Description

The invention relates to an apparatus for reproducing information from an optically readable 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 an optical detector *via* the record carrier which detector comprises four sub-detectors situated in four separate quadrants of an imagiary X—Y-coordinate system whose origin is situated on the optical axis of the optical system and of which the X-axis extends effectively in the track direction and the Y-axis extends effectively transversely of the track direction, a first adder circuit for adding the signals supplied by diagonally disposed first and third sub-detectors to form a first signal (S_1), a second adder circuit for adding the signals supplied by at least the other two sub-detectors to form a second signal (S_0) and a tracking error signal generator for deriving a tracking error signal from the first and second signal in dependence on the time difference between corresponding zero-crossings of the first and second signal respectively, to which end the tracking error signal generator is provided with zero-cross detectors for detecting zero-crossings of the first and second signal and means for measuring the time interval between the detections of the corresponding zero-crossings and for generating a time difference signal indicative for the time interal measured.

Such apparatus is known from the European Patent Application No. 0.087.973.

In the known apparatus a time difference signal, in the form of a time difference pulse with a width indicative for the time interval between the corresponding zero-crossings, is generated in response to each detection of the corresponding zero-crossings of the first and second signal. The time difference pulses are supplied to low-pass filters. The output signals of the low-pass filters are combined to the tracking error signal. In the known apparatus the instantaneous frequency of the signal read influence the amplitude of the error signal, so that a frequency-dependent relationship is established between the tracking error signal and the tracking error.

It is the object of the invention to provide an apparatus of the type specified in the opening paragraph in which the generated tracking error signal is more independent of the recorded information.

According to the invention this object is obtained in an apparatus which is characterized in that the tracking error signal generator further comprises means for maintaining the generation of the time difference signal until the next detection of the corresponding zero-crossings, and in that the time difference signal forms the tracking error signal. In this apparatus continuous generation of the time difference signal is obtained, so that the amplitude of the time difference signal is independent on the frequency of the read signal.

An embodiment of the apparatus in accordance with the invention which is intended for reading a record carrier in which information of a substantially fixed frequency is stored may be further characterized in that the zero-crossings detectors are adapted for generating first and second pulses respectively at the zero-crossings of the first and second signal respectively, and in that the signal generator maintaining means comprise first and second tuned circuits (36, 37) for receiving the first and second pulses respectively for the excitations of the first and second timed circuit, which tuned circuits are tuned to the bit frequency or upper harmonic thereof, respectively and in that the measuring means (39, 40, 41, 43) comprises a first phase detector for detecting the phase difference between the signals supplied by the first and second tuned circuit in order to measure the said time interval.

In this embodiment the first tuned circuit is excited in response to a detection of a zero-crossing of the first signal. As this circuit is tuned to the bit frequency of the recorded signal the zero-crossings of the first signal always appears in phase with the wave form on the output of the wave form on the output of the first tuned circuit.

The instants at which the zero-crossings of the first signal appears are then defined by the instantaneous phase of the output of the first tuned circuit. The first tuned circuit thus functions as a hold circuit for the zero crossing instant of the first signal. In the same way the second tuned circuit functions as a hold circuit for the zero-crossing instant of the second signal.

The time difference between the zero-crossings instants, hold in the tuned circuits, is determined by the phase detector for determining the phase difference between the wave forms on the outputs of the tuned circuits, so that the generation of the time difference signal is guaranteed during the whole time interval until the next zero-crossing detection.

This embodiment has the advantage that the time measurement is reduced to a phase measurement with constant frequency, which can be effected very simply.

This embodiment may be further characterized in in that the tracking error signal generator comprises a third zero-crossing detector for supplying third pulses at zero crossings of the third signal, in that the signal generation maintaining means comprise a third tuned circuit which is tuned to the bit frequency or an upper harmonic thereof, and which is excited by said third zero-crossing detector and in that the measuring means comprise a second phase detector for detecting the phase difference between the signals supplied by the second and the third tuned circuits, and a summing device for adding the signals supplied by the first and the second phase detector.

An alternative to this embodiment may be characterized in that the measuring means comprise means for generating a pulse-shaped signal of a duration corresponding to the interval

between corresponding zero crossings of the first and the second signal, time-measurement means for determining the duration of the pulses of said pulse-shape signal, direction-detection means for detecting the sequence in which corresponding zero crossings of the first and the second signal occur and in response thereto inverting or not inverting the polarity of the output signal of the time-measurement means, and in that the signal generation maintaining means comprise storage means for storing the result of the time interval measurement.

With respect to the means for generating the pulse-shaped signal, this embodiment may be characterized in that the means for generating a pulse-shaped signal comprise first and second limiter means for converting the first and the second signal into a substantially rectangular signal, and a gate circuit with an exclusive-OR function to which said limited signals are applied, and with respect to the direction-detection means, in that the direction-detection means comprise a detector which determines the polarity of the first signal at the instant of a zero-crossing of the second signal.

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

Fig. 1 shows a known apparatus for reading an optically readable record carrier,

Fig. 2 shows a known tracking-error detector for use in the apparatus shown in Fig. 1,

Fig. 3 shows some signal waveforms to illustrate the principle underlying the apparatus in accordance with the invention,

Fig. 4 shows a first example of a tracking-error signal generator for use in apparatus in accordance with the invention,

Fig. 5 shows some signal waveforms to illustrate the operation of the apparatus shown in Fig. 4, and

Fig. 6 shows a second example of a tracking-error signal generator for use in an apparatus in accordance with the invention.

Fig. 1 shows a round disc-shaped record carrier 1 in radial cross-section. The information structure is assumed to be reflecting and comprises tracks of optically detectable areas alternating with intermediate areas. The information tracks bear the reference numeral 3. A radiation source 6, for example a semiconductor laser, emits a read beam. A mirror 9 reflects this beam to an objective system 11, which is schematically represented by a single lens. In the path of the read beam *b* an auxiliary lens 7 is arranged, which ensures that the read beam fills the pupil of the objective system entirely. A radiation spot of minimal dimensions is then formed on the surface 2 of the information structure.

The read beam is reflected by the information structure and, as the record carrier rotates about a spindle 5 which projects through a centre hole 4, this beam is time-modulated in conformity with the information stored in the track to be read. The modulated read beam again passes through the objective system and is reflected by the mirror 9 in the same direction as the beam emitted by the source. Elements for separating the paths of the modulated and the unmodulated read beams are arranged in the radiation path of the read beam. These elements may comprise, for example, an assembly of a polarization-sensitive beam-splitter prism and a $\gamma/4$ plate. For simplicity it is assumed that in Fig. 1 the said means comprise a semi-transparent mirror 8. This mirror reflects a part of the modulated read beam to a radiation-sensitive detection system 12.

The optical details of the information structure are very small. The read spot should therefore remain centred very accurately on the track to be read.

In order to enable centring errors to be detected, the detection system 12 comprises, for example, four radiation-sensitive detectors, as is shown in Fig. 2. The four detectors 13, 14, 15 and 16 are disposed in four different quadrants of an X—Y-coordinate system. When a track portion to be read is projected onto the detection system the longitudinal direction and the lateral direction of the track portion extend parallel to the X-axis and the Y-axis respectively.

As is also shown in Fig. 2, the output signals of the detectors 13 and 15 are added to each other by means of the adder circuit 17 and the output signals of the detectors 14 and 16 are added to each other by means of the adder circuit 18. The output signals S_1 and S_2 of the adder circuits 17 and 18 are subtracted from each other in the subtractor circuit 19. The output of this circuit is connected to one of the inputs of a multiplier circuit 22. The output signal of the circuit 22 is applied to a low-pass filter 23. The desired control signal is obtained on the output 28 of this filter. Moreover, the output signals of the adder circuits 17 and 18 are added to each other in an adder circuit 24. The sum S_0 of the signals read by means of the four detectors 13, 14, 15 and 16, *i.e.* the desired read signal, then appears on the output of this adder circut 24. As the signal supplied by the subtractor circuit 19, which signal is the difference between the signals supplied by the two pairs of diagonally situated detectors 13, 15 and 14, 16 has a polarity which depends on the direction of the tracking error, *i.e.* the deviation of the spot formed by the laser beam *b* from the information track 3 to be followed, and varies when an optically detectable area or an intermediate area in the track 3 is scanned, the directional information is not available in the output signal of the subtractor circuit 19. In order to obtain this information the sum signal from the adder circuit 24 is 90° shifted in phase in the phase shifter 25 and applied to the other input of the multiplier 22, which thus operates as a synchronous detector. The direction information of the tracking error is then contained in said output signal as the polarity of the low-frequency component (which is passed by the filter 23). For a further description of this known apparatus reference is made to Netherlands Patent Application no. 7600842 (PHN 8290).

Fig. 3 shows some waveform diagrams to

illustrate the principle of the apparatus in accordance with the invention. The Figure shows an example of the variation of the signals S_1, S_2 and S_0 when an optically detectable area passes the spot where the beam is incident. The signal S_0 then intersects the zero axis at an instant t_0. If the spot formed by the beam has such a deviation from the track that the image of the optically detectable area situated above the X-axis in the Figure, assuming that owing to the displacement of the record carrier this image moves to the left in the Figure, the passage of optically detectable areas will be detected by the detectors 13 and 15 before the detectors 14 and 16, which can be seen in the diagrams of Figure 3 in that the signal S_1 intersects the zero axis at the instant t_1, which appears a time ΔT before the instant t_0, and in that the signal S_2 intersects the zero axis at the instant t_2, which appears a time ΔT after the instant t_0. If the deviation of the spot is exactly the opposite, the signal S_2 will intersect the zero axis at the instant t_1 and the signal S_1 at the instant t_2. The magnitude of e time interval ΔT is then a measure of the eviation of this spot. A tracking signal can then be found by measuring said time ΔT, whilst it is possible to measure the time interval between the instants t_1 and t_2, *i.e.* between the zero crossings of the signals S_1 and S_2 or, alternatively, to measure the time interval between one of the instants t_1 and t_2 and the instant t_0, *i.e.* between the zero crossings of the signal S_1 or S_2 and the signal S_0.

In comparison with the known apparatus a time measurement yields the following advantages:

—it is not necessary to subject a signal whose instantaneous frequency is not fixed to a 90° phase shift,

—the measurement is locked to the zero crossings of the detected signal, *i.e.* to an instantaneous repetition frequency which follows the instantaneous frequency of the signal read, which means that crosstalk of the signal into the detected tracking-error signal on the output 28 is minimal,

—the amplitude of the signal being read hardly plays a role. The generation of the tracking-error signal is highly independent of the detected amount of light, *i.e.* of the reflection coefficient of the disc and the intensity of the laser beam,

—the instantaneous frequency of the signal being read does not influence the amplitude of the tracking-error signal, which is in contradistinction to the known apparatus where a phase difference is detected by synchronous detection. The relationship between the tracking error and said phase difference is then inversely proportional to the instantaneous signal frequency,

—a variation of the d.c. level within specific limits will not affect the time measurement. Indeed, such a variation will give rise to a simultaneous shift of the instants t_0, t_1 and t_2 (Fig. 3), which will not affect the length of ΔT.

Fig. 4 shows an embodiment of an apparatus in accordance with the invention which is intended in particular for use in conjunction with record carriers on which a digital signal (for example a digital audio signal) of fixed bit frequency is recorded, and in which the detectors 13 to 16 and the adder circuits 17, 24 and 18 are identical to those in Fig. 2. The signals S_1, S_2 and S_0 supplied by said adder circuits are applied to limiter circuits 30, 31 and 32 and subsequently to zero-crossing detectors 33, 34 and 35 which supply a pulse in the case of a zero crossing of their input signals, and which may comprise for example monostable multivibrators, differentiators and exclusive- or gates, to which the signal is applied directly and with a specific time delay. The zero-crossing detectors 33, 34 and 35 excite band-pass filters 36, 37 and 38 which are tuned to a frequency of which corresponds to the bit frequency of the reproduced signal. The operation of this part of the apparatus shown in Fig. 4 will be described with reference to Fig. 5. From top to bottom this Figure shows the signal S_0 on the output of the adder circuit 24, the signal S_3 on the output of the limiter circuit 31, the signal S_4 on an output of the zero-crossing detector 34, and the signal S_5 on the output of the band-pass filter 37. The signal S_0 is limited, so that a squarewave signal S_3 is obtained whose zero crossings coincide with the zero crossings of the signal S_0. The signal S_4 then comprises pulses in synchronism with the zero crossings. The narrow-band band-pass filter 37 is then excited by these pulses. As this filter is tuned to the bit frequency of the recorded signal the pulses at the zero crossings always appear in phase with the waveform on the output of the band-pass filter 37. The signal S_5 is a waveform of the frequency fo, which is excited each time and whose amplitude decays after every excitation. The instants at which the zero crossings of the signal S_0 appear are then defined by the instantaneous phase of the signal S_5. The band-pass filter thus functions as a hold circuit for the zero-crossing instant.

Similarly the band-pass filters 36 and 38 supply waveforms of the frequency fo. Their mutual phase relationship depends on the intervals between the zero-crossing instants of the signals S_0, S_1 and S_2 and consequently on the tracking error.

The phase differences and the tracking-error signal are further determined in the same manner as in the apparatus shown in Fig. 2, but now by means of signals of constant frequency fo. In order to preclude problems as a result of the varying amplitude of the output signals of the band-pass filters 36, 37 and 38, the signals are applied to a limiter circuits 40, 41 and 42. The output signals of the limiter circuits 40 and 41 are applied to a multiplier 43 and the output signals of the limiter circuits 41 and 42 are applied to a multiplier 44. The low-frequency component of the output signal of the multiplier 43 then depends on time interval (t_1—t_0 (Fig. 3) and the low-frequency component of the output signal of the multiplier 44 on the time interval t_0—t_2. The two output signals are added to each other in the adder 45 and subsequently they are applied to the output 28 *via* the low-pass filter 23.

A disadvantage of the tracking-error detection in accordance with Fig. 4 is that the maximum time

ΔT which can be measured unambiguously is in principle equal to one period of the waveform of the frequency fo and, as a result of the use of multipliers for the phase detectors, it is even limited to a quarter of this period.

Fig. 6 shows a second embodiment of an apparatus in accordance with the invention whose use is not limited to reading record carriers on which information of a substantially fixed bit frequency is recorded and whose measurement range is in principle equal to the length of the optically detectable area being read. In the same way as the apparatus shown in Fig. 4 it comprises the detectors 13, 14, 15 and 16, the adder circuits 17, 18 and 24, and the limiter circuits 30, 32 and 31. The output signals of the limiter circuits 30 and 32 are applied to an exclusive-or gate 46. This gate then supplies an output signal during the intervals in which the output signals of the limiters 30 and 32 are of opposite polarity, *i.e.* during the intervals t_1 to t_2 (Fig. 3). The duration of the output signal of this exclusive-or gate 46 is consequently a measure of the tracking error. In order to measure this duration the output signal of the gate 46 closes a switch 47, so that the current from a current source 48 charges a capacitor 49. The charge of this capacitor after the switch 47 has been opened again is then a measure of the duration of the output signal of the gate 46 and hence a measure of the tracking error. *Via* a voltage follower 50 and a switch 51 the capacitor 49 is connected to a capacitor 52. The switch 51 is actuated by the output signal of a pulse shaper 53 which responds to the negative edge of the output signal of the gate 46, so that the switch 51 is closed after switch 47 has been opened again and the capacitor 52 is charged to the value of the charge on the capacitor 49. The switch 51 and the capacitor 52 thus function as a hold circuit. A pulse shaper 54 responds to the negative edge of the output signal of the pulse shaper 53 and controls a switch 55 which is arranged in parallel with capacitor 49, so that after the charge of capacitor 49 has been detected via the switch 51, the capacitor 49 is discharged again *via* the switch 55.

The charge on capacitor 52 is a measure of the tracking error. However, the direction of this tracking error is still unknown. For this purpose the charge on capacitor 52 is applied to a switchable inverter circuit 57 *via* a voltage follower, so that the polarity of the signal after said switchable inverter circuit 57 is an indication of the direction of the tracking error. The output signal of said switching inverter circuit is applied to an output 28*via* output 28 *via* the low-pass filter 23.

In order to determine the direction of the tracking error the output signal of the limiter 32 is applied to the D-input of a D-flip-flop 58, the output signal of the limiter 31 being applied to the clock input C. The flip-flop 58 is of a type which is triggered on the negative edge of the signal on its clock input C, so that the output signal of the flip-flop 58 follows the output signal of the limiter 32 at the zero-crossing instants during the negative edges of the signal S_0 (*i.e.* instant t_3 in Fig. 3). The output signal on the Q-output of the flip-flop 58 is then high if the signal S_2 is high at the instant t_3, or if the signal S_2 lags the signal S_0. Similarly, the output signal of the limiter 32 is applied to the 0-input of a D flip-flop 59 and the inverted output signal of the limiter 31 is applied to the clock input C, so that flip-flop 59 is triggered on the zero-crossings of the signal S_0 during positive edges, or at the instant t_0 (Fig. 3). The inverted output $\bar{Q}$ of flip-flop 59 is then if the signal S_2 is low at the instant t_0 or if the signal S_2 is lagging.

Via a change-over switch 60 which is actuated by the clock signal from flip-flop 59, the Q-output of flip-flop 58 and the $\bar{Q}$-output of flip-flop 59 are alternately connected to the D-input of a D flip-flop 61 which is clocked by the negative edges of the output signal of the pulse shaper 53, *i.e.* at the same time that the switch 61 which samples the charge on the capacitor 49 is closed. Thus, the flip-flop 61 generates a signal of a polarity corresponding to the direction of the tracking error, which flip-flop is clocked again after every time measurement. The flip-flop 61 in its turn controls the switchable inverter circuit 57.

In the apparatus shown in Fig. 6 the time interval t_1—t_2 (Fig. 3) is measured in the similar manner. A digital measurement is also possible, for example in the apparatus shown in Fig. 6 by starting a counter by means of the exclusive-or gate 46, which counter counts the counting pulses supplied by a high-frequency counting-pulse oscillator.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which information is stored in the form of a track (3) of optically detectable areas which alternate with intermediate areas, which apparatus comprises an optical system (7, 8, 9, 11) for projecting a light beam on an optical detector (12) *via* the record carrier (1), which detector comprises four sub-detectors (13, 14, 15, 16) situated in four separate quadrants of an imaginary X—Y-coordinate system whose origin is situated on the optical axis of the optical system and of which the X-axis extends effectively in the track direction and the Y-axis extends effectively transvesely of the track direction, a first adder circuit (17) for adding the signals supplied by diagonally disposed first (13) and third sub-detectors (15) to form a first signal (S_1), a second adder circuit (18) for adding the signals supplied by at least the other two sub-detectors (14, 16) to form a second signal (S_2) and a tracking error signal generator for deriving a tracking error signal from the first and second signal in dependence on the time difference between corresponding zero-crossings of the first and second signal respectively, to which end the tracking error signal generator is provided with zero-cross detectors (30, 32, 33, 35) for detecting zero-crossings of the first and second signal and means for measuring the time

ΔT which can be measured unambiguously is in principle equal to one period of the waveform of the frequency fo and, as a result of the use of multipliers for the phase detectors, it is even limited to a quarter of this period.

Fig. 6 shows a second embodiment of an apparatus in accordance with the invention whose use is not limited to reading record carriers on which information of a substantially fixed bit frequency is recorded and whose measurement range is in principle equal to the length of the optically detectable area being read. In the same way as the apparatus shown in Fig. 4 it comprises the detectors 13, 14, 15 and 16, the adder circuits 17, 18 and 24, and the limiter circuits 30, 32 and 31. The output signals of the limiter circuits 30 and 32 are applied to an exclusive-or gate 46. This gate then supplies an output signal during the intervals in which the output signals of the limiters 30 and 32 are of opposite polarity, *i.e.* during the intervals t_1 to t_2 (Fig. 3). The duration of the output signal of this exclusive-or gate 46 is consequently a measure of the tracking error. In order to measure this duration the output signal of the gate 46 closes a switch 47, so that the current from a current source 48 charges a capacitor 49. The charge of this capacitor after the switch 47 has been opened again is then a measure of the duration of the output signal of the gate 46 and hence a measure of the tracking error. *Via* a voltage follower 50 and a switch 51 the capacitor 49 is connected to a capacitor 52. The switch 51 is actuated by the output signal of a pulse shaper 53 which responds to the negative edge of the output signal of the gate 46, so that the switch 51 is closed after switch 47 has been opened again and the capacitor 52 is charged to the value of the charge on the capacitor 49. The switch 51 and the capacitor 52 thus function as a hold circuit. A pulse shaper 54 responds to the negative edge of the output signal of the pulse shaper 53 and controls a switch 55 which is arranged in parallel with capacitor 49, so that after the charge of capacitor 49 has been detected via the switch 51, the capacitor 49 is discharged again *via* the switch 55.

The charge on capacitor 52 is a measure of the tracking error. However, the direction of this tracking error is still unknown. For this purpose the charge on capacitor 52 is applied to a switchable inverter circuit 57 *via* a voltage follower, so that the polarity of the signal after said switchable inverter circuit 57 is an indication of the direction of the tracking error. The output signal of said switching inverter circuit is applied to an output 28*via* output 28 *via* the low-pass filter 23.

In order to determine the direction of the tracking error the output signal of the limiter 32 is applied to the D-input of a D-flip-flop 58, the output signal of the limiter 31 being applied to the clock input C. The flip-flop 58 is of a type which is triggered on the negative edge of the signal on its clock input C, so that the output signal of the flip-flop 58 follows the output signal of the limiter 32 at the zero-crossing instants during the negative edges of the signal S_0 (*i.e.* instant t_3 in Fig. 3). The output signal on the Q-output of the flip-flop 58 is then high if the signal S_2 is high at the instant t_3, or if the signal S_2 lags the signal S_0. Similarly, the output signal of the limiter 32 is applied to the 0-input of a D flip-flop 59 and the inverted output signal of the limiter 31 is applied to the clock input C, so that flip-flop 59 is triggered on the zero-crossings of the signal S_0 during positive edges, or at the instant t_0 (Fig. 3). The inverted output $\bar{Q}$ of flip-flop 59 is then if the signal S_2 is low at the instant t_0 or if the signal S_2 is lagging.

Via a change-over switch 60 which is actuated by the clock signal from flip-flop 59, the Q-output of flip-flop 58 and the $\bar{Q}$-output of flip-flop 59 are alternately connected to the D-input of a D flip-flop 61 which is clocked by the negative edges of the output signal of the pulse shaper 53, *i.e.* at the same time that the switch 61 which samples the charge on the capacitor 49 is closed. Thus, the flip-flop 61 generates a signal of a polarity corresponding to the direction of the tracking error, which flip-flop is clocked again after every time measurement. The flip-flop 61 in its turn controls the switchable inverter circuit 57.

In the apparatus shown in Fig. 6 the time interval t_1—t_2 (Fig. 3) is measured in the similar manner. A digital measurement is also possible, for example in the apparatus shown in Fig. 6 by starting a counter by means of the exclusive-or gate 46, which counter counts the counting pulses supplied by a high-frequency counting-pulse oscillator.

Claims

1. An apparatus for reproducing information from an optically readable record carrier (1) on which information is stored in the form of a track (3) of optically detectable areas which alternate with intermediate areas, which apparatus comprises an optical system (7, 8, 9, 11) for projecting a light beam on an optical detector (12) *via* the record carrier (1), which detector comprises four sub-detectors (13, 14, 15, 16) situated in four separate quadrants of an imaginary X—Y-coordinate system whose origin is situated on the optical axis of the optical system and of which the X-axis extends effectively in the track direction and the Y-axis extends effectively transvesely of the track direction, a first adder circuit (17) for adding the signals supplied by diagonally disposed first (13) and third sub-detectors (15) to form a first signal (S_1), a second adder circuit (18) for adding the signals supplied by at least the other two sub-detectors (14, 16) to form a second signal (S_2) and a tracking error signal generator for deriving a tracking error signal from the first and second signal in dependence on the time difference between corresponding zero-crossings of the first and second signal respectively, to which end the tracking error signal generator is provided with zero-cross detectors (30, 32, 33, 35) for detecting zero-crossings of the first and second signal and means for measuring the time

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interval between the detections of the corresponding zero-crossings and for generating a time difference signal indicative for the time interval measured, characterized in that the tracking error signal generator further comprises means (36, 38, 52) for maintaining the generation of the time difference signal until the next detection of the corresponding zero-crossings, and in that the time difference signal forms the tracking error signal.

2. An apparatus as claimed in Claim 1, which is intended for reading a record carrier in which information of a substantially fixed bit frequency is recorded, characterized in that the zero-crossings detectors are adapted for generating first and second pulses respectively at the zero-crossings of the first and second signal respectively, and in that the signal generation maintaining means comprise first and second tuned circuits (36, 38) for receiving the first and second pulses respectively for the excitations of the first and second timed circuit, which tuned circuits are tuned to the bit frequency or upper harmonic thereof, respectively and in that the measuring means (40, 42, 43, 44) comprises a first phase detector for the detecting the phase difference between the signals supplied by the first and second tuned circuit in order to measure the said time interval.

3. An apparatus as claimed in Claim 2, characterised in that the second adder circuit is adapted to add the signals supplied by all the four sub-detectors and comprising a third adder circuit (24) for adding the signals supplied by the second and the fourth sub-detectors to form a third signal, in that the tracking error signal generator comprises a third zero-crossing detector (31, 34) for supplying third pulses at zero crossings of the third signal in that the signal generation maintaining means comprise a third tuned circuit (37) which is tuned to the bit frequency or an upper harmonic thereof and which is excited by said third zero-crossing detector, and in that the measuring means comprise a second phase detector (39, 41) for detecting the phase difference between the signals supplied by the second (38) and the third tuned circuit (37), and a summing device for adding (45) the signals supplied by the first and the second phase detector.

4. An apparatus as claimed in Claim 1, characterized in that the measuring means comprise means (30, 32, 46) for generating a pulse-shaped signal of a duration corresponding to the interval between corresponding zero crossings of the first and the second signal, time-measurement means (47, 40, 49) for determining the duration of the pulses of said pulse-shaped signal, direction-detection means (57, 58, 59, 60, 61) for detecting the sequence in which corresponding zero crossings of the first and the second signal occur and in response thereto inverting or not inverting the polarity of the output signal of the time-measurement means, and in that the signal generation maintaining means comprise storage means (52) for storing the result of the time interval measurement.

5. An apparatus as claimed in Claim 4, characterized in that the means for generating a pulse-shaped signal comprise first (30) and second limiter (32) means for converting the first and the second signal into a substantially rectangular signal, and a gate circuit (46) with an exclusive-or function to which said limited signals are applied.

6. An apparatus as claimed in Claim 4 or 5, characterized in that the direction-detection means comprise a detector which determines the polarity of the first signal at the instant of a zero crossings of the second signal.

Patentansprüche

1. Gerät zur Wiedergabe von Informationen auf einem optisch lesbaren Aufzeichnungsträger (1), auf dem Informationen in Form einer Spur (3) optisch detektierbarer Gebiete gespeichert sind, die mit Zwischengebeiten abwechseln, und dieses Gerät entält ein optisches System (7, 8, 9, 11) zum Projizieren eines Lichtstrahls über den Aufzeichnungsträger (1) auf einem optischen Detektor (12), der vier Unterdetektoren (13, 14, 15, 16) enthält, die in vier getrennten Quadranten eines imaginären X—Y-Koordinatensystems angeordnet sind, deren Ursprung auf der optischen Achse des optischen Systems liegt, deren X-Achse sich wirksam in der Spurrichtung und deren Y-Achse sich wirksam quer zur Spurrichtung erstrecken, eine erste Additionsschaltung (17) zum Zusammenfügen der von in diagonaler Richtung einander gegenüberliegenden ersten (13) und dritten Unterdetektoren (15) gelieferten Signale zur Bildung eines ersten Signals (S_1), eine zweite Additionsschaltung (18) zum Summieren der von wenigstens den anderen zwei Unterdetektoren (14, 16) gelieferten Signale zur Bildung eines zweiten Signals (S_2) und einen Nachführungsfehlergenerator zum Ableiten eines Nachführungsfehlersignals von den ersten und zweiten Signalen in Abhängigkeit vom zeitlichen Unterschied zwischen entsprechenden Nulldurchgängen des ersten bzw. des zweiten Signals, und dazu ist der Nachführungsfehlersignalgenerator mit Nulldurchgangsdetektoren (30, 32, 33, 35) zum Detektieren der Nulldurchgänge des ersten und des zweiten Signals und mit Mitteln zum Messen des Zeitintervalls zwischen den Detektionen der entsprechenden Nulldurchgänge und zum Erzeugen eines für das gemessene Zeitintervall bezeichnenden Zeitdifferenzsignals versehen, dadurch gekennzeichnet, daß der Nachführungsfehlersignalgenerator weiter Mittel (36, 38, 52) zum Fortsetzen der Erzeugung des Zeitdifferenzsignals bis zur folgenden Detektion der entsprechenden Nulldurchgänge enthält, und daß das Zeitdifferenzsignal das Nachführungsfehlersignal bildet.

2. Gerät nach Anspruch 1, das zum Lesen eines Aufzeichnungsträgers dient, auf dem Information mit einer im wesentlichen festen Bitfrequenz aufgezeichnet ist, dadurch gekennzeichnet, daß die Nulldurchgangsdetektoren zum Erzeugen erster bzw. zweiter Impulse an den Nulldurchgängen

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des ersten bzw. des zweiten Signals dienen, und daß die Signalerzeugungsfortsetzungsmittel erste und zweite Abstimmkreise (36, 38) zum Empfangen der ersten bzw. der zweiten Impulse zum Erregen der ersten und zweiten Abstimmkreise enthalten, die auf die Bitfrequenz oder auf ihre höhere Harmonische abgestimmt sind, und daß die Meßmittel (40, 42, 43, 44) einen ersten Phasendetektor zum Detektieren des Phasenunterschieds zwischen den vom ersten und vom zweiten Abstimmkreis gelieferten Signalen enthält, um das Zeitintervall zu messen.

3. Gerät nach Anspruch 2, dadurch gekennzeichnet, daß die zweite Additionsschaltung zum Summieren der von allen vier Unterdetektoren gelieferten Signale dient und eine dritte Additionsschaltung (24) zum Summieren der vom zweiten und vierten Unterdetektor gelieferten Signale enthält, daß der Nachführungsfehlersignalgenerator einen dritten Nulldurchgangsdetektor (31, 34) zur Lieferung dritter Impulse bei Nulldurchgängen des dritten Signals enthält, daß die Signalerzeugungs-Fortsetzungsmittel einen dritten Abstimmkreis (37) enthält, der auf die Bitfrequenz oder auf eine höhere Harmonische dieser Bitfrequenz abgestimmt ist und vom dritten Nulldurchgangsdetektor erregt wird, und daß die Meßmittel einen zweiten Phasendetektor (39, 41) zum Detektieren des Phasenunterschieds zwischen den vom zweiten (38) und dritten Abstimmkreis (37) gelieferten Signalen und einer Summiereinrichtung zum Summieren (45) der vom ersten und vom zweiten Phasendetektor gelieferten Signale enthält.

4. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß die Meßmittel Mittel (30, 32, 46) zum Erzeugen eines impulsförmigen Signals mit einer Dauer entsprechend dem Intervall zwischen entsprechenden Nulldurchgängen des ersten und des zweiten Signals, Zeitmeßmittel (47, 40, 49) zum Bestimmen der Dauer der Impulse des impulsförmigen Signals, und Richtungsdetektionsmittel (57, 58, 59, 60, 61) zum Detektieren der Reihenfolge enthalten, in der entsprechende Nulldurchgänge des ersten und des zweiten Signals auftreten und in Beantwortung dazu die Polarität des Ausgangssignals der Zeitmeßmittel invertieren oder nicht invertieren, und daß die Signalerzeugungs-Fortsetzungsmittel Speichmittel (52) zum Speichern des Ergebnisses der Zeitintervallmessung enthalten.

5. Gerät nach Anspruch 4, dadurch gekennzeichnet, daß die Mittel zum Erzeugen eines impulsförmigen Signals erste (30) und zweite (32) Begrenzermittel zum Umsetzen des ersten und des zweiten Signals in ein im wesentlichen rechteckiges Signal und ein EXKLUSIV-ODER-Gatter (46) enthalten, an die die begrenzten Signale gelegt werden.

6. Gerät nach Anspruch 4 oder 5, dadurch gekennzeichnet, daß die Richtungsdetektionsmittel einen Detektor enthalten, der die Polarität des ersten Signals zum Zeitpunkt eines Nulldurchgangs des zweiten Signals bestimmt.

Revendications

1. Appareil pour reproduire de l'information d'un support d'enregistrement à lecture optique (1) sur lequel de l'information est stockée sous la forme d'une piste (3) de zones optiquement détectables alternant avec des zones intermédiaires, appareil comportant un système optique (7, 8, 9, 11) pour projeter, via un support d'enregistrement (1), un faisceau lumineux sur un détecteur optique (12) comportant quatre sous-détecteurs (13, 14, 15, 16) situés dans quatre quadrants d'un système imaginaire de coordonnées X—Y dont l'origine est située sur l'axe optique du système optique et dont l'axe X s'étend effectivement dans la direction de la piste et l'axe Y s'étend effectivement transversalement à la direction de la piste, un premier circuit additionneur (17) pour additionner les signaux fournis par des premier (13) et troisième (15) sous-détecteurs de façon à former un premier signal (S_1), un deuxième circuit additionneur (18) pour additionner les signaux fournis par au moins les deux autres sous-détecteurs (14, 16) de façon à former un deuxième signal (S_2), et un générateur de signaux d'erreur de poursuite de piste pour déduire un signal d'erreur de poursuite de piste du premier et du deuxième signal en fonction de la différence de temps entre des passages par zéro correspondants du premier signal d'une part et du deuxième signal d'autre part, but dans lequel le générateur de signaux d'erreur de poursuite de piste est muni de détecteurs de passages par zéro (30, 32, 33, 35) pour détecter des passages par zéro du premier et du deuxième signal et de moyens pour mesurer l'intervalle de temps séparant les détections des passages par zéro correspondants et pour engendrer un signal de différence de temps, indicatif de l'intervalle de temps mesuré, caractérisé en ce que le générateur de signaux d'erreur de poursuite de piste comporte en outre des moyens (36, 38; 52) pour maintenir la génération du signal de différence de temps jusqu'à la détection suivante des passages par zéro correspondants, et en ce que le signal de différence de temps forme le signal d'erreur de poursuite de piste.

2. Appareil selon la revendication 1, conçu pour lire un support d'enregistrement dans lequel est enregistrée de l'information de fréquence de bits sensiblement fixe, caractérisé en ce que les détecteurs de passages par zéro sont prévus pour engendrer des première et deuxième impulsions respectivement lors des passages par zéro du premier et du deuxième signal, et en ce que les moyens pour maintenir la génération de signal comporte des premier et deuxième circuits accordés (36, 38) pour recevoir des première et deuxième impulsions respectivement pour les excitations du premier et du deuxième circuit accordé, circuits accordés qui sont accordés à la fréquence de bits ou à l'harmonique supérieur de celle-ci, et en ce que les moyens de mesure (40, 42, 43, 44) comportent un premier détecteur de phase pour détecter la différence de phase entre

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les signaux fournis par le premier et le deuxième circuit accordé afin de mesurer ledit intervalle de temps.

3. Appareil selon la revendication 2, caractérisé en ce que le second circuit additionneur est conçu pour additionner les signaux fournis par tous les quatre sous-détecteurs, appareil comportant un troisième circuit additionneur (24) pour additionner les signaux fournis par les deuxième et quatrième sous-détecteurs de façon à former un troisième signal, en ce que le générateur de signaux d'erreur de poursuite de piste comporte un troisième détecteur de passages par zéro (31, 34) pour fournir de troisièmes impulsions lors de passages par zéro du troisième signal, en ce que les moyens pour maintenir la génération de signal comportent un troisième circuit accordé (37) qui est accordé à la fréquence de bits ou à un harmonique supérieur de celle-ci et qui est excité par ledit troisième détecteur de passages par zéro, et en ce que les moyens de mesure comportent un second détecteur de phase (39, 41) pour détecter la différence de phase entre les signaux fournis par les deuxième (38) et troisième (37) circuits accordés, et un dispositif sommateur (45) pour additionner les signaux fournis par les premier et second détecteurs de phase.

4. Appareil selon la revendication 1, caractérisé en ce que les moyens de mesure comportent des moyens (30, 32, 46) pour engendrer un signal impulsionnel d'une durée correspondant à l'intervalle de temps entre des passages par zéro correspondants du premier et du deuxième signal, des moyens de mesure de temps (47, 48, 49) pour déterminer la durée des impulsions dudit signal impulsionnel, des moyens de détection de direction (57, 58, 59, 60, 61) pour détecter l'ordre dans lequel apparaissent des passages par zéro correspondants du premier et du deuxième signal et, en réaction à cela, invertir ou non invertir la polarité du signal de sortie des moyens de mesure de temps, et en ce que les moyens pour maintenir la génération de signal comportent des moyens de stockage (52) pour stocker le résultat de la mesure d'intervalle de temps.

5. Appareil selon la revendication 4, caractérisé en ce que les moyens pour engendrer un signal impulsionnel comportent des premiers (30) et seconds (32) moyens limiteurs pour convertir le premier et le deuxième signal en un signal sensiblement rectangulaire, et un circuit de porte (46) ayant une fonction ou-exclusif et auquel sont appliqués lesdits signaux limités.

6. Appareil selon la revendication 4 ou 5, caractérisé en ce que les moyens de détection de direction comportent un détecteur qui détermine la polarité du premier signal à l'instant d'un passage par zéro du deuxième signal.

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