Description

The invention relates to an apparatus for reproducing information from an optically readable record carrier on which 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,

an optical detector for detecting the light beam which has been modulated by the record carrier and generating a detection signal which is determined by said modulation, and

track-loss detection means for generating a track-loss signal which is an indication of a condition in which the spot produced by the light beam is positioned off the track to a specific extent.

Such apparatus is known *inter alia* as the "compact disc digital audio" player, which is commercially available from N. V. Philips' Gloeilampenfabricken under the type number CD 100. Such an apparatus is also known from GB—A—2029051. In this apparatus the amplitude of the detection signal, after this detection signal has been filtered in a high-pass filter in order to remove low-frequency variations, is used for detecting a loss of track. However, detecting only the amplitude of the high-frequency signal has the disadvantage that decreases in signal amplitude due to other causes, such as fingermarks on the record carrier, may be interpreted as a loss of track. In order to preclude this, variations of the average value of the detection signal are also detected and a track-loss signal is generated only if the amplitude of the high-pass filtered detection signal drops below a reference value and the average value of the detection signal remains above a reference value. Moreover, the use of a high-pass filter in the known method has the disadvantage that in the case of pulse-shaped signal variations such as a signal drop-out due to a defect in the disc results in an error propagation which is caused by the pulse response of said filter.

It is the object of the invention to provide an apparatus of the type specified in the opening paragraph in which loss of track can be detected in a simple but yet reliable manner.

To this end the invention is characterized in that the apparatus comprises means for deriving, from the detection signal, a first signal which is indicative for the detection signal value during the scanning of optically detectable areas, means for deriving, from the detection signal, a second signal which is indicative for the detection signal value during the scanning of intermediate areas, and means for effecting a comparison between the first and second signal, which means are adapted for generating the track loss signal when the detection signal value indicated by the first signal is larger than a determined fraction of the detection signal value indicated by the second signal.

This method of detecting loss of track automatically distinguishes between signal variations as a result of a loss of track, which results in an increase of the signal during scanning of the optically detectable areas, and signal variation as a result of fingermarks which results in a decrease of the signal during scanning of the intermediate areas.

In order to preclude erroneous loss-of-track detection during signal drop-outs the apparatus in accordance with the invention may be further characterized in that the apparatus comprises detection means for detecting signal drop-outs which are identified in that the first signal is substantially identical to the second signal, the track-loss detection means being adapted to inhibit the generation of a track-loss signal during the occurrence of such a signal drop-out.

In order to reduce the influence of variations in parameters, such as laser-light intensity and disc-reflection coefficient, the apparatus in accordance with the invention may be further characterized in that said fraction comprises a modulating factor which is determined by the average strength of the first signal and the average strength of the second signal.

In the known apparatus the track-loss signal is derived in a similar manner from the digital signals originating from the disc, which track-loss signal therefore often has a poor signal-to-noise ratio and is also frequently inaccurate because the information is disturbed by the irregular data signal.

To this end, an apparatus in accordance with the invention, in which the generation of the track-loss signal is improved, is characterized in that the apparatus comprises:

oscillator means for supplying a clock signal,

an analog-to-digital converter which is clocked by the oscillator means for sampling the detection signal detected by the detector both during scanning of the optically detectable areas and during scanning of the intermediate areas,

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

signal-separating means for separating, under command of the detection means, the samples taken during scanning of the optical detectable areas and the samples taken during scanning of the intermediate areas.

This apparatus may be further characterized in that the detection means are adapted to detect one sample per optically detectable area and one sample per intermediate area, the clock frequency being equal to or being a multiple of the bit frequency of the digital information being read.

By selecting one sample every time, the instantaneous sampling frequency after selection will vary in accordance with the instantaneous information-signal frequency, so that cross-talk of spectral components of this 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 only

when the optically detectable areas and intermediate areas are longer than a predetermined number of periods of the bit frequency.

This step ensures that the influence of the optical transefer 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 and second storage means to which the samples are applied, the first storage means are switched on by the detection means only upon detection of said one sample if this sample originates from an intermediate area and the second storage means are switched on by the detection means only upon detection of said one sample if this sample originates from an optically detectable area.

With respect to the detection means the preferred embodiment may be further 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 of bit frequency and to generate a control signal for the first storage means when a predetermined count is reached while scanning an intermediate area and a control signal for the second storage means when said predetermined count is reached while scanning an optically detectable area, the samples being applied to the storage means with a delay of a predetermined number of clock periods.

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

Figure 1 shows the block diagram of an apparatus to which the steps in accordance with the invention may be applied,

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

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

Figure 4 is a diagram to explain the operation of the circuit shown in Figure 5, and

Figure 5 is an example of that part of the circuit 37 (Figure 1) which supplies the signals TL, DO and HFL in conformity with the invention.

Figure 1 shows an apparatus to which the steps in accordance with the invention may be applied. 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 track *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 focusing 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 lower local 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 form by means of a multiplexer 14, they are digitized in an 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 Figure 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 a, 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 of 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 Figure 5, 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 Figure 5. The phase-error signal on output 59 controls the oscillator 18 *via* a low-pass filter 61.

Figure 2 shows an example of the detector 19 in the apparatus shown in Figure 1, and Figure 3 shows some diagrams to explain the operation of the circuit shown in Figure 2. In the circuit shown in Figure 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, Figure 3a shows a part of a data track on the record carrier, which track comprises pits 3 and intermediate areas 4 between these pits. Figure 3b shows the samples A+B originating from the track shown in Figure 3a. Figure 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. Figure 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 at Figure 3e. The counter 65 supplies a pulse each time that the count "six" is reached and for a positive data signal (Figure 3c), *i.e.* during an intermediate area, a pulse will appear on output 21 (Figure 3f), whilst for a negative data signal, *i.e.* during a pit, the pulse will appear on output 20 (Figure 3g). The signals A, B and C, which have been delayed by three clock periods, are thus sampled. Figure 3h shows the signal A which has been delayed by three clock periods and for which the hold circuit 32 (Figure 1) holds the third sample from each intermediate area longer than five clock periods (signal shown in

Figure 3i) and the sample and hold circuit 33 holds the third sample from each pit longer than five clock periods (signal shown in Figure 3j).

Figure 5 shows an example of that part of the circuit 37 (Figure 1) which supplies the signals TL, DO and HFL, Figure 4 illustrating some faults which may occur during the reproduction of the data from a disc. The variation of the signals a+b (the sum of the samples a and b taken during long intermediate areas and $\bar{a}+\bar{b}$ (the sum of the samples $\bar{a}$ and $\bar{b}$ taken during long pits) is plotted in Figure 4. The ranges V represent the values of the signals during undisturbed reproduction. In the range I loss of track occurs. The signal a+b produced by the intermediate areas does not vary, whilst the signal $\bar{a}+\bar{b}$ increases substantially because more light is reflected from the lands between the tracks. In range II a fingermark occurs. The reflection from both the pits and intermediate areas decreases and both signals have become smaller. In range III a "black" signal drop-out occurs, so that neither the intermediate areas nor the pits reflect any light and consequently both the signal a+b and the signal $\bar{a}+\bar{b}$ become zero. Such a signal drop-out may for example occur if the reflecting layer 5 of the disc is missing locally. In range IV a "white" signal drop-out occurs, the signal $\bar{a}+\bar{b}$ then becoming equal to the signal a+b, which for example occurs in the case of the local absence of pits on the disc.

A suitable criterion for determining a signal drop-out is the criterion that the high-frequency signal amplitude, *i.e.* the difference between the signal at the location of an intermediate area and that location of a pit or, if limited to samples during long pits and intermediate areas, the signal $(a+b)-(\bar{a}+\bar{b})$ decreases to a specific extent. In the circuit shown in Figure 5 the adder 115 therefore determines the sum of signals a and b and the adder 116 determines the sum of the signals $\bar{a}$ and $\bar{b}$, whilst the subtractor circuit 136 forms the difference signal $(a+b)-(\bar{a}+\bar{b})$. In order to detect the decrease of this signal a low-pass filter 117 determines the average of this signal, which average is compared with the instantaneous value of the signal in the comparator 118. If this instantaneous value is, for example, less than 15% of the average value, a signal (DO) is supplied to the output 47. In addition, a comparator 119 determines whether the instantaneous signal $(a+b)-(\bar{a}+\bar{b})$ is smaller than for example 50% of the average value and, if this is the case, a signal (HFL) is produced on output 48 as a sign that the data signal has dropped out. Thus, this signal HFL is not only produced during a signal drop-out (situations III and IV) in Figure 4) but for example also in the case of fingermarks (situation II) and loss of track (situation I).

As, for example in the case of fingermarks, the disturbance may be less serious, the time constant of the filter 117 is comparatively small so that the average $(a+b)-(\bar{a}+\bar{b})$ decreases relatively fast in the case of, for example, fingermarks (situation II) and the signal HFL will disappear in the case of prolonged disturbances. In the case of signal drop-outs as in the situations III and IV this is not permissible. Therefore, the signal DO switches the time constant of the filter 117 to a substantially higher value during such faults. During faults for which the signal decreases to a level between 15 and 50% of the undisturbed level, the filter 117 operates with a small time constant and during faults for which the signal decreases to a level below 15% it operates with a large time constant.

In order to detect loss of track it is ascertained whether the signal during the pits $(\bar{a}+\bar{b})$ is larger than a specific fraction α (for example $\alpha=0.5$) of the signal during the intermediate areas (a+b), or:

$$\bar{a}+\bar{b}>\alpha(a+b).$$

However, since in particular the magnitude of the signal $(\bar{a}+\bar{b})$ in the pits depends on the disc quality and these signals also depend on, for example, the laser intensity, it is necessary, in order to make the detector independent of these parameters, that the factor α depends on these parameters by making it dependent on the modulation factor. This modulation factor is, for example, the average of the average value of the signal $\bar{a}+\bar{b}$ and the average value of the signal a+b. In the apparatus shown in Figure 5 the signals a+b and $\bar{a}+\bar{b}$ on the outputs of the adders 115 and 116 respectively are therefore averaged with low-pass filters 120 and 121 respectively and the sum of the averages is taken by means of the summing device 122. The signal a+b on the output of the adder 115 is halved by the divider 123 and subsequently multiplied by the output signal of the summing device 122 in the multiplier 124. The output signal of this multiplier 124 is compared with the output signal $\bar{a}+\bar{b}$ of the adder 116 in the comparator 125, thus yielding an output signal in conformity with the aforementioned criterion

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

where

$$\alpha=\tfrac{1}{2}\times\{\text{average of } (\bar{a}+\bar{b})+\text{average } (a+b)\}.$$

Since this criterion is also valid for signal drop-outs in accordance with situation IV, this signal is combined with the inverse of the signal DO in an AND-gate 126, so that on output 46 a signal TL appears which is indicative of situation I only.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which the 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, an optical detector (11a, 11b, 11c, 11d) for detecting the light

Figure 3i) and the sample and hold circuit 33 holds the third sample from each pit longer than five clock periods (signal shown in Figure 3j).

Figure 5 shows an example of that part of the circuit 37 (Figure 1) which supplies the signals TL, DO and HFL, Figure 4 illustrating some faults which may occur during the reproduction of the data from a disc. The variation of the signals a+b (the sum of the samples a and b taken during long intermediate areas and $\bar{a}+\bar{b}$ (the sum of the samples $\bar{a}$ and $\bar{b}$ taken during long pits) is plotted in Figure 4. The ranges V represent the values of the signals during undisturbed reproduction. In the range I loss of track occurs. The signal a+b produced by the intermediate areas does not vary, whilst the signal $\bar{a}+\bar{b}$ increases substantially because more light is reflected from the lands between the tracks. In range II a fingermark occurs. The reflection from both the pits and intermediate areas decreases and both signals have become smaller. In range III a "black" signal drop-out occurs, so that neither the intermediate areas nor the pits reflect any light and consequently both the signal a+b and the signal $\bar{a}+\bar{b}$ become zero. Such a signal drop-out may for example occur if the reflecting layer 5 of the disc is missing locally. In range IV a "white" signal drop-out occurs, the signal $\bar{a}+\bar{b}$ then becoming equal to the signal a+b, which for example occurs in the case of the local absence of pits on the disc.

A suitable criterion for determining a signal drop-out is the criterion that the high-frequency signal amplitude, *i.e.* the difference between the signal at the location of an intermediate area and that location of a pit or, if limited to samples during long pits and intermediate areas, the signal $(a+b)-(\bar{a}+\bar{b})$ decreases to a specific extent. In the circuit shown in Figure 5 the adder 115 therefore determines the sum of signals a and b and the adder 116 determines the sum of the signals $\bar{a}$ and $\bar{b}$, whilst the subtractor circuit 136 forms the difference signal $(a+b)-(\bar{a}+\bar{b})$. In order to detect the decrease of this signal a low-pass filter 117 determines the average of this signal, which average is compared with the instantaneous value of the signal in the comparator 118. If this instantaneous value is, for example, less than 15% of the average value, a signal (DO) is supplied to the output 47. In addition, a comparator 119 determines whether the instantaneous signal $(a+b)-(\bar{a}+\bar{b})$ is smaller than for example 50% of the average value and, if this is the case, a signal (HFL) is produced on output 48 as a sign that the data signal has dropped out. Thus, this signal HFL is not only produced during a signal drop-out (situations III and IV) in Figure 4) but for example also in the case of fingermarks (situation II) and loss of track (situation I).

As, for example in the case of fingermarks, the disturbance may be less serious, the time constant of the filter 117 is comparatively small so that the average $(a+b)-(\bar{a}+\bar{b})$ decreases relatively fast in the case of, for example, fingermarks (situation II) and the signal HFL will disappear in the case of prolonged disturbances. In the case of signal drop-outs as in the situations III and IV this is not permissible. Therefore, the signal DO switches the time constant of the filter 117 to a substantially higher value during such faults. During faults for which the signal decreases to a level between 15 and 50% of the undisturbed level, the filter 117 operates with a small time constant and during faults for which the signal decreases to a level below 15% it operates with a large time constant.

In order to detect loss of track it is ascertained whether the signal during the pits $(\bar{a}+\bar{b})$ is larger than a specific fraction α (for example $\alpha=0.5$) of the signal during the intermediate areas (a+b), or:

$$\bar{a}+\bar{b}>\alpha(a+b).$$

However, since in particular the magnitude of the signal $(\bar{a}+\bar{b})$ in the pits depends on the disc quality and these signals also depend on, for example, the laser intensity, it is necessary, in order to make the detector independent of these parameters, that the factor α depends on these parameters by making it dependent on the modulation factor. This modulation factor is, for example, the average of the average value of the signal $\bar{a}+\bar{b}$ and the average value of the signal a+b. In the apparatus shown in Figure 5 the signals a+b and $\bar{a}+\bar{b}$ on the outputs of the adders 115 and 116 respectively are therefore averaged with low-pass filters 120 and 121 respectively and the sum of the averages is taken by means of the summing device 122. The signal a+b on the output of the adder 115 is halved by the divider 123 and subsequently multiplied by the output signal of the summing device 122 in the multiplier 124. The output signal of this multiplier 124 is compared with the output signal $\bar{a}+\bar{b}$ of the adder 116 in the comparator 125, thus yielding an output signal in conformity with the aforementioned criterion

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

where

$$\alpha=\tfrac{1}{2}\times\{\text{average of } (\bar{a}+\bar{b})+\text{average } (a+b)\}.$$

Since this criterion is also valid for signal drop-outs in accordance with situation IV, this signal is combined with the inverse of the signal DO in an AND-gate 126, so that on output 46 a signal TL appears which is indicative of situation I only.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which the 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, an optical detector (11a, 11b, 11c, 11d) for detecting the light

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beam modulated by the record carrier (1) and generating a detection signal which is determined by said modulation, and track-loss detection means for generating a track-loss signal (TL) which is an indication of a condition in which the spot produced by the light beam is positioned off the track to a specific extent, characterized in that the apparatus comprises means for deriving, from the detection signal, a first signal $(\overline{a}+\overline{b})$ which is indicative for the detection signal value during the scanning of the optically detectable areas, means for deriving, from the detection signal, a second signal (a+b) which is indicative for the detection signal value during the scanning of the intermediate areas, and means (123, 124, 125) for effecting a comparison between the first and second signal, which means are adapted for generating the track loss signal (TL) when the detection signal value indicated by the first signal $(\overline{a}+\overline{b})$ is larger than a determined fraction of the detection signal value indicated by the second signal (a+b).

2. An apparatus as claimed in Claim 1, characterized in that the apparatus comprises detection means for detecting signal drop-outs (DO) which are identified by the first signal $(\overline{a}+\overline{b})$ being substantially identical to the second signal (a+b), the track-loss detection means being adapted to inhibit the generation of a track-loss signal (TL) during the occurrence of such a signal drop-out (DO).

3. An apparatus as claimed in Claim 1 or 2, characterized in that said fraction comprises a modulation factor which is determined by the average strength of the first signal $(\overline{a}+\overline{b})$ and the average strength of the second signal (a+b).

4. An apparatus as claimed in Claim 1, 2 or 3, characterized in that the apparatus comprises:

oscillator means (18) for supplying a clock signal,

an analog-to-digital converter (15) which is clocked by the oscillator means (18) for sampling a detection signal detected by the detector (11a, 11b, 11c, 11d) both during scanning of the optically detectable areas (3) and during scanning of the intermediate areas (4),

detection means (25, 24, 19) for identifying samples as originating either from an optically detectable area (3) or from an intermediate area (4), and

signal-separating means (32, 33, 34, 35) for separating, under command of the detection means (25, 24, 19) the samples taken during scanning of the optically detectable areas (3) and the samples taken during scanning of the intermediate areas (4).

5. An apparatus as claimed in Claim 4, characterized in that the detection means (25, 24, 19) are adapted to detect one sample per optically detectable area (3) and one sample per intermediate area (4), the clock frequency being equal to or being a multiple of the bit frequency of the digital information being read.

6. An apparatus as claimed in Claim 5, characterized in that the detection means (25, 24, 19) are adapted to detect said one sample only when the optically detectable areas (3) and intermediate areas (4) are longer than the predetermined number of periods of the bit frequency.

7. An apparatus as claimed in Claim 6, characterized in that the signal-separating means (32, 33, 34, 35) comprise: first and second storage means to which the samples are applied, the first storage means (32, 34) are switched on by the detection means (23, 24, 19) only upon detection of said one sample if this sample originates from intermediate area (4) and the second storage means (33, 35) are switched on by the detection means (25, 24, 19) only upon detection of said one sample if this sample originates from an optically detectable area (3).

8. An apparatus as claimed in Claim 7, characterized in that the detection means (62—68) 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 of bit frequency and to generate a control signal for the first storage means (32, 34) when a predetermined count is reached while scanning an intermediate area (4) and a control signal for the second storage means (33, 35) when said predetermined count is reached while scanning an optically detectable area (3), the samples being applied to the storage means (32, 33, 34, 35) with a delay (26, 27) of a predetermined number of clock periods.

Patentansprüche

1. Gerät zur Wiedergabe von Information auf einem optische lesbaren Informationsträger (1), auf dem die Information in Form einer Spur optisch detektierbarer Gebiete (3) gespeichert ist, die mit Zwischengebeiten (4) abwechseln, und dieses Gerät enthält ein optisches System (7, 8, 9) zum Prodizieren eines Lichstrahls auf den Aufzeichnungsträger, einen optischen Detektor (11a, 11b, 11c, 11d) zum Detektieren des vom Aufzeichnungsträger (1) modulierten Lichtstrahls und zum Erzeugen eines Detektorsignals, das durch diese Modulation bestimmt ist, und Spurverlustdetektormittel zum Erzeugen eines Spurverlustsignals (TL), das eine Anzeige eines Zustands ist, in dem der vom Lichstrahl erzeugte Fleck gewissermassen entspurt ist, dadurch gekenneichnet, dass das Gerät Mittel zum Ableiten eines ersten Signals $(\overline{a}+\overline{b})$ aus dem Detektorsignal, wobei das erste Signal für den Detektorsignalwert beim Abtasten der optisch detektierbaren Gebiete bezeichnend ist, Mittel zum Ableiten eines zweiten Signals (a+b) aus dem Detektorsignal, wobei dieses zweite Signal für den Detektorsignalwert beim Abtasten der Zwischengebiete bezeichnend ist, und Mittel (123, 124, 125) zum Durchführen eines Vergleichs zwischen dem ersten und dem zweiten Signal enthält, wobei diese Mittel zum Erzeugen des Spurverlustsignals (TL) dienen, wenn der vom ersten Signal $(\overline{a}+\overline{b})$ angegebene Detektorsignalwert grösser als ein bestimmter Teil des vom

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zweiten Signal (a+b) angegebenen Detektorsignalwerts ist.

2. Gerät nach Anspruch 1, dadurch gekennzeichnet, dass es Detektormittel zum Detektieren von Signalausfällen (DO) enthält, die vom ersten Signal $(\overline{a}+\overline{b})$ als im wesentlichen gleich dem zweiten Signal (a+b) erkannt werden, wobei die Spurverlustdetektormittel die Erzeugung eines Spurverlustsignals (TL) beim Erscheinen eines derartigen Signalausfalls (DO) verhindern.

3. Gerät nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass der Teil einen Modulationsfaktor enthält, der von der mittleren Stärke des ersten Signals $(\overline{a}+\overline{b})$ und von der mittleren Stärke des zweiten Signals (a+b) bestimmt wird.

4. Gerät nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, das das Gerät folgende Mittel enthält:

einen Oszillator (18) zum Erzeugen eines Taktsignals,

einen Analog/Digital-Wandler (15), der vom Oszillator (18) zum Abtasten eines vom Detektor (11a, 11b, 11c, 11d) detektierten Detektorsignals sowohl beim Abtasten der optische detektierbaren Gebiete (3) und beim Abtasten der Zwischengebiete (4) getaktet wird,

Detektormittel (25, 24, 19) zum Identifizieren von Abtastproben sowohl aus einem optisch detektierbaren Gebiet (3) als auch aus einem Zwischengebiet (4), und

Signalabtrennmittel (32, 33, 34, 35) zum Abtrennen der beim Abtasten der optisch detektierbaren Gebiete (3) gezogenen Abtastproben und der beim Abtasten der Zwischengebiete (4) gezogenen Abtastproben unter der Steuerung der Detektormittel (25, 24, 19).

5. Gerät nach Anspruch 4, dadurch gekennzeichnet, dass die Detektormittel (25, 24, 19) zum Detektieren einer Abtastprobe je optisch detektierbares Gebiet (3) und einer Abtastprobe je Zwischengebiet (4) dienen, wobei die Taktfrequenz gleich der Bitfrequenz der zu lesenden digitalen Information oder ein Vielfaches davon ist.

6. Gerät nach Anspruch 5, dadurch gekennzeichnet, dass die Detektormittel (25, 24, 19) zum Detektieren dieser einen Abtastprobe dienen, nur wenn die optische detektierbaren Gebiete (3) und die Zwischengebiete (4) länger als die vorgegebene Anzahl von Perioden der Bitfrequenz sind.

7. Gerät nach Anspruch 6, dadurch gekennzeichnet, dass die Signalabtrennmittel (32, 33, 34, 35) erste und zweite Speicher enthält, an die die Abtastproben gelegt werden, wobei der erste Speicher (32, 34) von den Detektormitteln (25, 24, 19) nur bei der Detektion dieser einen Abtastprobe eingeschaltet wird, wenn sie aus einem Zwischengebiet (4) herrührt, und der zweite Speicher (33, 35) von den Detektormitteln (25, 24, 19) nur bei der Detektion der einen Abtastprobe eingeschaltet wird, wenn sie aus einem optisch detektierbaren Gebiet (3) herrührt.

8. Gerät nach Anspruch 7, dadurch gekennzeichnet, dass die Detektormittel (62—68) Zählmittel (65) enthalten, die bei jedem Übergang zwischen einem optisch detektierbaren Gebiet (3) und einem Zwischengebiet (46) gestartet werden, zum Zählen im Rhythmus des Taktsignals der Bitfrequenz zum Erzeugen eines Steuersignals für den ersten Speicher (32, 34) angeordnet sind, wenn ein vorgegebener Zählstand beim Abtasten eines Zwischengebiets (4) erreicht wird, und zum Erzeugen eines Steuersignals für den zweiten Speicher (33, 35) angeordnet sind, wenn der vorgegebene Zählstand beim Abtasten eines optisch detektierbaren Gebiets (3) erreicht wird, wobei die Abtastproben mit einer Verzögerung (26, 27) einer vorgegebenen Anzahl von Taktseiten an die Speicher (32, 33, 34, 35) gelegt werden.

Revendications

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

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

un détecteur optique (11a, 11b, 11c, 11d) pour détecter le faisceau lumineux modulé par le support d'information (1) et pour engendrer un signal de détection déterminé par ladite modulation et

des moyens de détection de pertes de piste pour engendrer un signal de perte de piste (TL) indicatif d'un état où le spot est écarté de la piste dans une mesure déterminée, caractérisé en ce qu'il comporte des moyens pour déduire du signal de détection un premier signal $(\overline{a}+\overline{b})$ qui est indicatif de la valeur du signal de détection au cours de l'exploration des zones optiquement détectables, des moyens pour déduire du signal de détection un deuxième signal (a+b) qui est indicatif de la valeur du signal de détection au cours de l'exploration des zones intermédiaires, et des moyens (123, 124, 125) pour effectuer une comparaison entre le premier et le deuxième signal, moyens qui sont conçus pour engendrer le signal de perte de piste (TL) lorsque la valeur du signal de détection indiquée par le premier signal $(\overline{a}+\overline{b})$ est supérieure à une fraction déterminée de la valeur du signal de détection indiquée par le deuxième signal (a+b).

2. Appareil selon la revendication 1, caractérisé en ce qu'il comporte des moyens de détection pour détecter des pertes de signal (DO) identifiées par le fait que le premier signal $(\overline{a}+\overline{b})$ est sensiblement identique au deuxième signal (a+b), les moyens de détection de pertes de piste étant conçus pour empêcher la génération d'un signal de perte de piste (TL) lors de l'apparition d'une telle perte de signal (DO).

3. Appareil selon la revendication 1 ou 2, caractérisé en ce que ladite fraction comporte un facteur de modulation déterminé par l'intensité moyenne du premier signal $(\overline{a}+\overline{b})$ et l'intensité moyenne de deuxième signal (a+b).

4. Appareil selon la revendication 1, 2 ou 3, caractérisé en ce qu'il comporte:

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

un convertisseur analogique-numérique (15) rythmé par les moyens oscillateurs (18) pour échantillonner le signal de détection détecté par le détecteur (11a, 11b, 11c, 11d) tant au cours de l'exploration des zones optiquement détectables (3) qu'au cours de l'exploration des zones intermédiaires (4).

des moyens de détection (25, 24, 19) pour identifier les échantillons comme provenant soit d'une zone optiquement détectable (3), soit d'une zone intermédiaire (4) et

des moyens séparateurs de signaux (32, 33, 34, 35) pour séparer, sous la commande des moyens de détection (25, 24, 19) d'une part, les échantillons pris au cours de l'exploration des zones optiquement détectables (3) et, d'autre part, les échantillons pris au cours de l'exploration des zones intermédiaires (4).

5. Appareil selon la revendication 4, caractérisé en ce que les moyens de détection (25, 24, 19) sont conçus pour détecter un seul échantillon par zone optiquement détectable (3) et un seul échantillon par zone intermédiaire (4), la fréquence d'horloge étant égale à la fréquence de bits de l'information numérique lue ou à un multiple de celle-ci.

6. Appareil selon la revendication 3, caractérisé en ce que les moyens de détection (25, 24, 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 de la fréquence de bits.

7. Appareil selon la revendication 6, caractérisé en ce que les moyens séparateurs de signaux (32, 33, 34, 35) comportent: des premiers et deuxièmes moyens de stockage auxquels sont appliqués le échantillons, les premiers moyens de stockage (32, 34) n'étant mis en circuit par les moyens détecteurs (25, 24, 19) que lors de la détection dudit seul échantillon si cet échantillon provient d'une zone intermédiaire (4), et les deuxièmes moyens de stockage (33, 35) n'étant mis en circuit par les moyens de détection (25, 24, 19) que lors de la détection dudit seul échantillon si cet échantillon provient d'une zone optiquement détectable (3).

8. Appareil selon la revendication 7, caractérisé en ce que les moyens de détection (62—68) 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 le rythme du signal d'horloge à fréquence de bits et pour engendrer un signal de commande pour les premiers moyens de stockage (32, 34) lorsqu'une position de comptage prédéterminée est atteinte pendant l'exploration d'une zone intermédiaire (4) et un signal de commande pour les deuxièmes moyens de stockage (33, 35) lorsque ladite position de comptage prédéterminée est atteinte pendant l'exploration d'une zone optiquement détectable (3), les échantillons étant appliqués aux moyens de stockage (32, 33, 34, 35) avec un retard (26, 27) égal à un nombre prédéterminé de périodes d'horloge.

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