. The synchronisation may involve the imposition of a fixed relation between the synchronisation patterns in the position information and synchronisation patterns present in the user information signal to be recorded.

Figure 7 shows an embodiment of signal processor 39 for extracting the position information from the push-pull signal S_p. The signal S_p is connected to the input of an analog-to-digital convertor 50, which converts the analog signal S_p into a digital output signal by taking samples at a rate determined by a clock signal S_c. The digital output signal is connected to a high-pass filter 51, 52, which passes only the clock marks present in digital output signal. In the embodiment shown the filter comprises a high-pass filter 51 and a cosine filter 52. The output of the high-pass filter is fed into cosine filter 52, which is a two-tab finite response filter having a zero at half the sample frequency used in the high-pass filter. A peak detector 53 determines the peak value of the filtered clock marks. The peak detector has such a time constant that a running value of the peak values is obtained. The output of the peak detector and the filtered clock marks are both connected to a comparator 54. The comparator provides an output signal only when the signal of a clock mark exceeds half the peak value of a clock mark, thereby avoiding that the circuit is triggered by noise. The output signal of the comparator is connected to the reset input of a counter 55. The counter has a count input connected to the clock signal S_c and counts the number of samples in between two clock marks. A subtracter 56 subtracts this number of samples from a reference number N_s, indicating the desired number of samples between two clock pulses, e.g. 2400. If the number of bits between two clock marks is chosen as six, the number of samples for each bit, i.e. for each 810° section of a track, is equal to 300. A switch 57, controlled by the output of comparator 54, passes the difference value of the subtracter to an integrator 58. The output of the integrator is converted from digital to analog by a digital-to-analog convertor 59. The analog output signal of the convertor is used as input for a voltage-controlled oscillator 60, providing clock signal S_c. This clock signal is used for controlling the sample rate and processing rate of all components 50 to 59. The components 50 to 60 form a closed loop which sets the number of samples between two consecutive clock marks at the predetermined value N_s, independent of the scanning speed of the record carrier.

The digital output signal of the analog-to-digital convertor 50 is connected to an input of a band-pass filter, which, in the embodiment of the Figure, comprises a high-pass filter 61, a low-pass filter 62 and a cosine filter 63. The band-pass filter passes the wobble signal representing the track modulation and blocks the passage of the clock marks. The output of the band-pass filter is connected to two switches 64 and 65, controlled by a timing circuit 66. The timing circuit determines the points of time, or positions along a track, where the wobble signal has a value characteristic of the position information encoded in the servo tracks.

If the modulation patterns have the form shown in Figure 4, the positions for first servo tracks are 90°, 270°, 450° and 630° (Figure 4b and c); the track deviations of the second servo tracks at these positions are zero. The positions for second servo tracks are 180°, 360°, 540° and 720° (Figure 4d and e); the track deviations of the first servo tracks at these positions are zero. Since the band-pass filter requires a settling time to adapt its output signal to its input signal, the positions are preferably chosen near the end of a pattern, i.e. at 450° or 630° for the first servo tracks and at 540° or 720° for the second servo tracks. If the position for the first servo tracks is taken to be 450°, timing circuit 66 closes switch 64 momentarily to pass that sample out of the 300 samples in each bit of the wobble signal which has an ordinal number closest to 450*300/810. Instead of choosing the closest sample, it is also possible to calculate the measured track deviation at the required instant by interpolating between the samples. If the sample has a positive value, a logical '1' is output as position information bit of the first servo track; if it is negative, a logical '0' is output. Likewise, if the position for the second servo tracks is taken to be 540°, switch 65 closes momentarily to pass the sample in each bit having an ordinal number closest to 540*300/810. If the sample has a positive value, a logical '1' is output as position information bit of the second servo track; if it is negative, a logical '0' is output. The consecutive bits at the output of switch 64 represent a position information signal S_1 of the first servo tracks, those at the output of switch 65 a position information signal S_2 of the second servo tracks. When scanning either first or second servo tracks, only the signal S_1 or S_2 is available. When scanning a non-servo track, both signals S_1 and S_2 are available.

In an alternative embodiment of signal processor 39 as shown in Figure 7, the closed loop 50 to 60 is entirely digital. Analog-to-digital converter 50 is replaced by an analog-to-digital converter sampling at a fixed, high rate. The samples of the convertor are fed into a down-sampler, which reduces the number of samples in accordance with a reduction factor input in the down-sampler. The output of the down-sampler is connected to the inputs of filters 51 and 61. Digital-to-analog converter 59 and voltage-controlled oscillator 60 in Figure 7 are not needed, and the output of integrator 58 is used as reduction factor for the down-sampler.

Figure 8 shows an apparatus for manufacturing a record carrier according to the invention. The apparatus comprises an optical system 70, in which a radiation source 71 generates a radiation beam 72, which is guided through a collimator lens 73, a modulating unit 74 and an objective lens 75 to a radiation spot 76 on a radiation-sensitive layer 77 of a record carrier 78. A micro-processor 79 controls an actuator 80, which controls the position

of the optical system 70 with respect to the record carrier 78. If the record carrier is disc-shaped, the actuator controls the radial position of the optical system. The tangential position of the radiation spot 76 on the record carrier is controlled by a drive, not shown in the Figure, which rotates the record carrier. The radiation spot 76 writes servo tracks in the form of a series of adjacent circular tracks or a series of 360° turns of a continuous spiral line.

During writing on the record carrier, the micro-processor sends position information to be recorded in the servo tracks to a modulator 82. The modulator transforms each bit of position information into a 810° section of a track according to the patterns shown in Figure 4 for first and second servo tracks and adds clock marks. The control signal is used to control the operation of the modulating unit 74. The modulating unit modulates the radiation beam such that the desired modulation of the servo track is achieved. If the radial position of the servo track is to be modulated, the modulating unit 74 will be a deflection unit, such as an acousto-optic device, changing the direction of the radiation beam, and therewith the position of the radiation spot 76 in a direction perpendicular to the direction of the track. If the width instead of the position of the servo track is to be modulated, the modulating unit 74 may be a device having an controllable transmission of the radiation beam, thereby controlling the amount of radiation energy deposited on the record carrier 78. A large amount of energy will result in a wider servo track than a small amount of energy. In that case the modulating unit 74 may be integrated with the radiation source 71, forming a source of which the radiation output power can be controlled.

After the record carrier has been irradiated as described in the foregoing, it is subjected to an etching process to remove the portions of the radiation-sensitive layer 77 which have been exposed to the radiation beam 72, yielding a master disc in which a groove is formed which exhibits a wobble. If the consecutive servo tracks are numbered, the wobble in the even-numbered tracks is modulated in conformity with the modulation patterns of Figure 4b and c and the wobble in the odd-numbered tracks is modulated in conformity with the modulation patterns of Figure 4d and e. From this master disc replicas are made on which the recording layer 6 is deposited. In record carriers of the inscribable type thus obtained, the part corresponding to the part of the master disc from which the radiation sensitive layer 77 has been removed is used as servo track (which may be either a groove or a ridge).

CLAIMS:



1. An optical record carrier comprising a recording layer having substantially parallel tracks for recording user information in a pattern of optically detectable marks, the tracks forming in a direction perpendicular to the track direction a repeated succession of a first servo track, a non-servo track, a second servo track and a non-servo track, the servo tracks having a track modulation different from the user information pattern, and the first and second servo tracks having a first and second modulation patterns representing first and different, second position information, characterized in that the track modulations of the first and second servo track have a predetermined phase relation.

2. Optical record carrier according to Claim 1, wherein the track modulation has a predetermined value at regular, predetermined positions along the servo track.

3. Optical record carrier according to Claim 2, wherein the track modulation has a sinusoidal pattern of at least one of position, width or depth of the servo track.

4. Optical record carrier according to Claim 3, wherein the track modulation in the first servo track is 90° out of phase with respect to the track modulation of the second servo track.

5. Optical record carrier according to Claim 3, wherein the position information is encoded in the servo track by 180° phase-shift keying.

6. Optical record carrier according to Claim 1, wherein the servo tracks are provided with clock marks.

7. Optical record carrier according to Claim 6, wherein the track modulation representing position information has a finite derivative with respect to the position along the track.

8. A method of scanning a record carrier having substantially parallel tracks for recording user information in a pattern of optically detectable marks, the tracks forming in a direction perpendicular to the track direction a repeated succession of a first servo track, a non-servo track, a second servo track and a non-servo track, the servo tracks having a track modulation different from the user information pattern, characterized in that when scanning a non-servo track position information is read from the first servo track by sampling its track modulation at regular first positions along the non-servo track, and position information is read from the second servo track by sampling its track modulation at regular second positions along the non-servo track, which second positions are different from the first positions.

9. Method according to Claim 7, wherein the track modulation is a periodical variation and the first and second positions have a phase difference of 90° of the period of the variation.

10. An apparatus for scanning a record carrier having substantially parallel tracks for recording user information in a pattern of optically detectable marks, the tracks forming in a direction perpendicular to the track direction a repeated succession of a first servo track, a non-servo track, a second servo track and a non-servo track, the servo tracks having a track modulation different from the information pattern, the apparatus comprising an optical system for scanning tracks by a radiation beam, a detector for detecting the radiation beam coming from the record carrier and modulated by the track modulation of at least one servo track, and a signal processor for deriving position information from an output signal of the detector, characterized in that the signal processor is provided with a timer for locating positions along the track being scanned and a sampler connected to the timer for sampling the output signal of the detector, and a signal circuit for forming a first information signal representing position information stored in the first servo track from samples taken at regular first positions and for forming a second information signal representing position information stored in the second servo track from samples taken at regular second positions, the first positions and second positions being different.

11. An apparatus for manufacturing a record carrier as claimed in Claim 1, comprising an optical system for scanning a radiation-sensitive layer of a record carrier by a radiation beam along a path corresponding to the servo tracks to be formed in the radiation-

sensitive layer and a modulation unit for modulating the radiation beam in such a way that the pattern formed by the radiation beam corresponds to a control signal applied to the modulation unit, characterized in that the apparatus comprises a circuit for forming a control signal from first position information to be recorded in the first servo tracks and second servo information to be recorded in the second servo tracks in such the way that the resulting modulations of the first and second servo track have a predetermined phase relation.