The invention relates to a track control circuit for an optical scanner, wherein the track error signal TE is produced from the difference between two photoelectric voltages, wherein the direction in which the scanning light beam was removed from the data track to be scanned is ascertained by means of a directional logic means, and wherein an up-down counter counts the number of data tracks over which the light beam travelled on removal from the data track to be scanned.

The structure and operation of an optical scanner, a so-called optical pick-up*, are described in Electronic Components and Applications, vol.6 No.4, 1984, pages 209-215.

The light beam emitted by the laser diode is focused on the compact disc by lenses and reflected thence onto a photodetector. The data stored on the compact disc and the actual value for the focusing control circuit and for the track control circuit are obtained from the output signal from the photodetector. In the above reference the difference between the actual value and the specified value for the focusing control circuit is described as the focusing error, while the difference between the actual and the specified value of the track control circuit is termed the radial tracking error.

The actuator for the focusing control circuit is a coil, the magnetic field of which can move an objective lens along the optical axis. By displacing the lens the circuit causes the light beam emitted by the laser diode to be focused constantly on the compact disc. The optical scanner can be displaced radially of the disc by means of the track control circuit, which is often referred to as the radial drive. This enables the light beam to be guided over the spiral data tracks of the disc.

In some equipment the radial drive is made up of a so-called coarse drive and a so-called precision drive. The coarse drive may, for example, be in the form of a spindle, by means of which the whole optical scanner comprising the laser diode, the lenses, the prismatic beam splitter and the photodetector can be displaced radially. The precision drive can tilt the light beam radially, e.g. through a predetermined small angle, so that the beam can travel a short distance along a radius of the compact disc purely through this tilting movement.

To obtain satisfactory reproduction of data, whether it be e.g. video and sound in a video disc player or sound only in a compact disc player, it is essential to have accurate focusing of the light beam onto the video or compact disc and precise guidance along the data tracks of the disc.

Fig. 1 shows the photodetector PD of the optical scanner of a compact disc player, wherein three laser beams L1, L2 and L3 are focused onto the compact disc. The laser beams L1 and L2 are the + 1st order and - 1st order diffraction beams. In the above reference a scanner of this type is described as a three-beam pick-up.

In the photodetector four square photodiodes A, B, C and D are joined together to form another square. Two further rectangular photodiodes E and F are located diagonally opposite one another relative to this square made up of the four photodiodes A, B, C and D.

The central laser beam L1, which is focused onto the four photodiodes A, B, C and D, generates the data signal HF = AS + BS + CS + DS and the focusing error signal FE = (AS + CS) - (BS + DS). The two outer light beams L2 and L3, of which the front one L2 falls onto the photodiode E and the rear one L3 onto the photodiode F, generate the track fault signal TE = ES - FS. AS, BS, CS, DS, ES and FS are the photovoltages of the diodes A, B, C, D, E and F. Since a collimator lens with an astigmatic effect is provided in the optical scanner in the path of the central laser beam L1, the beam L1 becomes circular when it is focused accurately on the large square made up of the four photodiodes A, B, C and D, whereas it takes on an elliptical shape when it is out of focus.

Fig. 1a shows the case of focusing and precise track guidance, which will be discussed later. Since the luminous spot formed on the large square by the laser beam L1 has a circular shape, the focusing error signal for FE = (AS + CS) - (BS + DS = 0 is produced. The focusing control circuit recognises from the zero value of the signal that the beam is focused accurately.

One case of defocusing, where the compact disc is too far away from the objective lens, is shown in Fig. 1b. The focusing error signal FE is negative: FE = (AS + CS) - (BS + DS) < 0. The focusing control circuit recognises from the negative value of the focusing error signal FE that the distance between the compact disc and the objective lens it too great. The actuator of the circuit therefore moves the lens far enough towards the compact disc to bring the focusing error signal to zero.

The other case of defocusing, with the lens too close to the compact disc, is shown in Fig. 1c. The focusing error signal FE has a positive value: FE = (AS + CS) - (BS + DS) > 0. The focusing control circuit recognises from the positive value of the signal FE that the objective lens is too close to the compact disc. The actuator therefore moves the lens far enough away from the compact disc to bring the focusing error signal FE to zero.

The method of track guidance by means of the track control circuit will now be explained.

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

Fig. 1d shows the case where the laser beams L1, L2 and L3 are shifted to the right of the track. The track error signal assumes a negative value: TE = ES - FS < 0. The actuator of the track control circuit moves the optical scanner far enough to the left to bring the track error signal TE to zero.

In the opposite case, when the laser beams are shifted to the left of the track, the track error signal is positive: TE = ES - FS > 0. The actuator of the track control circuit now moves the optical scanner far enough to the right to bring the track error signal TE to zero.

If the laser beam L1 and the associated diffraction beams L2 and L3 run over a plurality of data tracks, the track error signal TE takes on the sinusoidal shape illustrated in Fig. 2. If, for example, the three laser beams L1, L2 and L3 are removed from the data track to be scanned by a mechanical vibration, they can only be received on the correct track again if the track deviation is not greater than 0.8 μm, half the distance between two adjacent data tracks. Otherwise the beams engage on the next track.

In a compact disc player the subcode can ascertain whether the beam has jumped onto an adjacent track, so the beam L1 can be guided back onto the correct data track. In the event of such deviations from the data track to be scanned, caused by mechanical vibrations or jolting of the compact disc player, the information signal is interrupted for at least one block unit or even one revolution, resulting in audible interruptions in the music or speech. A further disadvantage is that a relatively expensive program is required to guide the light beam back onto the correct data track with the aid of the subcode.

However one does not have this opportunity for correction with non-formatted magneto-optical discs or DRAW discs.

A track control circuit is known from JP-OS 60 10429, wherein the question of whether the light beam is moving over data tracks is recognised from the negative and positive envelope of the HF signal. But since a counter only counts the HF bursts it is not possible to establish the direction in which the light beam is moving, whether inwardly towards the centre of the disc or outwardly towards the edge. Only the HF bursts and thus the number of data tracks passed over are counted by the counter.

In the event of mechanical jolts or vibrations, however, errors in counting the data tracks passed over may occur owing to the eccentricity of the compact disc. If, for example, the scanner is jolted outwards and the data tracks below the scanner simultaneously run outwards too, faster than the scanner, owing to the eccentricity of the compact disc, then the scanner moves inwards relative to the data tracks. Because the counter counts the same data tracks a plurality of times in such cases, a far greater deviation from the correct track is assumed than is actually the case. The correct track cannot therefore be found without additional corrective steps.

A track control circuit is known from US-PS 4 484 319, wherein a directional logic means, substantially made up of filters, envelope detectors, monoflops and AND-gates, ascertains the direction - radially inwardly or outwardly - in which the light beam is moved over the data tracks of a disc. An up-down counter is connected to the output of the directional logic means and counts either up or down, dependent on the direction of movement

of the light beam. The output of the counter is connected to one input of a comparator, and the other input thereof has a reference track number register connected to it.

If the count on the up-down counter is not the same as the track number in the reference track number register, the comparator causes a control signal to be emitted to move the light beam to the data track to be scanned. If the comparator finds that the count and the track number in the register are the same, it causes a holding signal to be emitted so that the light beam is held at the track to be scanned.

A method and a circuit arrangement relating to change of track by a light beam on an optical recording carrier are known from JP-A 59 94 250. A recording carrier in disc form, e.g. a compact disc, is scanned by three light beams. The three light beams reflected by the disc generate a sinusoidal signal, each in its own photodetector, if the light beams cross data tracks on the disc e.g. owing to its eccentricity. The three sinusoidal signals are each out of phase by + or - 90°, dependent on the direction in which the light beams cross the data tracks. The three sinusoidal signals are converted to rectangular signals which are evaluated in a logic circuit. Dependent on the sign of the phase displacement the logic circuit emits an up-counting pulse to a counter, e.g. if the light beams cross a data track from right to left, or a down-counting pulse if they cross a track from left to right. An analog signal is obtained from the count and added to the track error signal by means of an adder. In this way allowance is made for the eccentricity of the disc.

A track control circuit with the following features is known from GB-A 2 154 030.

In the event of major deviations from the data track to be scanned a discriminator opens the track control circuit. The last address read out immediately before removal from the track is stored in a memory.

Another track control circuit is described in EP-A 0 272 873.

A detector ascertains the passages of the sinusoidal track error signal through zero. At each passage through zero it transmits a timing pulse to a D flip flop, the output signal of which opens and closes the track control circuit.

If the light beam scanning the data moves from the centre of the track to the next track on the left or right-hand side, the D flip flop closes a controllable switch which closes the loop of the track control circuit. But as soon as the light beam arrives midway between two tracks the control circuit is opened because the D flip flop opens the controllable switch. Only when the light beam reaches the centre of the adjacent track is the track control circuit closed again.

However this track control circuit presupposes a recording carrier in disc form with a special structure. At regular intervals on each data track three pits are provided in a so-

called servo section. The first pit is one quarter of the track spacing Q to the left of the centre of the track, the second pit one quarter of the track spacing to the right, and the third pit exactly in the centre. The distances between the three pits are laid down exactly. Between the individual servo sections there are recording sections in which data can be recorded magneto-optically.

The problem of the invention is therefore to construct a track control circuit for an optical scanning system, so that when the light beam scanning the data tracks has been removed from the track to be scanned, e.g. as a result of a mechanical jolt, it is guided back onto the track to be scanned reliably and quickly.

In a track control circuit as described in the generic part of claim 1 the invention solves this problem, in that a pulse shaper generates the control signal from the count, to direct the light beam back onto the data track to be scanned, and that the control loop is opened when the light beam is removed from the data track to be scanned, and reclosed after the correction has been made.

In the drawings:

Fig. 2 shows the sinusoidal track error signal TE
Fig. 3 is a first embodiment of the invention and
Fig. 4 is a second embodiment of the invention.

The first embodiment of the invention, shown in Fig. 3, will now be described and explained.

The track error signal TE = ES - FS is formed in a differential amplifier 2 from the photovoltages ES and FS coming from the optical scanner 1, and is passed through a controllable switch 3 to the input of the control amplifier 4 of the track control circuit, the output of which is connected to the input of the actuator of that circuit. The photovoltages ES and FS are further supplied to a directional logic means 5, the output of which is connected to the up-down counting input VR of an up-down counter 6. An output A1 of the up-down counter 6 is connected to the control input of the controllable switch 3. The outputs A2 of the up-down counter 6 from which the count and sign can be taken are connected to the input of a pulse shaper 7, the output of which is connected to the control amplifier 4.

The directional logic means 5 may be constructed e.g. as a D flip flop, with one photovoltage, e.g. FS, applied to its D input and the other photovoltage ES applied to its clock input. The Q output of the D flip flop is connected to the up-down counting input VR of the up-down counter 6. Since the clock input of the D flip flop is connected to the clock input CL of the up-down counter 6, both the D flip flop and the up-down counter 6 are timed by one photovoltage - in the example put forward by the photovoltage ES. In this embodiment the phase displacement between the two photovoltages ES and FE, the difference between which forms the track error signal TE, is approximately 90°.

As soon as the scanning light beam 8 leaves the data track to be scanned on the optical recording carrier, for example a compact disc 9, the up-down counter 6 receives a positive or negative counting pulse, according to the direction in which the light beam was removed from the track, from the D flip flop which is provided as a directional logic means 5. If the light beam leaves the track in the direction of the centre of the disc, the clock inputs of the D flip flop and of the up-down counter 6 receive a timing pulse first. But since a logical zero is applied to the D input of the D flip flop, its Q output remains on "LOW", so that the up-down counter 6 counts down. In the opposite case, when the light beam moves radially outwards from the track towards the edge of the disc, the D input of the D flip flop receives a pulse first, then its clock input and that of the up-down counter 6. Since the up-down counter 6 receives a timing pulse owing to the set D flip flop - its Q output is on "HIGH" - the up-down counter 6 now counts up.

The first counting pulse - positive or negative - brings the count to either + 1 or - 1. At this count the controllable switch is opened, thereby opening the control loop. Since the counter 6 receives a positive or negative counting pulse whenever the light beam crosses a data track, the count is proportional to the deviation of the light beam 8 from the track to be scanned. The pulse shaper 7 therefore obtains a correcting signal from the count, and this is passed to the control amplifier 4 which guides the light beam 8 quickly and accurately back onto the track to be scanned. During this operation the count returns to zero, for the up-down counter 6 keeps on counting. When the count is at zero the controllable switch 3 and thus the control loop are reclosed, for the light beam 8 is now scanning the correct track.

If the phase displacement between the two photovoltages ES and FS is 180°, as in most compact disc players operating by the three beam method, then the arrangement shown in Fig. 4 should be followed: the envelope of the data signal HF should be supplied to the clock input of the D flip flop instead of one of the photovoltages, and the track error signal TE should be supplied to the D input instead of the other photovoltage, since this makes two voltages available again, out of phase by 90°.

In the embodiment illustrated in Fig. 4 the clock input of the D flip flop is therefore connected to the output of the optical scanner 1 from which the envelope of the data signal HF can be taken. As shown in Fig. 1 and described at the beginning, the signal HF is formed from the sum of the four photovoltages AS, BS, CS and DS of the four square photodiodes A, B, C and D. The D input of the D flip flop is connected to the output of the differential amplifier 2.

The mode of operation in the Fig. 4 embodiment is similar to that in the Fig. 3 embodiment. Each time the light beam moves from one data track to the next an HF burst occurs in the data signal. The D flip flop therefore receives a pulse at its clock input whenever the light beam crosses a track. However, since the sign of the track error signal TE depends on the direction in which the light beam leaves a track, the D flip flop is set in one

direction - its output goes to "HIGH" - whereas in the other direction its output remains on "LOW". The counter 6 accordingly counts up in one direction and down in the other.

The connections to the inputs of the D flip flop 5 can also be interchanged. The envelope of the data signal HF would then be applied to the D input of the D flip flop 5 and the track error signal TE to its clock input.

The invention is suitable for compact disc players, DRAW disc players, video disc players and magneto-optical equipment.

Translator's Note:
Re: "Optical pick-up":

I have not used this term when translating "optische Abtastvorrichtung" in the description as it is translated as "optical scanner" in the claims.

CLAIMS

1. A track control circuit for an optical scanner (1), wherein the track error signal TE is produced from the difference between two photoelectric voltages (ES, FS), wherein the direction in which the scanning light beam was removed from the data track to be scanned is ascertained by means of a directional logic means (5), and wherein an up-down counter (6) counts the number of data tracks over which the light beam travelled on removal from the data track to be scanned, characterised in that the control loop is opened on removal of the light beam from the data track to be scanned, that a pulse shaper (7) generates a correction signal from the count, to direct the light beam back to the data track to be scanned, that the control loop is reclosed after the correction, that a D flipflop is provided as the directional logic means (5), one photoelectric voltage (FS) being applied to its D input and the other photoelectric voltage (ES) to its clock input, that the Q output of the D flipflop is connected to the up-down counting input (VR) of the up-down counter (6), and that the clock input of the D flipflop is connected to the clock input (CL) of the up-down counter (6).

2. A track control circuit for an optical scanner (1), wherein the track error signal TE is produced from the difference between two photoelectric voltages (ES, FS) wherein the direction in which the scanning light beam was removed from the data track to be scanned is ascertained by means of a directional logic means (5), and wherein an up-down counter (6) counts the number of data tracks over which the light beam travelled on removal from the data track to be scanned, characterised in that the control loop is opened on removal of the light beam from the data track to be scanned, that a pulse shaper (7) generates a correction signal from the count, to direct the light beam back to the data track to be scanned, that the control loop is reclosed after the correction, that a D flipflop is provided as the directional logic means (5), the envelope of the data signal (MF) or the track error signal (TE) being applied to its D input and respectively the track error signal (TE) or the envelope of the data signal (HF) to its clock input, that the Q output of the D flipflop is connected to the up-down counting input (VR) of the up-down counter (6), and that the clock input of the D flipflop is connected to the clock input (CL) of the up-down counter (6).

3. A track control circuit according to claim 1, characterised in that the photoelectric voltages ES and FS, from which the track error signal (TE = ES - FS) is formed in a differential amplifier (2), are supplied to the directional logic means (5), that the output of the differential amplifier (2) is connected to the input of a control amplifier (4) by way of a controllable switch (3) with its control input connected to an output (A1) of the up-down

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counter (6), that the output of the control amplifier (4) is connected to the actuator of the track control circuit, that the output of the directional logic means (5) is connected to the up-down counting input (VR) of the up-down counter (6), and that the outputs (A2) of the up-down counter (6), from which the count and the sign can be obtained, are connected to the inputs of the pulse shaper (7), the output of which is connected to the control amplifier (4).

4. A track control circuit according to claim 2, characterised in that the track error signal (TE) and the data signal (HF) are supplied to the directional logic means (5), that the output of a differential amplifier (2) which forms the track error signal (TE) is connected to the input of a control amplifier (4) by way of a controllable switch (3) with its control input connected to an output (A1) of the up-down counter (6), that the output of the control amplifier (4) is connected to the actuator of the track control circuit, that the output of the directional logic means (5) is connected to the up-down counting input (VR) of the up-down counter (6), and that the outputs (A2) of the up-down counter 96), from which the count and the sign can be obtained, are connected to the inputs of the pulse shaper (7), the output of which is connected to the control amplifier (4).

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