The invention relates to a device for reproducing data which can be read with the aid of an optical scanning device from the data tracks of a recording carrier, wherein at least one light beam can be focused on to the recording carrier with the aid of a focus control circuit and can be guided with the aid of a track control circuit on the data tracks, wherein the light beam is reflected from the recording carrier on to a photodetector, with the aid of which an electrical data signal, a focus error signal as actual value of the focus control circuit and a track error signal as actual value of the track control circuit are produced.

These devices, e.g. CD players, magneto optical devices for playback and recording, recording and playback devices for Draw Discs or video disc players are equipped with an optical scanning device, comprising a laser diode, several lenses, a prism beam splitter and a photodetector. Construction and functioning of an optical scanning device, a so-called optical pickup, are described in Electronic components & applications, Vol. 6, No. 4, 1984 on pages 209-215.

The light beam emitted by the laser diode is focused with the aid of lenses on to the CD disc and reflected from there on to a photodetector. The data stored on the CD disc and the actual value of the focus and track control circuits are obtained from the output signal of the photodetector. In the bibliography mentioned the actual value of the focus control circuit is designated as 'focusing error', while 'radial tracking error' is the expression selected for the actual value of the track control circuit.

As positioning element for the focus control circuit there serves a coil, an objective lens being movable along the optical axis by means of its magnetic field. The focus control circuit, due to displacement of the objective lens, causes the light beam emitted by the laser diode to be always focused on to the CD disc. With the aid of the track control circuit which is often designated as a radial drive, the optical scanning device can be displaced radially with respect to the CD disc. As a result the light beam may be guided on the spiral data tracks of the CD disc.

In some devices the radial drive is constructed from a so-called coarse and a so-called fine drive. The coarse drive is implemented for example as a spindle, with the aid of which the whole optical scanning device comprising the laser diode, the lenses, the prism beam splitter and the photodetector can be displaced radially. The light beam can be tilted radially with the fine drive, for example about a predetermined small angle, so that the light beam may move a small way along a radius of the CD disc solely through this tilting movement.

In order to achieve perfect reproduction of the data, whether this is picture and sound in a video disc player or only sound in a CD player for example, then precise guidance along the data

tracks of the disc is necessary besides accurate focusing of the light beam on to the video or CD disc.

As with all other control amplifiers, the control amplifier of the focus control circuit is subject to an offset voltage, of which the magnitude on the one hand depends on the temperature and on the other hand is subject to a long-term drift. The drift of the offset voltage and also of other parameters of an amplifier in the course of time are caused by ageing of the amplifier.

In order that the data reproduction is not disturbed by the offset voltage of the control amplifier of the focus control circuit, compensation of the offset voltage is necessary. By adjusting a balancing potentiometer provided in the control circuit by hand, however, compensation can only be carried out approximately, because changes in the offset voltage resulting from temperature fluctuations and ageing of the control amplifier are still not taken into account.

From JP-A 61 32228 it is known, in a track control circuit of an optical playback device, to store the track error signal in the case of a depression, which is also called a gap or a groove, and in the case of an elevation, which is also called a land. The two stored values of the track error signal are subtracted from each other in a differential amplifier, at the output of which an offset-free track error signal can therefore be tapped.

In order to compensate the offset in the focus control circuit of an optical playback device, according to JP-A-598144 the light source is modulated, the light beam of which reads the data from the recording carrier. The modulation components caused by modulation of the light source are detected in the data signal. An offset compensation voltage is fed into the focus control circuit and is changed until the modulation components in the data signal become zero.

It is the object of the invention to so design a device for data reproduction according to the preamble of claim 1 that the offset voltage of the control amplifier in the focus control circuit is automatically compensated during operation.

The invention achieves this object with the features provided in claim 1.

In which:

Figure 1 shows a photodetector of a CD player;
Figure 2 shows an embodiment of a CD player in accordance with the invention

The invention is described and explained together with Figures 1 and 2.

In Figure 1 the photodetector PD of the optical scanning device

of a CD player is shown, in which three laser beams L1, L2 and L3 are focused on to the CD disc. In the reference mentioned in the introduction, such a scanning arangement is called "Three Beam Pickup". In the photodetector PD four square photo diodes A, B, C and D are assembled so that in turn they form a square. Diagonally opposite to this square formed from the four photo diodes A, B, C and D there are two further photodiodes E and F which are also square.

The central laser beam L1, which is focused on to the four photodiodes A, B, C and D, produces the data signal HF = AS + BS + CS + DS and the focus error signal FE = (AS + CS) - (BS + DS). The two outer light beams L2 and L3 the front one L2 of which falls on to the photodiode E, the rear one L3 on to the photo diode F, produce the track error signal TE = ES - FS. In each case the photo voltages of the diodes A, B, C, D, E and F are designated AS, BS, CS, DS, ES and FS. Since in the optical scanning device in the beam path of the centre laser beam L1 an astigmatically acting collimator lens is provided, the centre laser beam L1 is circular with exact focusing on the large square, which is formed from the photo diodes A, B, C and D, while it assumes an ellipse shape with defocusing.

Figure 1a shows the case of focusing and of accurate tracking which will be gone into later. Because the light spot formed by the laser beam L1 on the large square is circular, the focus error signal amounts to FE = (AS + CS) - (BS + DS) = 0. At the value zero of the focus error signal FE the focus control circuit recognises that focusing is accurate.

In Figure 1b one case of defocusing, that the CD disc is too far away from the objective lens, is shown. The focus error signal FE is negative: FE = (AS + CS) - (BS + DS) < 0. From the negative value of the focus error signal FE the focus control circuit recognises that the spacing between the CD disc and the objective lens is too great. Therefore the objective lens is moved up to the CD disc by the adjusting element of the focus control circuit until the focus error signal FE becomes zero.

The other case of defocusing: that the objective lens is too close to the CD disc, is shown in Figure 1c. The focus error signal FE has a positive value: FE = (AS + CS) - (BS + DS) > 0. From the positive value of the focus error signal FE the focus control circuit recognises that the objective lens is too close to the CD disc. The objective lens is therefore moved away from the CD disc by the adjusting element until the focus error signal FE becomes zero.

It will now be explained how the tracking occurs with the aid of the track control circuit.

In Figures 1a, 1b and 1c the laser beams L1, L2 and L3 accurately follow the track. The track error signal TE has the value zero. TE = ES - FS = 0.

In Figure 1d the case is shown where the laser beams L1, L2 and L3 are displaced to the right of the track. The track error signal TE assumes a negative value : TE = ES - FS < 0. The adjusting element of the track control circuit moves the optical scanning device to the left until the track error signal TE becomes zero.

In the opposite case if the laser beams are displaced to the left of the track the track error signal is positive: TE = ES - FS > 0. Now the adjusting element of the track control circuit moves the optical scanning device to the right until the track error signal TE becomes zero.

The construction of an embodiment of the invention is first described together with Figure 2 and then its function is explained.

There is a voltage +UB in Figure 2 at the connected cathodes of the six photodiodes A, B, C, D, E and F of the photodetector PD. The anode of the photodiode F is connected to the inverting input of the control amplifier TR of the track control circuit via a resistor R1. The anode of the photodiode E is connected to the non-inverting input of the control amplifier TR of the track control circuit via a resistor R2. The connected anodes of the photodiodes A and C are connected via a resistor R3 to the non-inverting input of the control amplifier FR of the focus control circuit. The also connected anodes of diodes B and D are connected via a resistor R4 to the inverting input of the control amplifier FR of the focus control circuit. A series circuit comprising two resistors R5 and R6 is arranged between the connected anodes of the diodes A and C and the connected anodes of diodes B and D, the common connection point of the series circuit being connected to the input of an analogue switch AL. The output of the control amplifier FR of the focus control circuit is connected to the one contact of a controllable switch S1 and a controllable switch S2. The other contact of the controllable switch S1 is connected to the non - inverting input of an amplifier V and to one connection of a capacitance C1, the other connection of which is at reference potential. The other contact of the controllable switch S2 is connected to the inverting input of the amplifier V and to one connection of a capacitance C2, the other connection of which is also at reference potential. That output of the analogue switch AL which emits a pulse with a falling flank at the input is connected to the control input of the controllable switch S1, on the other hand that output of the analogue switch AL which emits a pulse with a rising flank at the input is connected to the control input of the controllable switch S2. The output of the amplifier V is connected to the input E1 of a microprocessor MP, whose output A3 is connected to the input of a digital / analogue converter DAF. The non-inverting input of the control amplifier FR of the focus control circuit is connected to the output of the digital / analogue converter DAF. At the output of the control amplifier FR of the focus control circuit the focus error signal FE can be tapped, at the output of the control amplifier TR of

the track control circuit the track error signal TE can be tapped and at the common connection point of the two resistors R5 and R6 the data signal HF can be tapped.

The functioning of the embodiment depicted in Figure 2 will now be described.

The analogue switch AL, the controllable switches S1 and S2, the capacitances C1 and C2 and the amplifier V form a phase comparator PH, in which the phase of the data signal HF is compared to that of the focus error signal FE. The signal at the output of the amplifier V indicates to the microprocessor MP whether the data signal HF is in phase with the focus error signal FE. The value which the microprocessor MP emits at its output A3 is converted with the aid of the digital / analogue converter DAF into an analogue voltage which is applied as an offset compensation voltage to the non-inverting input of the control amplifier FR. The microprocessor now changes the value at its output A3 until the amplifier V indicates that the data signal HF and the focus error signal FE are in phase. This value is retained, converted by the digital / analogue converter DAF into an analogue voltage which compensates the offset voltage of the control amplifier FR as an offset compensation voltage.

If the offset voltage changes for example due to temperature fluctuations, then the microprocessor MP immediately brings about the necessary correction in the offset compensation voltage. Therefore while the CD player is in operation the offset compensation voltage is constantly checked and continuously corrected according to the fluctuations in the offset voltage.

It will now be explained how the phase comparator PH operates.

The data signal HF is at the input of the phase comparator PH, the input of the analogue switch AL. With each falling flank of the data signal HF the analogue switch AL briefly closes the controllable switch S1 so that the capacitance C1 is charged up to the value which the focus error signal FE assumes at the point in time of a falling flank of the data signal HF.

With each rising flank of the data signal HF on the other hand the analogue switch AL briefly closes the controllable switch S2, so that the capacitance C2 is charged up to the value which the focus error signal FE assumes at the point in time of a rising flank of the data signal HF. Because the data signal HF, like the focus error signal FE, is formed from the photo voltages AS, BS, CS and DS of the four photodiodes A, B, C and D, on to which the laser beam L1 which scans the data is reflected by the CD disc, these two signals are in phase in the ideal case, i.e. without an offset voltage at the control amplifier FR. With the same phase position however the focus error signal FE has the same value at the point in time of a falling flank of the data signal HF as at the point in time of a

rising flank of the data signal, because the flanks represent the zero axis crossings of the data signal HF.

If on the other hand the control amplifier FR is subject to an offset voltage, then the zero axis crossings of the data signal HF no longer coincide with the zero axis crossings of the focus error signal FE. Therefore the focus error signal FE no longer has the same but rather different values at the points in time of rising and falling flanks of the data signal. The microprocessor MP recognises therefore, as already mentioned, from the output signal of the amplifier V whether the focus error signal FE and the data signal HF are in phase. If this is the case then the correct offset compensation voltage is at the non-inverting input of the control amplifier FR. Otherwise the microprocessor MP changes the value at its output A3 until the offset compensation voltage at the output of the digital / analogue converter DAF has adjusted to the correct value.

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Patent Claims

1. A device for reproducing data readable with the aid of an optical scanning device from the data tracks of a recording carrier, wherein at least one light beam can be focused on to the recording carrier with the aid of a focus control circuit and can be guided with the aid of a track control circuit along the data tracks, wherein the light beam is reflected from the recording carrier on to a photodetector (PD), with the aid of which a digital electrical data signal (HF), a focus error signal (FE) for the focus control circuit and a track error signal (TE) for the track control circuit are produced and wherein the value of the focus error signal (FE) is compared under different conditions of the digital data signal (HF), **characterised in that** in order to compensate the offset voltage of the control amplifier (FR) of the focus control circuit an offset compensation voltage lying at the input of the control amplifier (FR) is changed until the value which the focus error signal (FE) assumes with a falling flank of the data signal (HF) agrees with the value which the focus error signal (FE) assumes with a rising flank of the data signal (HF).

2. A device according to claim 1, **characterised in that** the data signal (HF) is supplied to one input and the focus error signal (FE) is supplied to the other input of a comparison circuit (PH), its output being connected to the input (E1) of a microprocessor (MP), and that the output (A3) of the microprocessor (MP) is connected to the input of a digital/analogue converter (DAF), its output being connected to an input of the control amplifier (FR) of the focus control circuit.

3. A device according to claim 2, **characterised in that** the output of the photodetector (PD), at which the data signal (HF) can be tapped, is connected to the input of an analogue switch (AL), whose output which reacts to a falling flank is connected to the control input of a first controllable switch (S1) and whose output reacting to a rising flank is connected to the control input of a second controllable switch (S2), that one contact of the two controllable switches (S1, S2) is connected to the output of the control amplifier (FR) of the focus control circuit, that the other contact of the first controllable switch (S1) is connected to the non-inverting input of an amplifier (V) and via a capacitance (C1) is applied to reference potential, that the other contact of the second controllable switch (S2) is connected to the inverting input of the amplifier (V) and via a capacitance (C2) is applied to reference potential and that the output of the amplifier (V) is connected to the input (E1) of the microprocessor (MP).