



### Optical scanning device

The present invention relates to an optical scanning device which is suitable for reading both an optical and a magneto-optic recording medium as well as a magneto-optic recording medium upon which items of data are stored on top of one another in both a magnetic layer and by means of so-called pits, wherein the light beam from a light source is focused on the recording medium and is reflected from the recording medium through a first  $\lambda/2$  plate to a first polarisation beam splitter which guides the light beam onto a first or second photodetector, wherein the output of the first and of the second photodetector are connected to the inputs of a first differential amplifier.

A known optical recording medium is, for example, the CD disc in which a light reflecting aluminium layer follows on the transparent layer. The light reflecting aluminium layer has depressions, so-called pits, which represent the items of data stored on the CD disc. The items of data are readable from the CD disc by means of an optical scanning device because the reflective behaviour of the light reflecting aluminium layer depends on the pattern which the depressions form on the disc. Less light is reflected from a depression, frequently also called a groove, than from a raised area which is often also referred to as a land.

From the intensity of the light reflected from the CD disc, the optical scanning device therefore recognises whether the scanned bit relates for example, to a logical one or a logical zero.

A further optical recording medium of this type, known under the designation of a magneto-optic disc, is described in the article "Magnetooptische Versuche dauern an" in Funkschau 13, 20th June 1986 at pages 37 - 41.

In contrast to a conventional CD disc, a magneto-optic disc does not have any pits. A magnetic layer, in which items of data are recordable and from which items of data are readable, is located behind the transparent layer. It will now be explained how items of data are written onto a magneto-optic disc.

The magnetic layer is heated above the Curie temperature by means of a laser beam focused onto the disc. Usually however, it is only necessary to heat up the magnetic layer to the compensation temperature which lies somewhat under the Curie temperature. An electromagnet, which magnetises the region heated by the laser beam in the one or the other direction of magnetisation, is arranged behind the focal point on the disc. Because, after switching off the laser beam, the heated spot cools once more below the Curie temperature, the direction of

magnetisation determined by the electromagnet is maintained: it is, so to speak, frozen in. The individual bits are stored in this manner in domains of different directions of magnetisation. Thereby, the one direction of magnetisation of a domain corresponds, for example, to a logical one, while the opposite direction of magnetisation represents a logical zero.

One makes use of the Kerr effect for reading the items of data. The plane of polarisation of a linearly polarised light beam is rotated by the reflection at a magnetised mirror by a measurable angle. In dependence upon the direction in which the mirror is magnetised, the plane of polarisation of the reflected light beam is rotated to the right or to the left. However, because the individual domains on the disc act like magnetised mirrors, the plane of polarisation of a scanning light beam is rotated by a measurable angle to the left or to the right in dependence upon the direction of magnetisation of the currently scanned domain.

The optical scanning device recognises which bit is present, a logical one or a logical zero, from the rotation of the plane of polarisation of the light beam reflected from the disc. In contrast to a CD disc having pits, a magneto-optic disc is erasable and re-writable virtually as often as desired.

A disc shaped recording medium which represents a combination of an optical and a magneto-optic disc is known from DE-OS 37 32 875. Items of data are stored on this recording medium by means of pits and also in the magnetic layer of the disc. Because the pits and the magnetic domains lie above one another, items of data are stored at one and the same place in the form of pits as well as in the magnetic layer. The storage capacity of this disc is therefore twice as great as that of a normal optical disc or a magneto-optic disc.

An optical scanning device is discussed in the DE-OS 37 32 874 which is suitable for the three types of disc mentioned, since this optical scanning device is able to read items of data from an optical disc, e.g. a compact disc, a magneto-optic disc as well as from a disc that is known from the DE-OS 37 32 875.

In this optical scanning device, the light from a laser is focused onto the disc and reflected from there to a polarisation beam splitter which, in dependence on its direction of polarisation, reflects it either onto a first or a second photodetector. The data signal, which is stored in the magnetic domains of the disc, is obtained from the difference of the photo voltages of the first and the second photodetector. That data signal, which reproduces the items of data stored on the disc by means of the pits, is produced from the sum of the photo



voltages of the first and the second photodetector. The optical scanning device described in DE-OS 37 32 874 may, in a disc such as is specified in DE-OS 37 32 875, simultaneously read both the items of data stored by means of the pits and the items of data stored in the magnetic domains.

However, because the pits likewise cause a - if only very small - rotation of the direction of polarisation of the light emitted by the laser, cross-talk between the data signal obtained by scanning the pits and the data signal read from the magnetic domains with the aid of the Kerr effect cannot be completely avoided.

The object of the invention therefore is to suppress the undesired cross-talk as completely as possible using simple means.

The invention achieves this object in that, the recording medium reflects the light beam through a second  $\lambda/2$  plate and a  $\lambda/4$  plate to a second polarisation beam splitter which guides the light beam in dependence on its direction of polarisation onto a third or fourth photodetector, that the output of the third and of the fourth photodetector are connected to the inputs of a second differential amplifier, that the output of the first differential amplifier is connected to the non-inverting input of a third differential amplifier from whose output the data signal which was obtained from the magnetic layer of the recording medium is derivable and that the output of the second differential amplifier is connected to the inverting input of the third differential amplifier.

There is shown in

Figure 1 an embodiment of the invention;

Figure 2 a cross-section through a magneto-optic disc having pits;

Figure 3 the magnet-optic data signal which is subject to cross-talk;

The construction of the embodiment shown in Figure 1 will now be described.

The light produced by a light source, for example, a laser LS, shines through a collimating lens KL, a prismatic beam splitter PS1 and an objective lens OL onto a magneto-optic recording medium CD on which the items of data are stored on top of each other in a magnetic layer and by means of pits. The light beam is focused onto the disc-like magneto-optic recording medium CD,



which will be subsequently referred to as magneto-optic discs, by means of the objective lens OL.

The magneto-optic disc CD reflects the light beam back to the objective lens OL and to the prismatic beam splitter PS1 which deflects it through a right angle to a prismatic beam splitter PS3. The prismatic beam splitter PS3 deflects one light beam through a right angle which then passes through a lens L5 and a cylindrical lens ZL onto a four quadrant photodetector PD5 which is formed by four photo diodes A, B, C and D. A light beam passes on in a straight line through the prismatic beam splitter PS3 to a prismatic beam splitter PS2 and then further through a  $\lambda/2$  plate and a  $\lambda/4$  plate to a polarisation beam splitter PO2. A light beam is deflected through a right angle by the prismatic beam splitter PS2 to a  $\lambda/2$  plate from which the light beam passes on further to a polarisation beam splitter PO1. The polarisation beam splitter PO1 guides the light beam in dependence on its direction of polarisation either through a lens L1 to a photodetector PD1 or through a lens L2 to a photodetector PD2. The polarisation beam splitter PO2 directs the light beam coming from the  $\lambda/4$  plate in dependence on its direction of polarisation either through a lens L3 to a photodetector PD3 or through a lens L4 to a photodetector PD4.

The outputs of the two diagonally opposite photodiodes A and C of the four quadrant photodetector PD5 are connected to a respective summing input of a differential amplifier DV4, while the other two diagonally opposite photodiodes B and D are connected to the subtracting inputs of the differential amplifier DV4. The two adjacent photodiodes A and D of the four quadrant photodetector PD5 are connected to the two summing inputs of a fifth differential amplifier DV5; the other two adjacent photodiodes C and B of the four quadrant photodetector PD5 are connected to the subtracting inputs of the differential amplifier DV5.

The output of the first photodetector PD1 is connected to the inverting input of a differential amplifier DV1 and to the first input of a summing amplifier AV. The output of the photodetector PD2 is connected to the non-inverting input of the differential amplifier DV1 and to the second input of the summing amplifier AV.

The output of the photodetector PD3 is connected to the inverting input of a differential amplifier DV2, whose non-inverting input is connected to the output of the photodetector PD4. The output of the differential amplifier DV2 is connected to the input of an amplifier V whose output is connected to the inverting input of a differential amplifier DV3. The output of



the differential amplifier DV1 is connected to the non-inverting input of the differential amplifier DV3.

The manner in which the cross-talk is created will be explained with the aid of the cross-section through a magneto-optic recording medium, which is shown in Figure 2, on which items of data are stored on top of each other in a magnetic layer as well as by means of pits.

A substrate layer is arranged on the magneto-optic disc behind a magneto-optic layer. However, the magneto-optic layer is not plane as in a conventional magneto-optic disc, but rather, it contains depressions, so-called pits, which serve for the storage of data as in an optical compact disc. If now, the linearly polarised light emitted by the laser is reflected at the magneto-optic layer MO of the disc, its direction of polarisation will be rotated through a small angle either to the right or to the left in dependence on the direction of magnetisation of the magneto-optic layer as a result of the Kerr effect. However, elliptically polarised light is produced upon reflection at the edges of the pits, which is what causes the cross-talk in the magneto-optic data signal.

As explained above, the light beam reflected from the disc is directed by the polarisation beam splitter PO1 either onto the photodetector PD1 or onto the photodetector PD2 in dependence on its direction of polarisation. The magneto-optic data signal MSN, which reproduces the items of data stored in the magnetic layer MO of the CD disc, is thus generated by forming the difference between the output signals of the two photodetectors PD1 and PD2 in the differential amplifier DV1.

The data signal PS, which reproduces the items of data stored by means of the pits in the disc, is obtained by addition of the output signals of the two photodetectors PD1 and PD2.

The magneto-optic data signal MSN present at the output of the differential amplifier DV1 which is shown in Figure 3 is, however, still subject to the interfering cross-talk.

Now the invention is based on the perception that a  $\lambda/4$  plate converts linearly polarised light into elliptically polarised light. The light reflected by the compact disc, which on the one hand is linearly polarised in a particular plane in dependence on the direction of magnetisation of the magnetic layer, and which on the other hand also contains elliptically polarised components as a result of the reflection at the edges of the pits, shines on the prismatic beam splitter PS2 which guides it not only to the polarisation beam splitter PO1 but also via the  $\lambda/2$  plate PL2 and the  $\lambda/4$  plate PL3 to the polarisation beam



splitter PO2. The  $\lambda/4$  plate PL3 converts the linearly polarised component of the light, which represents the magneto-optic data signal, into elliptically polarised light. The elliptically polarised component of the light, which is caused by the reflection at the edges of the pits, is, in contrast, converted into virtually linearly polarised light. The polarisation beam splitter PO2 guides the light either onto the photodetector PD3 or PD4 in dependence on its direction of polarisation.

The signal ES, which is produced by the difference between the output signals of the two photodetectors PD3 and PD4 by means of the differential amplifier DV2, is shown in Figure 4. Because the magneto-optic data signal is suppressed to a large extent in the signal ES, the signal ES is the interference signal which is causing the cross-talk.

Consequently, by subtraction of the signal ES from the signal MSN in the differential amplifier DV3, a magneto-optic data signal MS, which is completely free of cross-talk and which reproduces the items of data stored in the magnetic layer MO of the CD disc, is produced at the output of the differential amplifier DV3. The magneto-optic data signal MS, which is free of cross-talk, is depicted in Figure 5.

The amplification of the amplifier V, which serves for matching the circuit arrangement consisting of the differential amplifiers DV1, DV2 and DV3, can be determined experimentally for example. The amplification of the amplifier V has to be altered until such time as the signal MS at the output of the differential amplifier DV3 exhibits rectangular pulses having steep edges.

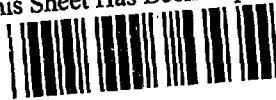
The cross-talk of a disc is dependent upon how great the component of the elliptically polarised light is in the light reflected from the disc. The greater the component of the elliptically polarised light, the greater the cross-talk. However, because the component of the elliptically polarised light varies from disc to disc in dependence on the quality of the disc, the discs exhibit differing degrees of cross-talk.

Consequently, one embodiment of the invention provides for measuring the slope of the edges of the signal MS at the output of the differential amplifier DV3 and regulating the amplification of the amplifier V such that the slope of the edges is a maximum when reading a disc. Due to this measure, the amplification of the amplifier V is optimally matched to the specific reflective properties of the disc which is currently being scanned. Consequently, the cross-talk is optimally eliminated for each disc in dependence on the reflective properties of the discs.



The invention is suitable for an optical recording and/or reproduction device which can read both optical and magneto-optic recording media as well as a combination of both. The invention can be advantageously used for data processing because items of data can be simultaneously read and recorded. However, the invention also offers the advantage for example, that sound and pictures can be recorded in CD players and video disc players simultaneously with the reproduction.

This Sheet Has Been Replaced



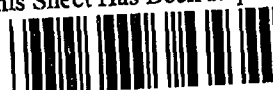
Claims

1. Optical scanning device which is suitable for reading both an optical and a magneto-optic recording medium as well as a magneto-optic recording medium (CD) upon which items of data are stored on top of one another in both a magnetic layer (MO) and by means of so-called pits (P), wherein the light beam from a light source (LS) is focused on the recording medium (CD) and is reflected by the recording medium (CD) through a first  $\lambda/2$  plate (PL1) to a first polarisation beam splitter (PO1) which guides the light beam in dependence on its direction of polarisation onto a first or second photodetector (PD1, PD2), wherein the output of the first and of the second photodetector (PD1, PD2) are connected to the inputs of a first differential amplifier (DV1), characterised in that, the recording medium (CD) reflects the light beam through a second  $\lambda/2$  plate (PL2) and a  $\lambda/4$  plate (PL3) to a second polarisation beam splitter (PO2) which guides the light beam in dependence on its direction of polarisation onto a third or fourth photodetector (PD3, PD4), that the output of the third and of the fourth photodetector (PD3, PD4) are connected to the inputs of a second differential amplifier (DV2), that the output of the first differential amplifier (DV1) is connected to the non-inverting input of a third differential amplifier (DV3) from whose output the data signal (MS) which is free of cross-talk and which was obtained from the magnetic layer (MO) of the recording medium (CD) is derivable and that the output of the second differential amplifier (DV2) is connected to the inverting input of the third differential amplifier (DV3).

2. Optical scanning device in accordance with Claim 1, characterised in that, an equalizing amplifier (V) is provided between the second differential amplifier (DV2) and the third differential amplifier (DV3).

3. Optical scanning device in accordance with Claim 1 or 2, characterised in that, the light beam from the light source (LS) passes through a collimating lens (KL) and a first prismatic beam splitter (PS1) to an objective lens (OL) which focuses the light beam onto the recording medium (CD), that the magneto-recording medium (CD) reflects the light beam back to the first prismatic beam splitter (PS1) which guides it to a second prismatic beam splitter (PS2), that the second prismatic beam splitter (PS2) guides one light beam to the first  $\lambda/2$  plate (PL1) and further to the first polarisation beam splitter (PO1), that the second prismatic beam splitter (PS2) guides a light beam to the second  $\lambda/2$  plate (PL2), further to the  $\lambda/4$  plate (PL3) and to the second polarisation beam splitter (PO2), that the first polarisation beam splitter (PO1) directs one light beam via a first lens (L1) onto the first photodetector (PD1)

This Sheet Has Been Replaced





and a light beam via a second lens (L2) onto the second photodetector (PD2), that the second polarisation beam splitter (PO2) directs one light beam via a third lens (L3) onto the third photodetector (PD3) and a light beam via a fourth lens (L4) onto the fourth photodetector (PD4), that the output of the first photodetector (PD1) is connected to the inverting input of the first differential amplifier (DV1), that the output of the second photodetector (PD2) is connected to the non-inverting input of the first differential amplifier (DV1), that the output of the third photodetector (PD3) is connected to the inverting input of the second differential amplifier (DV2), that the output of the fourth photodetector (PD4) is connected to the non-inverting input of the second differential amplifier (DV2) and that the output of the first differential amplifier (DV1) is connected to the non-inverting input of the third differential amplifier (DV3) and that the output of the second differential amplifier (DV2) is connected to the input of the amplifier (V) whose output is connected to the non-inverting input of the third differential amplifier (DV3).

4. Optical scanning device in accordance with Claim 1, 2 or 3, characterised in that, a third prismatic beam splitter (PS3), which directs a light beam via a fifth lens (L5) and a cylindrical lens (ZL) onto a four-quadrant photodetector (PD5), is provided between the first prismatic beam splitter (PS1) and the second prismatic beam splitter (PS2).

5. Optical scanning device in accordance with Claim 4, characterised in that, the outputs of two respectively diagonally opposite photodiodes (A and C or B and D) are connected to the two summing inputs or subtracting inputs respectively of a fourth differential amplifier (DV4) from whose output the focussing error signal (FE) for a focussing control loop is derivable.

6. Optical scanning device in accordance Claim 4 or 5, characterised in that, two respectively adjacent photodiodes (A and B or C and D) are connected to the two summing inputs or the two subtracting inputs respectively of a fifth differential amplifier (DV5).

7. Optical scanning device in accordance with Claim 1, 2, 3, 4, 5 or 6, characterised in that, the output of the first photodetector (PD1) and of the second photodetector (PD2) are connected to the inputs of a summing amplifier (AV) from whose output the data signal (PS) obtained from the pits of the recording medium (CD) is derivable.

8. Optical scanning device in accordance with Claim 1, 2, 3, 4, 5, 6 or 7, characterised in that, the amplification of the



Amplifier (V) is set such that the slope of the edges in the signal (MS) at the output of the third differential amplifier (DV3) attains a predetermined threshold value or is a maximum.

9. Optical scanning device in accordance with Claim 8, characterised in that, the amplification of the amplifier (V) is automatically altered until such time as the slope of the edges in the signal (MS) at the output of the third differential amplifier (DV3) attains the predetermined threshold value or is a maximum.



This Sheet Has Been Replaced

