Description

The invention relates to an apparatus for reproducing information from an optically readable record carrier on which digital information is stored in the form of a track of optically detectable areas which alternate with intermediate areas, which apparatus comprises:

an optical system for projecting a light beam on the record carrier,

at least two optical detectors which are so arranged in the beam which has been modulated by the record carrier that in the case of a correct tracking the two detectors are disposed symmetrically with respect to the image of the track,

a signal-generating circuit for generating at least a first and a second detection signal as a function of the amounts of light detected by the optical detectors, and

a control-signal generator for generating at least one control signal which is a measure of the location of the spot produced by the light beam relative to the track.

Such apparatus is known inter alia as the commercially available "Compact Disc Digital Audio" player which is described in "Philips Technical Review", Vol. 40, 1982, No. 6, the entire issue, such a player being also described in, for example Japanese Patent Application No. 56-49094.

In the known apparatuses various control signals are derived in an analog manner from the digital signals originating from the disc, which control signals often exhibit a very low signal-to-noise ratio and often are also inaccurate because the control information is disturbed by the irregular data signal.

One of these control signals is the radial error signal, which can be derived from the difference of the first and the second detector signals. In the player known from the Japanese Patent Application No. 56-49094 this radial error signal is corrected for an inclined position of the disc relative to the position of the optical system in that the signal of one of the detectors is multiplied by a factor determined by the value of the uncorrected radial error signal at the intermediate areas.

EP—A—0070408 discloses an apparatus of the kind mentioned in the opening paragraph, in which the control signal for radial tracking is derived in an analog manner from the information signal obtained during scanning of the optically detectable areas only. This known apparatus, however, shows the disadvantage that the control signal is inaccurate, because it comprises components due to offset-errors, like asymmetries in the beam, which are not due to tracking errors.

It is the object of the invention to improve the generation of the control signals in an apparatus of the type specified in the opening paragraph and to this end the invention is characterized in that the control signal generator comprises:

oscillator means for supplying a clock signal,

sampling means which is clocked by the oscillator means for sampling the detection signals with the clock signal both during scanning of the optically detectable areas and during scanning of the intermediate areas,

detection means for identifying the samples as originating from either an optically detectable area or an intermediate area,

signal-separating means for separating, under control of the detection means, the samples taken during scanning of the optically detectable areas and the samples taken during scanning of the intermediate areas, and a processing circuit for deriving the control signal from the samples taken during scanning of the optically detectable areas, which control signal is corrected for offset-errors by a correction signal, which is derived from at least the samples taken during scanning of the intermediate areas.

The invention is based on the recognition of the fact that offset-errors can be derived from the samples taken during the intermediate areas.

The apparatus in accordance with the invention is further characterized in that the detection means are adapted to detect one sample per optically detectable area and one sample per intermediate area both for the samples from the first detection signal and the samples from the second detection signal, said clock signal having a frequency which is equal to or is a multiple of the bit frequency.

By selecting one sample each time the instantaneous sampling frequency after selection will vary in conformity with the instantaneous information-signal frequency, so that cross-talk of spectral components of said information signal into said selected samples is minimal.

This apparatus in accordance with the invention is further characterized in that the detection means are adapted to detect said one sample exclusively when the optically detectable areas and intermediate areas are longer than a predetermined number of clock periods.

This step ensures that the influence of the optical transfer function, *i.e.* the amplitude of the signal read as a function of the length of the optically detectable areas, on the selected samples is minimal.

A preferred embodiment of an apparatus in accordance with the invention is characterized in that the signal separating means comprise: first, second, third and fourth storage means, the samples derived from the first detection signal being applied to the first and the second storage means, the samples derived from the second detection signal being applied to the third and the fourth storage means, the first and the third storage means being switched on by the detection means only upon detection of said one sample if this sample originates from an intermediate area, and the second and the fourth storage means being switched on by the detection means only upon detection of said one sample if this sample originates from an optically detectable area.

A further characteristic feature of this preferred embodiment is that the control signal is derived from the difference between the contents of the second and the fourth storage means and the correction signal is derived from the difference between the contents of the first and the third storage means.

This apparatus may further be characterized in that the corrected control signal is derived in accordance with the formula:

$$(\bar{a}-\bar{b})-\frac{\bar{a}+\bar{b}}{a+b}(a-b)$$

where a, $\bar{a}$, b and $\bar{b}$ are the contents of the first, the second, the third and the fourth stage means respectively.

With respect to the detection means the preferred embodiment may be characterized in that the detection means comprise counting means which are started upon every transition between an optically detectable area and an intermediate area and which are arranged to count in the rhythm of the clock signal and to generate a control signal for the first and the third storage means when a predetermined count is reached while scanning an intermediate area and a control signal for the second and the fourth storage means when said predetermined count is reached while scanning an optically detectable area, the samples derived from the first and the second detection signal being applied to the storage means with a delay of a predetermined number of clock periods.

A preferred embodiment of the apparatus in accordance with the invention may further be characterized in that a third detection signal is derived from the sum of the amounts of light received by the two outer sub-detectors, which third detection signal is sampled in the same way as the first and the second detection signal, the resulting samples being applied to fifth storage means which in the same way as the first and the third storage means, are switched on by the detection means, and a focusing-error signal is derived in accordance with the formula

$$a+b-2c$$

where a, b and c are the contents of the first, the third and the fifth storage means respectively.

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is the block diagram of an embodiment of the invention,

Fig. 2 shows an example of the detector 19 in the apparatus shown in Fig. 1,

Fig. 3 shows some diagrams to explain the operation of the detector shown in Fig. 2,

Fig. 4 shows an example of a part of the circuit 37 (Fig. 1) for generating the control signals RE, FE and CE.

Fig. 1 shows an apparatus in accordance with the invention.

In this Figure a disc-shaped record carrier 1 is shown in a schematic cross-sectional view. This record carrier comprises a substrate 2 in which a track structure is formed, which structure comprises pits 3 and intermediate areas 4. This relief type track structure is coated with a reflecting layer 5 and a transparent protective layer 6. The information contained in the relief-type track structure is read in that a laser beam generated by a laser 7 is projected and focused on the tracks *via* a lens system 8, the reflected beam being projected on an in-line array of four optical detectors 11a, 11b, 11c and 11d *via* a semi-transparent mirror 9 and a beam splitter 10. The currents supplied by these photodetectors are converted into the signal voltages V_1, V_2, V_3 and V_4 by means of a current-voltage converter 12.

For a correct read-out the focussing of the lens system 8 is controlled in a manner, not shown, by means of a focusing control signal FE'. For radial tracking the radial location of the spot produced by the laser beam is controlled by means of a radial control signal RE'. This is a fine-control system. Coarse control is obtained (in a manner not shown) by moving the entire optical system 7, 8, 9, 10, 11 in a radial direction under command of a control signal CE'.

The control signals CE', RE' and FE' are derived from the signal voltages V_1, V_2, V_3 and V_4. In addition to the sum

$$V_1+V_2+V_3+V_4$$

required for recovering the high-frequency data signal, the signal

$$(V_1+V_4)-(V_2+V_3)$$

is required for the signal FE' and the signal

$$(V_1+V_2)-(V_3+V_4)$$

is required for the signal CE' and the signal RE'. All these control signals can be derived from three signals A', B' and C' which are obtained by combining the signals V_1, V_2, V_3 and V_4. In the present embodiment these signals are related as follows:

$$A'=V_1+V_2$$
$$B'=V_3+V_4$$
$$C'=V_1+V_4.$$

The combination of the signals V_1, V_2, V_3 and V_4 described in the foregoing is obtained by means of a matrix 13. This combination has the advantage that only three instead of four signals must be digitized, so that a local lower clock frequency can be used than would be the case if these signals are digitized serially. For this purpose the signals A', B' and C' are converted into serial forms by means of a multiplexer 14, they are digitized in an analog-to-digital converter 15 and they are reconverted into parallel form to obtain the corresponding digital samples A, B and C by means of a demultiplexer

16. The multiplexer 14, the analog-to-digital converter 15 and the demultiplexer 16 receive clock signals from a clock-signal generating circuit 17, which supplies the required clock signals in the correct phase relationship under control of an oscillator 18, in such a manner that the samples A, B and C are supplied in synchronism with the bit frequency of the data signal.

For generating the various control signals it is important to suppress the data-signal spectrum as far as possible. This is achieved by selecting samples in synchronism with the data pattern (pits and intermediate areas), so that the instantaneous sampling frequency becomes equal to the instantaneous frequency of the data signal. For this purpose one sample for each pit (3) and for each intermediate area (4) is selected from each of the samples A, B and C and, in order to minimize the effect of the optical transfer function of the read-out (the signal amplitude is a function of the location of the projected laser beam relative to the pits and decreases towards the edges of the pits), the samples are taken only for pits and intermediate areas which are longer than a specific number of clock periods, in the present example longer than 5 clock periods. For this purpose a detector 19 (which will be described in more detail with reference to Fig. 2) generates a pulse on an output 20 when the sixth sample in one pit is detected and a pulse on output 21 when the sixth sample in one intermediate area is detected. The detector 19 receives the clock signals from the oscillator 18 on an input 22 and the digital sum of the signals A and B, obtained by means of the adder 25 and equalized by means of the circuit 24, on an input 23.

The samples A, B and C are each delayed by three clock periods (τ) of the oscillator 18 by means of delay networks 26, 27 and 28 respectively, are equalized by means of the equalizers 29, 30 and 31 respectively, and are applied to the hold circuits 32 and 33, 34 and 35, and 36 respectively. The hold circuits 32, 34 and 36 are clocked by the signal on output 21 of the detector 19 and the hold circuits 33 and 35 by the signal on output 20. During each intermediate area longer than five periods the third samples as b and c of the samples A, B and C respectively then appear on the outputs 38, 40 and 42 respectively of the hold circuits 32, 34 and 36 respectively and during each pit which is longer than five clock periods the third samples $\bar{a}$ and $\bar{b}$ of the samples A and B respectively then appear on the outputs 39 and 41, respectively of the hold circuits 33 and 35 respectively.

It is to be noted that in principle it is also possible to select the sample depending on the length of the pit or intermediate area, for example by taking the central sample in the case long pits and intermediate areas.

The signals a, $\bar{a}$, b, $\bar{b}$ and c are applied to a processing circuit 37 (which is described in more detail with reference to Figs. 4, 6 and 12), which supplies the signals RE, CE and FE on outputs 43, 44 and 45 respectively, and a signal TL representing a loss of track, a signal DO indicating a signal drop-out, a signal HFL indicating that the level of the high-frequency data signal is too low, and a signal SL which is a decision level for the data-signal processing, on outputs 46, 47, 48 and 49, respectively. The signals RE, CE and FE are converted into analog signals by means of digital-to-analog converters 50, 51 and 52 and subsequently they are amplified by the amplifier 53, 54 and 55 to form the analog control signals RE', CE' and FE' for focusing and tracking control.

The sum of the signals A+B formed by means of the adder 25 and the equalizer 24 is not only applied to a detector 19 but also to a comparator 56 which also receives the decision level SL for restoring the digital data signal and applying it to an output 57 and to a phase comparator circuit 58, which compares the phase of the samples A+B with the phase of the data signal on the record carrier 1 and which supplies a signal which is a measure of this phase to an output 59 and a signal which is a measure of the asymmetry of the signal A+B to an output 60, which last-mentioned signal is applied to a circuit 37, which will be described in more detail with reference to Fig. 8. The phase-error signal on output 59 controls the oscillator 18 *via* a low-pass filter 61.

Fig. 2 shows an example of the detector 19 in the apparatus shown in Fig. 1, and Fig. 3 shows some diagrams to explain the operation of the circuit shown in Fig. 2. In the circuit shown in Fig. 2 the signal A+B from the equalizer 24 is applied to a high-pass filter 62 *via* an input 23 in order to remove the low-frequency components, thereby enabling the digital data signal to be restored by means of a simple comparator 63. The edges of the rectangular data signal are detected by means of a circuit 64, for example a differentiator. This edge detector starts a counter 65 which counts the clock pulses (from the oscillator 18) on its input 22 from the instant defined by the pulses from the edge detector 64. A decoder circuit 66 decodes a specific count, in the present example six. When the count "six" is reached, the pulses are applied to AND-gates 67 and 68. The gate 67 also receives the restored data signal on an inverting input and the gate 68 receives this signal on a non-inverting input. As a result of this, a pulse will appear on output 21 when the count "six" is reached during a positive data signal (3c) and on output 20 when the count "six" is reached during a negative data signal.

To illustrate this, Fig. 3a shows a part of a data track on the record carrier, which track comprises pits 3 and intermediate areas 4 between these pits. Fig. 3b shows the samples A+B originating from the track shown in Fig. 3a. Fig. 3c shows the restored data signal after the comparator 63, which is a substantially rectangular signal with a period corresponding to the length of the pits and intermediate areas. Fig. 3d shows the starting pulses for the counter 65 formed on the edges of the data signal, which counter counts the pulses of the clock signal shown in Fig. 3e. The counter 65 supplies a pulse each time that the count "six"

is reached and for a positive data signal (Fig. 3c), *i.e.* during an intermediate area, a pulse will appear on output 21 (Fig. 3f), whilst for a negative data signal, *i.e.* during a pit, the pulse will appear on output 20 (Fig. 3g). The signals A, B and C, which have been delayed by three clock periods, are thus sampled. Fig. 3h shows the signal A which has been delayed by three clock periods and for which the hold circuit 32 (Fig. 1) holds the third sample from each intermediate area longer than five clock periods (signal shown in Fig. 3i) the sample and hold circuit 33 holds the third sample from each pit longer than five clock periods (signal shown in Fig. 3j).

Fig. 4 shows an example of that part of the circuit 37 (Fig. 1) which derives the control signals RE, CE and FE from the signal a, $\bar{a}$, b, $\bar{b}$ and c.

The radial error signal RE can be obtained by taking the difference between the signals from the halves of the detector 11 (Fig. 1) disposed on each side of a tangential line of symmetry, *i.e.* 11a+11b and 11c+11d. This means that the signal A−B is required, namely at the location of the pits or the signal $\bar{a}-\bar{b}$ after sampling during long pits only. As in the case of a displacement of the objective (8, 9) relative to the beam splitter 10 the light beam is not symmetrically incident on this beam splitter, differences will occur between the signals $\bar{a}$ and $\bar{b}$ which are not due to tracking errors. As this asymmetry also occurs during the intermediate areas it will also appear in the signal a−b. By adapting the signal a−b to the amplitude during the pits, *i.e.* by multiplying by

$$(\bar{a}+\bar{b})/(a+b),$$

which is the ratio between the signal amplitudes during the pits and during the intermediate areas the influence of the asymmetry of the signal $\bar{a}-\bar{b}$ can be determined. The corrected radial error signal is then:

$$RE=\bar{a}-\bar{b}-(a-b)\cdot\frac{(\bar{a}+\bar{b})}{(a+b)}$$

In the circuit shown in Fig. 4, this digital signal RE is obtained on an output 43 by forming the signals a−b and $\bar{a}-\bar{b}$ with subtractor circuits 69 and 70, the signals a+b and $\bar{a}+\bar{b}$ with adder circuits 71 and 72, the signal

$$(\bar{a}+\bar{b})\,(a+b)$$

with divider 74, the signal

$$-(\bar{a}+\bar{b})/(a+b)$$

with inverter 75, the signal

$$-(a-b)\,(\bar{a}+\bar{b})/(a+b)$$

with multiplier 76, and finally the signal RE in conformity with the above relationship by means of adder 77.

The radial error signal RE is employed in order to ensure that the image of the laser beam exactly follows the track, for example by moving the lens system 8 in a radial direction, which gives rise to the aforementioned asymmetry.

A signal which is a measure of this asymmetry may therefore be employed for moving the entire optical system in a radial direction so as to minimize the oblique orientation as a result of the radial tracking. This signal CE is the signal a−b, which appears on the output of the subtractor circuit and which is available on output 44. The signal CE in effect provides "coarse control", whilst the signals RE provides "fine control".

A correction signal FE for the focusing of the laser beam in the intermediate areas may be derived from the difference between the radiation detected by the detectors 11a, 11d and 11b, 11c during the intermediate areas. This signal, which is obtained in analog form as the signal

$$(V_2+V_3)-(V_1+V_4)$$

during the intermediate areas is as follows expressed in samples a, b and c:

$$FE=a+b-2c.$$

In the circuit shown in Fig. 4 the signal FE is obtained on output 45 by doubling the signal c on input 42 by multiplier 73 and subsequently subtracting it from the signal a+b on the output of adder 71 by means of subtractor circuit 78.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which digital information is stored in the form of a track of optically detectable areas (3) which alternate with intermediate areas (4), which apparatus comprises:

an optical system (7, 8, 9) for projecting a light beam on the record carrier (1),

at least two optical detectors (11a, 11b; 11c, 11d) which are so arranged in the beam which has been modulated by the record carrier that in the case of correct tracking the two detectors (11a, 11b; 11c, 11d) are disposed symmetrically with respect to the image of the track,

a signal-generating circuit (13) for generating at least a first (A') and a second (B') detection signal as a function of the amounts of light detected by the optical detectors (11a, 11b; 11c, 11d), and

a control-signal generator for generating at least a control signal (RE') which is a measure of the position of the spot produced by the light beam relative to the track, characterized in that the control signal generator comprises oscillator (18) means for supplying a clock signal,

sampling means (15) which is clocked by the oscillator means (18) for sampling the detection signals (A', B') with the clock signal both during scanning of the optically detectable areas (3) and during scanning of the intermediate areas (4),

is reached and for a positive data signal (Fig. 3c), *i.e.* during an intermediate area, a pulse will appear on output 21 (Fig. 3f), whilst for a negative data signal, *i.e.* during a pit, the pulse will appear on output 20 (Fig. 3g). The signals A, B and C, which have been delayed by three clock periods, are thus sampled. Fig. 3h shows the signal A which has been delayed by three clock periods and for which the hold circuit 32 (Fig. 1) holds the third sample from each intermediate area longer than five clock periods (signal shown in Fig. 3i) the sample and hold circuit 33 holds the third sample from each pit longer than five clock periods (signal shown in Fig. 3j).

Fig. 4 shows an example of that part of the circuit 37 (Fig. 1) which derives the control signals RE, CE and FE from the signal a, $\bar{a}$, b, $\bar{b}$ and c.

The radial error signal RE can be obtained by taking the difference between the signals from the halves of the detector 11 (Fig. 1) disposed on each side of a tangential line of symmetry, *i.e.* 11a+11b and 11c+11d. This means that the signal A−B is required, namely at the location of the pits or the signal $\bar{a}-\bar{b}$ after sampling during long pits only. As in the case of a displacement of the objective (8, 9) relative to the beam splitter 10 the light beam is not symmetrically incident on this beam splitter, differences will occur between the signals $\bar{a}$ and $\bar{b}$ which are not due to tracking errors. As this asymmetry also occurs during the intermediate areas it will also appear in the signal a−b. By adapting the signal a−b to the amplitude during the pits, *i.e.* by multiplying by

$$(\bar{a}+\bar{b})/(a+b),$$

which is the ratio between the signal amplitudes during the pits and during the intermediate areas the influence of the asymmetry of the signal $\bar{a}-\bar{b}$ can be determined. The corrected radial error signal is then:

$$RE=\bar{a}-\bar{b}-(a-b)\cdot\frac{(\bar{a}+\bar{b})}{(a+b)}$$

In the circuit shown in Fig. 4, this digital signal RE is obtained on an output 43 by forming the signals a−b and $\bar{a}-\bar{b}$ with subtractor circuits 69 and 70, the signals a+b and $\bar{a}+\bar{b}$ with adder circuits 71 and 72, the signal

$$(\bar{a}+\bar{b})\,(a+b)$$

with divider 74, the signal

$$-(\bar{a}+\bar{b})/(a+b)$$

with inverter 75, the signal

$$-(a-b)\,(\bar{a}+\bar{b})/(a+b)$$

with multiplier 76, and finally the signal RE in conformity with the above relationship by means of adder 77.

The radial error signal RE is employed in order to ensure that the image of the laser beam exactly follows the track, for example by moving the lens system 8 in a radial direction, which gives rise to the aforementioned asymmetry.

A signal which is a measure of this asymmetry may therefore be employed for moving the entire optical system in a radial direction so as to minimize the oblique orientation as a result of the radial tracking. This signal CE is the signal a−b, which appears on the output of the subtractor circuit and which is available on output 44. The signal CE in effect provides "coarse control", whilst the signals RE provides "fine control".

A correction signal FE for the focusing of the laser beam in the intermediate areas may be derived from the difference between the radiation detected by the detectors 11a, 11d and 11b, 11c during the intermediate areas. This signal, which is obtained in analog form as the signal

$$(V_2+V_3)-(V_1+V_4)$$

during the intermediate areas is as follows expressed in samples a, b and c:

$$FE=a+b-2c.$$

In the circuit shown in Fig. 4 the signal FE is obtained on output 45 by doubling the signal c on input 42 by multiplier 73 and subsequently subtracting it from the signal a+b on the output of adder 71 by means of subtractor circuit 78.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which digital information is stored in the form of a track of optically detectable areas (3) which alternate with intermediate areas (4), which apparatus comprises:

an optical system (7, 8, 9) for projecting a light beam on the record carrier (1),

at least two optical detectors (11a, 11b; 11c, 11d) which are so arranged in the beam which has been modulated by the record carrier that in the case of correct tracking the two detectors (11a, 11b; 11c, 11d) are disposed symmetrically with respect to the image of the track,

a signal-generating circuit (13) for generating at least a first (A') and a second (B') detection signal as a function of the amounts of light detected by the optical detectors (11a, 11b; 11c, 11d), and

a control-signal generator for generating at least a control signal (RE') which is a measure of the position of the spot produced by the light beam relative to the track, characterized in that the control signal generator comprises oscillator (18) means for supplying a clock signal,

sampling means (15) which is clocked by the oscillator means (18) for sampling the detection signals (A', B') with the clock signal both during scanning of the optically detectable areas (3) and during scanning of the intermediate areas (4),

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detection means (19) for identifying the samples as originating from either an optically detectable area (3) or an intermediate area (4),

signal-separating means (32, 33, 34, 35, 36) for separating, under command of the detection means (19), the samples taken during scanning of the optically detectable areas (3) and the samples taken during scanning of the intermediate areas (4), and

a processing circuit (37, 50, 53) for deriving the control signal from the samples taken during scanning of the optically detectable areas, which control signal is corrected for offset-errors by a correction signal, which is derived from at least the samples taken during scanning of the intermediate areas.

2. An apparatus as claimed in Claim 1, characterized in that the first detection signal (A') is representative of the amount of light received by one of the two detectors (11a, 11b) and the second detection signal (B') is representative of the amount of light received by the other of the two detectors (11c, 11d), that the control signal ($\bar{a}$ $\bar{b}$) is derived from the difference between samples of the two detection signals originating from optically detectable areas (3) and that the correction signal (a−b) is derived from the difference between samples of the two detection signals originating from intermediate areas.

3. An apparatus as claimed in Claim 1 or 2, characterized in that the detection means (19) are adapted to detect one sample per optically detectable area (3) and one sample per intermediate area (4) both for the samples from the first detection signal (A') and for the samples from the second detection signal (B'), said clock signal having a frequency which is equal to or is a multiple of the bit frequency.

4. An apparatus as claimed in Claim 3, characterized in that the detection means (19) are adapted to detect said one sample exclusively when the optically detectable areas (3) and the intermediate areas (4) are longer than a predetermined number of clock periods.

5. An apparatus as claimed in Claim 4, characterized in that the signal separating means comprise: first (32), second (33), third (34) and fourth (35) storage means, the samples derived from the first detection signal (A') being applied to the first (32) and the second (33) storage means, the samples derived from the second detection signal (B') being applied to the third (34) and the fourth (35) storage means, the first (32) and the third (34) storage means being switched on by the detection means (19) only upon detection of said one sample if this sample originates from an intermediate area (4), and the second (33) and the fourth (35) storage means being switched on by the detection means (19) only upon detection of said one sample if this sample originates from an optically detectable area (3).

6. An apparatus as claimed in Claim 5, characterized in that the first detection signal (A') is representative of the amount of light received by one of the two detectors (11a, 11b) and the second detection signal (B') is representative of the amount of light received by the other of the two detectors (11c, 11d), that the control signal ($\bar{a}$ $-\bar{b}$) is derived from the difference between the contents of the second (33) and the fourth (35) storage means and that the correction signal (a−b) is derived from the differences between the contents of the first (32) and the third (34) storage means.

7. An apparatus as claimed in Claim 6, characterized in that the corrected control signal is formed in accordance with the formula:

$$(\bar{a}-\bar{b})-\frac{\bar{a}+\bar{b}}{a+b}(a-b)$$

where a, $\bar{a}$, b and $\bar{b}$ are the contents of the first (32), the second (33), the third (34) and the fourth (35) storage means respectively.

8. An apparatus as claimed in Claim 5, 6 or 7, characterized in that the detection means (19) comprise counting means (65) which are started upon every transition between an optically detectable area (3) and an intermediate area (4) and which are arranged to count in the rhythm of the clock signal and to generate a control signal for the first (32) and the third (34) storage means when a predetermined count is reached while scanning an intermediate area (4) and a control signal for the second (33) and the fourth (35) storage means when said predetermined count is reached while scanning an optically detectable area (3), the samples derived from the first (A') and the second (B') detection signal being applied to the storage means with a delay (26, 27) of a predetermined number of clock periods.

9. An apparatus as claimed in Claim 5, 6, 7 or 8, wherein each of the optical detectors is divided into two subdetectors (11a, 11b, 11c, 11d) in order to obtain a focusing-error signal (FE'), characterized in that a third detection signal (C') is derived from the sum of the amounts of light received by the two outer sub-detectors (11a, 11d), which third detection signal (C') is sampled in the same way as the first (A') and the second (B') detection signal, the resulting samples being applied to fifth storage means (36) which, in the same way as the first (32) and third (34) storage means, are switched on by the detection means (19), and a focusing-error signal (FE') is derived in accordance with the formula:

$$a+b-2c$$

where a, b and c are the contents of the first (32), the third (34) and the fifth (36) storage means respectively.

Patentansprüche

1. Gerät zur Wiedergabe von Informationen auf einem optisch lesbaren Aufzeichnungsträger (1), auf dem digitale Information in Form einer Spur optisch detektierbarer Gebiete (3) gespeichert

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wird, die durch Zwischengebiete (4) abgewechselt werden, und diese Gerät enthält

ein optisches System (7, 8, 9) zum Projizieren eines Lichtstrahls auf den Aufzeichnungsträger (1),

wenigstens zwei optische Detektoren (11a, 11b; 11c, 11d), die derart in dem vom Aufzeichnungsträger modulierten Strahl aufgestellt sind, daß bei richtiger Spurnachführung die beiden Detektoren (11a, 11b; 11c, 11d) in bezug auf das Spurbild symmetrisch angeordnet sind,

eine Signalerzeugungsschaltung (13) zum Erzeugen wenigstens eines ersten (A') und eines zweiten (B') Detektorsignals abhängig von den durch die optischen Detektoren (11a, 11b; 11c, 11d) detektierten Lichtmengen, und

einen Steuersignalgenerator zum Erzeugen wenigstens eines Steuersignals (RE') als Maßangabe für die Stelle des vom Lichtstrahl erzeugten Flecks in bezug auf die Spur, dadurch gekennzeichnet, daß der Steuersignalgenerator folgende Mittel enthält:

einen Oszillator (18) zur Lieferung eines Taktsignals,

einen vom Oszillator (18) getakteten Abtaster (15) zum Abtasten der Detektorsignale (A', B') mit dem Taktsignal sowohl beim Abtasten der optisch detektierbaren Gebiete (3) als auch beim Abtasten der Zwischengebiete (4),

einen Detektor (19) zum Identifizeren der Abtastproben bei der Ankunft aus einem optisch detektierbaren Gebiet (3) oder einem Zwischengebiet (4),

Signalabtrennmittel (32, 33, 34, 35, 36) zum Abtrennen der beim Abtasten der optisch detektierbaren Gebiete (3) gezogenen Abtastproben und der beim Abtasten der Zwischengebiete (4) gezogenen Abtastproben unter der Steuerung des Detektors (19), und

eine Verarbeitungsschaltung (37, 50, 53) zum Ableiten des Steuersignals aus den beim Abtasten der optisch detektierbaren Gebiete gezogenen Abtastproben, wobei das Steuersignal für Offset-Fehler von einem Korrektursignal korrigiert wird, das wenigstens aus den beim Abtasten der Zwischengebiete gezogenen Abtastproben abgeleitet ist.

2. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das erste Detektorsignal (A') die von einem der zwei Detektoren (11a, 11b) empfangene Lichtmenge und das zweite Detektorsignal (B') die vom anderen der zwei Detektoren (11c, 11d) empfangene Lichtmenge darstellen, daß das Steuersignal $(\bar{a}-\bar{b})$ vom Unterschied zwischen den Abtastproben der beiden Detektorsignale aus optisch detektierbaren Gebieten (3) und das Korrektursignal (a−b) aus dem Unterschied zwischen den Abtastproben der beiden Detektorsignale aus den Zwischengebieten abgeleitet werden.

3. Gerät nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Detektor (19) zum Detektieren einer Abtastprobe je optisch detektierbares Gebiet (3) und einer Abtastprobe je Zwischengebiet (4) sowohl für die Abtastproben aus dem ersten Detektorsignal (A') als auch für die Abtastproben aus dem zweiten Detektorsignal (B') dient, wobei das Taktsignal eine Frequenz gleich der Bitfrequenz hat oder ein Vielfaches davon ist.

4. Gerät nach Anspruch 3, dadurch gekennzeichnet, daß der Detektor (19) zum ausschließlichen Detektieren der einen Abtastprobe dient, wenn die optische detektierbaren Gebiete (3) und die Zwischengebiete (4) länger sind als eine vorgegebene Anzahl von Taktzeiten.

5. Gerät nach Anspruch 4, dadurch gekennzeichnet, daß die Signalabtrennmittel erste (32), zweite (33), dritte (34) und vierte (35) Speicher enthalten, wobei die vom ersten Detektorsignal (A') abgeleiteten Abtastproben an die ersten (32) und zweiten (33) Speicher gelegt werden, die vom zweiten Detektorsignal (B') abgeleiteten Abtastproben an die dritten (34) und vierten (35) Speicher gelegt werden, die ersten (32) und dritten (34) Speicher vom Detektor (19) nur bei der Detektion der einen Abtastprobe eingeschaltet werden, wenn diese Abtastprobe von einem Zwischengebiet (4) herrührt, und die zweiten (33) und vierten (35) Speicher vom Detektor (19) nur bei der Detektion der einen Abtastprobe eingeschaltet werden, wenn diese Abtastprobe von einem optisch detektierbaren Gebiet (3) herrührt.

6. Gerät nach Anspruch 5, dadurch gekennzeichnet, daß das erste Detektorsignal (A') die von einem der zwei Detektoren (11a, 11b) empfangene Lichtmenge und das zweite Detektorsignal (B') die vom anderen der zwei Detektoren (11c, 11d) empfangene Lichtmenge darstellen, daß das Steuersignal $(\bar{a}-\bar{b})$ vom Unterschied zwischen den Inhalten des zweiten (33) und des vierten (35) Speichers und das Korrektursignal (a−b) von den Unterschieden zwischen den Inhalten des ersten (32) und des dritten (34) Speichers abgeleitet werden.

7. Gerät nach Anspruch 6, dadurch gekennzeichnet, daß das korrigierte Steuersignal entsprechend nachstehender Formel gebildet wird:

$$(\bar{a}-\bar{b})-\frac{\bar{a}+\bar{b}}{a+b}(a-b)$$

worin a, $\bar{a}$, b und $\bar{b}$ die Inhalte des ersten (32), des zweiten (33), des dritten (34) bzw. des vierten (35) Speichers sind.

8. Gerät nach Anspruch 5, 6 oder 7, dadurch gekennzeichnet, daß der Detektor (19) einen Zähler (65) enthält, der bei jedem Übergang zwischen einem optisch detektierbaren Gebiet (3) und einem Zwischengebiet (4) gestartet, zum Zählen im Rhythmus des Taktsignals und zum Erzeugen eines Steuersignals für den ersten (32) und den dritten (34) Speicher, wenn ein vorgegebener Zählstand beim Abtasten eines Zwischengebiets (4) erreicht wird, und zum Erzeugen eines Steuersignals für den zweiten (33) und den vierten (35) Speicher angeordnet ist, wenn der vorgegebene Zählstand beim Abtasten eines optisch detektierbaren Gebiets (3) erreicht wird, wobei die vom ersten (A') und vom zweiten (B') Detektorsignal abgeleiteten Abtastproben mit einer Verzögerung

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26, 27) um eine vorgegebene Anzahl von Taktzeiten an die Speicher gelegt werden.

9. Gerät nach Anspruch 5, 6, 7 oder 8, in dem jeder der optischen Detektoren in zwei Unterdetektoren (11a, 11b; 11c, 11d) unterteilt ist, um ein Fokusfehlersignal (FE') zu erhalten, dadurch gekennzeichnet, daß ein drittes Detektorsignal (C') von der Summe der in den zwei äußersten Unterdetektoren (11a, 11b) Lichtmengen abgeleitet wird, und dieses dritte Detektorsignal (C') genau so wie das erste (A') und das zweite (B') Detektorsignal abgetastet wird, wobei die daraus entstehenden Abtastproben an einen fünften Speicher (36) gelegt wird, der genau so wie der erste (32) und der dritte (34) Speicher vom Detektor (19) eingeschaltet wird, und ein Fokusfehlersignal (FE') entsprechend der Formel

$$a+b-2c$$

abgeleitet wird, worin a, b und c die Inhalte des ersten (32), des dritten (34) bzw. des fünften (36) Speichers sind.

Revendications

1. Appareil pour reproduire de l'information d'un support d'information à lecture optique (1) sur lequel de l'information numérique est stockée sous la forme d'une piste de zones optiquement détectables (3) alternant avec des zones intermédiares (4), appareil comportant:

un système optique (7, 8, 9) pour projeter un faisceau lumineux sur le support d'information (1),

au moins deux détecteurs optiques (11a, 11b, 11c, 11d) qui, dans le faisceau modulé par le support d'information, sont disposés de façon que, dans le cas d'une poursuite de piste correcte, les deux détecteurs (11a, 11b; 11c, 11d) soient situés symétriquement par rapport à l'image de la piste,

un circuit générateur de signaux (13) pour engendrer au moins un premier (A') et un deuxième (B') signal de détection en fonction des quantités de lumière détectées par les détecteurs optiques (11a, 11b; 11c, 11d) et

un générateur de signaux de réglage pour engendrer au moins un signal de réglage (RE') qui est une mesure de la position du spot produit par le faisceau lumineux par rapport à la piste, caractérisé en ce que le générateur de signaux de réglage comporte:

des moyens oscillateurs (18) pour fournir un signal d'horloge,

des moyens d'échantillonnage (15) rythmés par les moyens oscillateurs (18) pour échantiller les signaux de détection (A', B') par le signal d'horloge aussi bien pendant l'exploration des zones optiquement détectables (3) que pendant l'exploration des zones intermédiaires (4),

des moyens de détection (19) pour identifier les échantillons comme échantillons provenant soit d'une zone optiquement détectable (3), soit d'une zone intermédiaire (4),

des moyens séparateurs de signaux (32, 33, 34, 35, 36) pour séparer, sous la commande des moyens de détection (19), les échantillons pris au cours de l'exploration des zones optiquement détectables (3) et les échantillons pris au cours de l'exploration des zones intermédiaires (4), et

un circuit de traitement (37, 50, 53) pour déduire le signal de réglage des échantillons pris au cours de l'exploration des zones optiquement détectables, signal de réglage qui est corrigé en ce qui concerne des erreurs de décalage par un signal de correction au moins déduit des échantillons pris au cours de l'exploration des zones intermédiaires.

2. Appareil selon la revendication 1, caractérisé en ce que le premier signal de détection (A') est représentatif de la quantité de lumière reçue par l'un des deux détecteurs (11a, 11b) et le deuxième signal de détection (B') est représentatif de la quantité de lumière reçue par l'autre détecteur (11c, 11d), en ce que le signal de réglage ($\bar{a}-\bar{b}$) est déduit de la différence entre des échantillons des deux signaux de détection provenant de zones optiquement détectables (3) et en ce que le signal de correction (a−b) est déduit de la différence entre des échantillons des deux signaux de détection provenant de zones intermédiaires.

3. Appareil selon la revendication 1 ou 2, caractérisé en ce que les moyens de détection (19) sont conçus pour détecter un seul échantillon par zone optiquement détectable (3) et un seul échantillon par zone intermédiaire (4) tant pour les échantillons du premier signal de détection (A') que pour les échantillons de deuxième signal de détection (B'), ledit signal d'horloge ayant une fréquence égale à la fréquence de bits ou à un multiple de cette fréquence.

4. Appareil selon la revendication 3, caractérisé en ce que les moyens de détection (19) sont conçus pour détecter ledit seul échantillon uniquement si les zones optiquement détectables (3) et les zones intermédiaires (4) ont une longueur supérieure à un nombre prédéterminé de périodes d'horloge.

5. Appareil selon la revendication 4, caractérisé en ce que les moyens séparateurs de signaux comportent: des premiers (32), deuxièmes (33), troisièmes (34) et quatrièmes (35) moyens de stockage, les échantillons déduits du premier signal de détection (A') étant appliqués aux premiers (32) et aux deuxièmes (33) moyens de stockage, les échantillons déduits du deuxième signal de détection (B') étant appliqués aux troisièmes (34) et aux quatrièmes (35) moyens de stockage, les premiers (32) et les troisièmes (34) moyens de stockage n'étant mis en circuit par les moyens de détection (19) que lors de la détection dudit seul échantillon si cet échantillon provient d'une zone intermédiaire (4), et les deuxièmes (33) et les quatrièmes (35) moyens de stockage n'étant mis en circuit par les moyens de détection (19) que lors de la détection dudit seul échantillon si cet échantillon provient d'une zone optiquement détectable (3).

6. Appareil selon la revendication 5, caractérisé

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en ce que ledit premier signal de détection (A') est représentatif de la quantité de lumière reçue par l'un des deux détecteurs (11a, 11b) et le deuxième signal de détection (B') est représentatif de la quantité de lumière reçue par l'autre détecteur (11c, 11d), en ce que le signal de réglage ($\bar{a}-\bar{b}$) est déduit de la différence entre les contenus des deuxièmes (33) et des quatrièmes (35) moyens de stockage et en ce que le signal de correction (a−b) est déduit des différences entre les contenus des premiers (32) et des troisièmes (34) moyens de stockage.

7. Appareil selon la revendication 6, caractérisé en ce que le signal de réglage corrigé est formé suivant l'expression:

$$(\bar{a}-\bar{b})-\frac{\bar{a}+\bar{b}}{a+b}(a-b)$$

où a, $\bar{a}$, b et $\bar{b}$ sont respectivement les contenus des premiers (32), des deuxièmes (33), des troisièmes (34) et des quatrièmes (35) moyens de stockage.

8. Appareil selon la revendication 5, 6 ou 7, caractérisé en ce que les moyens de détection (19) comportent des moyens de comptage (65) qui sont démarrés lors de chaque passage entre une zone optiquement détectable (3) et une zone intermédiaire (4) et qui sont prévus pour compter dans le rythme du signal d'horloge et pour engendrer un signal decommande pour les premiers (32) et les troisièmes (34) moyens de stockage lorsqu'une position de comptage prédéterminée est atteinte pendant l'exploration d'une zone intermédiaire (4) et un signal de commande pour les deuxièmes (33) et les quatrièmes (35) moyens de stockage lorsque ladite position de comptage prédéterminée est atteinte pendant l'exploration d'une zone optiquement détectable (3), les échantillons déduits du premier (A') et du deuxième signal (B') de détection étant appliqués aux moyens de stockage avec un retard (26, 27) égal à un nombre prédéterminé de périodes d'horloge.

9. Appareil selon la revendication 5, 6, 7 ou 8, dans lequel chacun des détecteurs optiques est divisé en deux sous-détecteurs (11a, 11b, 11c, 11d) pour permettre d'obtenir un signal d'erreur de focalisation (FE'), caractérisé en ce qu'un troisième signal de détection (C') est déduit de la somme des quantités de lumière reçues par les deux sous-détecteurs extérieurs (11a, 11d), troisième signal de détection (C') qui est échantillonné de la même manière que le premier (A') et le deuxième (B') signal de détection, les échantillons ainsi obtenus étant appliqués à des cinquièmes moyens de stockage (36) qui, de la même manière que les premiers (32) et les troisièmes (34) moyens de stockage, sont mis en circuit par les moyens de détection (19), et en ce qu'un signal d'erreur de focalisation (FE) est déduit suivant la formule

$$a+b-2c$$

où a, b et c sont les contenus respectifs des premiers (32), des troisièmes (34) et des cinquièmes (36) moyens de stockage.

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