OPTICAL SCANNING DEVICE

This invention relates to an optical scanning device with an objective lens for a recording and/or reproduction device in which a light beam is focused onto a recording medium by an objective lens according to the single beam technique and is reflected from the recording medium onto a photodetector in which the light beam is guided onto the data tracks of the recording medium by a tracking control circuit which is constructed from a coarse drive and a fine drive mechanically coupled to the coarse drive, in which the objective lens can be moved by the fine drive in a direction which makes a predetermined angle α to the normals to the direction of the track in which an astigmatically acting element is provided in the path of the beam and in which the light beam reflected from the recording medium is directed onto a photodetector consisting of a plurality of photodiodes.

The light beam emitted from a laser diode is focused onto the recording medium, for example a compact disc, by an objective lens and is reflected from the disc onto a four-quadrant photodetector consisting of four photodiodes A, B, C and D. Because an astigmatically acting element, for example a cylindrical lens, is located in the beam path, the projection of the light beam is circular when the beam is accurately focused onto the large square, which is formed from the four photodiodes A, B, C and D, and is elliptical when the beam is defocussed.

Figure 1a shows the case of precise focusing. Because the light spot formed by the laser beam L on the large square is circular in shape, the focusing error signal is FE = (AS + CS) - (BS + DS) = O. With the value of zero of the focusing error signal FE, the focusing control circuit recognises that the focussing is exact.

In Figure 1b there is shown the first case of defocussing, in which the disc is too far away from the objective lens. The focussing error signal FE is negative, i.e. FE = (AS + CS) - (BS + DS) < O. With the negative value of the focussing error signal FE the focussing control circuit recognises that the spacing between the disc and the objective lens is too large. Therefore, the objective lens is moved by the actuator of the focussing control circuit towards the disc until the focussing error signal FE becomes zero.

The other case of defocussing in which the objective lens is too near the compact disc, in shown in Figure 1c. The focussing error signal FE has a positive value,

i.e. FE = (AS + CS) - (BS + DS) > 0. With the positive value of the focussing error signal FE the focussing control circuit recognises that the objective lens is too near the disc. Therefore, the objective lens is moved by the actuator of the focussing control circuit away from the disc until the focussing error signal FE becomes zero.

Three data tracks S of the disc, which has pits P written on it, are shown in Figure 2. The direction of rotation of the disc is indicated by the arrow designated T.

Because the objective lens is moved by the fine drive in a direction which makes an angle α relative to the radial direction, the light beam L on the disc also travels at the angle α. One axis of the four-quadrant photodetector, hereinafter referred to as the y-axis, runs in a tangential direction with respect to the data tracks. The other axis of the four-quadrant photodetector which is perpendicular to the y-axis and which is parallel to the radial direction, is hereinafter designated the x-axis.

When the fine drive moves the objective lens in the specified direction W, which is at the angle α relative to the radial direction, so that the light beam follows the data track, the spot of light L on the four-quadrant photodetector travels a straight line W which also is at the angle α with respect to the x-axis.

By moving the objective lens in the direction specified, however, imaging defects of the light beam on the four-quadrant photodetector are caused which invalidate the focussing error signal FE. Therefore, the light beam can no longer be accurately focussed onto the recording medium, the disc.

It is, therefore, an object of the invention to minimise incorrect focussing caused by imaging defects.

The invention achieves this object in that a selected axis of the astigmatically acting element lying in the beam path also makes the angle α relative to the normals to the track direction.

Figure 3 shows a first embodiment.

Figure 4 shows a second embodiment.

Figure 5 shows a third embodiment of the invention.

The first embodiment shown in Figure 3 will now be described and explained.

In the first embodiment of the invention a convex cylindrical lens ZX is provided as an astigmatically acting element. The light beam emitted from a laser diode LS can be directed onto the disc CD e.g. by a prismatic beam splitter PS. From there it is reflected and radiates through the prismatic beam splitter PS onto a four-quadrant photodetector PD.

The convex cylindrical lens ZX is arranged in the path of the beam between the objective lens O and the four-quadrant photodetector PD such that its longitudinal axis LA extends parallel to the direction of movement W of the objective lens O. The convex side of the cylindrical lens ZX can face either the disc CD or the four-quadrant photodetector PD. Although imaging defects arise here also, they do not invalidate the focussing error signal FE to any significant extent because of their symmetry with respect to the direction W.

In the second embodiment shown in Figure 4, a concave cylindrical lens ZK lies in the path of the beam between the objective lens O and the four-quadrant photodetector PD and serves as the astigmatically acting element. In order to ensure that the imaging defects mentioned above do not have a disturbing effect on the focussing, the concave cylindrical lens ZK is arranged in the path of the beam such that its transverse axis QA extends parallel to the direction of movement W of the objective lens. It does not matter whether the concave side of the cylindrical lens ZK faces the disc CD or the four-quadrant photodetector PD.

A third embodiment of the invention is provided with two mutually perpendicular plate members P1 and P2 of transparent material in order to generate astigmatism.

One plate P1 intersects the optical axis OA at an angle of $+45^{\circ}$ so that the other plate P2 perpendicular thereto intersects the optical axis OA at an angle of -45°. Furthermore, the two plates P1 and P2 are adjusted such that the line of intersection SG, where the two plates P1 and P2 intersect, extends perpendicular to the direction of motion W of the objective lens O. The side edges of the two plates P1 and P2, are therefore parallel to the direction of motion W of the objective lens O if rectangular plates P1 and P2 are provided. When the objective lens O is moved by the fine drive in the direction W, the light beam traces on the two plates P1 and P2 a straight line WG which perpendicularly cuts the line of intersection SG and extends parallel to the direction of movement W and to the side edges.

The angle between plates P1 and P2 can be larger or smaller than 90^{o}; however, in order to achieve a clearly measurable astigmatic effect, the angle must exceed 0^{o} and be less than 180^{o} by certain amounts. The two plates P1 and P2 are arranged in the path of the light beam such that the plane which bisects the angle is perpendicular to the optical axis OA.

The two plates P1 and P2 can be two separate parts arranged in the path of beam, however they can also be joined to one another to form a single part. For example, plate P2 can be permanently adhered by an edge to plate P1.

The invention is suitable for optical scanning devices which focus a light beam onto a recording medium by means of an objective lens, and using the astigmatism technique, to read the data from the recording medium, the objective lens being movable in a direction which makes a predetermined angle α to the normals to the track direction.

Examples are CD players, video disc players, DRAW disc players and magneto-optical devices.

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CLAIMS

1. An optical scanning device with an objective lens (O) for a recording and/or reproduction device, in which a light beam (L) is focussed onto a recording medium (CD) according to the single beam technique and is reflected from the recording medium (CD) onto a photodetector (PD), in which the light beam (L) is guided onto the data tracks (S) of the recording medium (CD) by means of a tracking control circuit, constructed from a coarse drive and a fine drive mechanically coupled with the coarse drive, in which the objective lens (O) can be moved by means of the fine drive in a direction (W) which makes a predetermined angle (α) with the normals (R) to the track direction, in which an astigmatically acting element (ZX, ZK, P1 and P2) is provided in the path of the beam, and in which the light beam (PD) reflected from the recording medium (CD) is directed onto a photodetector consisting of a plurality of photodiodes (A, B, C, D), characterised in that a preferred axis (AL, AQ, WG) of the astigmatically acting element (ZX, ZK, P1 and P2) lying in the path of the beam also makes the angle α with the normals (R) to the track direction.

2. An optical scanning device according to claim 1, characterised in that a convex cylindrical lens (ZX) is provided as the astigmatically acting element, the longitudinal axis (LA) of which makes the angle (α) with the normals (R) to the track direction.

3. An optical scanning device according to claim 1, characterised in that a concave cylindrical lens (ZK) is provided as the astigmatically acting element, the transverse axis (QA) of which makes the angle (α) with the normals (R) to the track direction.

4. An optical scanning device according to claim 1, characterised in that two transparent plate members (P1, P2), which make an angle $\gamma < 180^{\circ}$, are provided as the astigmatically acting element and are arranged symmetrically in the path of the beam in such a way that the plane bisecting the angle γ lies perpendicular to the optical axis (OA) and that the line of intersection (SG), where the two plate members (P1, P2) intersect, extends perpendicular to the direction of movement (W) of the objective lens (O).

5. An optical scanning device according to claim 4, characterised in that the plate members (P1, P2) make a right angle so that one plate member (P1) intersects the optical axis (OA) at an angle of $+45^{\circ}$, while the other plate member (P2), positioned perpendicular to the first, intersects the optical axis (OA) at an angle of -45°.

6. An optical scanning device according to claim 4 or 5, characterised in that the two plate members (P1, P2) are formed as two separate parts.

7. An optical scanning device according to claim 4 or 5, characterised in that the two plate members (P1, P2) are connected to each other forming one part.

8. An optical scanning device according to claim 1,2,3,4,5,6 or 7, characterised in that the angle (α) is selected as 45^{o}.