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Description

The invention relates to an electro-optical apparatus for recording and/or reading recording tracks in a reflecting recording surface of an optical disc by means of a radiation beam, which disc has a transparent protective layer having a plane surface over the entire area of the recording surface, the radiation beam being incident on the disc surface, traversing the transparent layer, and being reflected by the recording surface, after which the reflected radiation beam again traverses the transparent layer and subsequently emerges from the disc surface, which electro-optical apparatus comprises: a frame, an objective having an optical axis and a lens system for concentrating the radiation beam to form a radiation spot, an objective bearing arrangement which permits limited pivotal movements of the optical axis of the objective in a plane which is substantially radial to the disc, and an electrical focussing actuator for moving the objective along the optical axis in order to focus the radiation spot on the recording surface.

Electro-optical apparatus of this type are, for example, employed in optical video-disc players, optical audio-disc players and optical storage-disc equipment. The radiation beam may be produced by a laser and the objective concentrates the laser beam so as to form a light spot of very small dimensions. In view of the very small depth of focus of the objective an electrical focussing actuator is used. The depth of focus is of the order of magnitude of a few microns, so that the inevitable minor variations in the position of the recording surface must be tracked by means of an automatic focussing system. The minimum dimension of the light spot is determined by the wavelength of the light source and the numerical aperture of the objective lens. The light spot comprises a bright central portion surrounded by concentric rings of substantially lower intensity. The intensity of the first ring is approximately 2% of the intensity in the centre of the light spot. If the centre of the light spot is located at a recording track a part of the light will also be incident on the adjacent tracks. The light which is reflected and which ultimately reaches the light-sensitive electronic means therefore not only contains the information relating to the desired recording track but also some information relating to adjacent tracks. For a more extensive description of the optics used in optical video-disc players and problems associated therewith, reference is made to the article "Video disk player optics" by G. Bouwhuis and J. J. M. Braat, Applied Optics, Volume 17, No. 13/1, July 1978 (herewith incorporated by reference).

The resulting cross-talk between adjacent recording tracks depends to a great extent on the light distribution on the light spot on the recording surface. The light distribution in the light spot is not only influenced by the optical quality of the optical system forming the light spot and the quality of the light source itself, but also by the obliquity of the disc surface relative to the objective axis. Said obliquity mainly gives rise to coma and increases the light intensity at one side of the central portion namely in the first ring of the intensity distribution of the light spot, that is, in the direction in which the disc surface is inclined. A certain obliquity of the disc surface in the radial direction therefore results in increased cross-talk between the recording tracks scanned by the light spot and the adjacent recording track towards which the portion of the first ring of increased light intensity points.

Current optical video-disc players intended for consumer applications, employ HeNe-lasers. The industry has put much efforts into the development of semiconductor lasers of the AlGaAs-type, because such lasers are much smaller and potentially cheaper. A comparison between optical video players equipped with HeNe-lasers and AlGaAs-lasers shows that for the same optical bandwidth or resolution the numerical aperture of the objective is 0.4 when the objective is used in connection with a HeNe-laser having a wavelength of 633 nanometers but the numerical aperture is 0.5 when said objective is used in conjunction with an AlGaAs-laser having a wavelength of 790 nanometers. As the coma caused by obliquity of the disc surface is proportional to the third power of the numerical aperture, the use of AlGaAs-lasers leads to a substantially increase in cross-talk between the recording tracks in the case of obliquity of the disc. Comparative tests reveal that when a HeNe-laser is used the obliquity of the disc should be smaller than 1°. When an AlGaAs-laser is used the obliquity should be smaller than 0.5°.

The obliquity of an optical disc depends on a number of factors. It is the obliquity in a radial direction which is of especial importance in relation to the cross-talk between the recording tracks. The principal factors to be considered are (a) various tolerances during manufacture and assembly of the disc layer and during manufacture of the disc, (b) incorrect positioning of the disc on the spindle of a disc player, and (c) cut-of-flatness of the disc surface under the influence of its own weight. Also, in optical discs comprising two separate disc sections glued to each other back to back, the deformation resulting from stresses in the layer of glue cannot always be ignored.

It is an object of the invention to provide an electro-optical apparatus of the type mentioned in the opening paragraph in which cross-talk between adjacent recording tracks as a result of obliquity of the disc is reduced, and the apparatus is characterized in that there are provided automatic correction means for, continually and automatically correcting the angular position of the optical axis during recording and/or reading of the recording tracks by tilting the objective within said plane through a correction angle which is related to the direction of the normal to the surface of the optical disc at the location where the optical axis of the objective intersects the

optical-disc surface, so as to reduce the angle between the optical axis and the normal in the case of an oblique position of the surface, which automatic correction means belong to the objective bearing arrangement and comprise mechanical guide means for guiding the objective along a curved path during its focussing movements.

In electro-optical apparatus in accordance with the invention the oblique position of the optical disc itself is not changed but its effect on cross-talk between adjacent recording tracks is reduced by correcting the position of the objective relative to the surface of the optical disc. The magnitude of a correction angle and thus the degree of tilting of the objective is related directly to the displacement from a neutral position relative to the frame to which the objective is subjected for the purpose of the focussing. Optical discs are manufactured within specific tolerances, so that each disc will not exhibit the same deformations. By means of measurements on a large number of optical discs which are representative of a normal fabrication process it is possible to determine a relationship between the objective position and the desired correction angle such that statistically an improvement of the average cross-talk is obtained. The relationship between the objective position and the correction angle is established mechanically in the bearing arrangement of the objective. The focussing actuator moves the objective up and down along its optical axis, the bearing arrangement of the objective ensuring at the same time that, depending on the objective position, the objective is tilted to a specific extent.

It is remarked that an optical player for grooved records is known from the DE—A—26 52 701, in which player correction means are used for correcting the angular position of the optical axis of an objective during reproducing an electrical signal which has been recorded in the grooves of the record. The objective is tiltable about in pivotal axis perpendicular to the optical axis through a correction angle which is related to the direction of the normal to the surface of the record. The known correction means are formed by a servomechanism comprising sensors to detect the angular position of the surface of the record and means for producing an error signal corresponding to the deviation of the normal with respect to the optical axis of the objective, which error signal dictates a desired connection angle. The correction means, furthermore, includes electro-magnetic means for tilting the objective in response to said error signal through the desired correction angle. The known player includes an actuator for moving the objective along its optical axis.

A suitable embodiment is characterized in that the objective bearing arrangement connects the objective to the frame by means of a pivotal device, the pivotal device, the objective and the frame together form a quadrangular linkage, the objective and the frame forming opposite sides of the quadrangular linkage and the other two sides belonging to the pivotal device, and said two other sides form an acute angle with each other. Preferably, an embodiment is used which is characterized in that said other two sides of the quadrangular linkage comprise two spaced leaf springs which are rigidly connected to the objective and the frame. Electro-optical equipment is known which employs a parallel objective guide-system comprising two parallelleaf springs. In comparison with such known electro-optical equipment the last-mentioned embodiment presents an improvement which can be obtained with a very small number of components. Indeed, it is necessary only to arrange the leaf springs in the slightly oblique position. Calculations demonstrate that the angle between the two leaf springs may, for example, be of the order of magnitude of 6°.

A further embodiment of the invention is characterized in that the mechanical guide means comprise a first bearing arrangement and a second bearing arrangement for the objective, the first and the second bearing arrangements guide the objective at locations which, viewed along the optical axis of the objective, are axially spaced from each other, and the first and the second bearing arrangements guide the objective in a first and a second direction respectively, which directions make angle with each other.

It may be advantageous to use an embodiment which is characterized in that the first and second bearing arrangements each comprise at least one straight guide rod which is rigidly connected to the frame and a sleeve bearing which is connected to the objective and which slides along the associated guide rod.

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

Figure 1 and 2 are a plan view and a sectional view respectively of an electro-optical apparatus comprising an objective mounted in a sleeve-bearing arrangement, represented at approximately two times the actual scale,

Figure 3 is a sectional view, at approximately three times the actual scale, of an electro-optical apparatus comprising an objective suspended in leaf springs,

Figures 4 and 5 are a plan view and a sectional view respectively of a detail, shown at two times the actual scale, of a part of the electro-optical apparatus shown in Figure 3,

Figure 6 illustrates the principle of an objective mounted on guide rods which make an angle with each other.

The electro-optical apparatus shown in Figures 1 and 2 is a modification of an apparatus known from United States Patent Specification 4,021,101 (herewith incorporated by reference) and is intended for scanning recording tracks in the reflecting recording surface 2 in a video disc 3 by means of a radiation beam 1 emitted by a HeNe-laser. On the recording layer a reflecting metallic layer 4 is formed, so that the recording surface is reflecting. Said surface is covered by a trans-

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párent protective layer 5 through which the radiation beam 1 is focussed to form a light spot 6. For this purpose there is provided an objective 7 having a lens system which *inter alia* comprises the lens 8 shown in Figure 1. The transparent protective layer 5 has a surface 9. The radiation beam 1 is concentrated by the objective 7 to form a radiation cone 10 which is incident on the disc surface, which subsequently traverses the transparent layer, is reflected by the recording surface 2 and then takes the same path back through the transparent layer 5 and the objective.

The electro-optical apparatus comprises a frame 11 which mainly comprises an axially magnetized permanent annular magnet 12, ferromagnetic end-plates 13 and 14, and a ferromagnetic central sleeve 15. Said sleeve is rigidly connected to the end plate 14 and extends through an opening in the end plate 13 which opening is dimensioned so that an air gap 16 is formed between the sleeve 15 and the end plate 13. The objective 7 is mounted in a mounting bush 17 and at its upper side it carries an annular focussing coil 18 which extends into the air gap 16. The mounting bush 17 together with the objective 7 is movable along the optical axis 19 of the objective. Arranged at the top the apparatus is a cover 20 provided with a flexible cut 21 which does not impede focussing movements of the objective 7. The mounting bush 17 is slidable in two bearing rings 22A and 22B which are connected to the frame 11. Said rings have bores 23A and 23B respectively with central axes 24A and 24B respectively, which make opposite angles φ with the optical axis 19 of the objective. At two levels the mounting bush 17 is formed with projections 25A and 25B respectively, which cooperate with the walls of the bores 23A and 23B. Thus, two axially spaced bearing arrangements for the objective are obtained, namely bearing ring 22A in conjunction with the projection 25A and bearing ring 22B in conjunction with projection 25B. Said bearing arrangements guide the objective along two axes 24A—B, which enclose an angle of 180°—2 φ. Thus, the objective is pivotable, to a limited extent, about a pivotal axis perpendicular to the plane of drawing, to the left of and outside the drawing.

There are provided first and second correction means for constantly and automatically correcting the neutral position of the optical axis 19 during reading of the recording tracks in the recording surface 2 when the video disc is being played, by tilting the objective about said pivotal axis disposed outside the drawing. Tilting is effected through a correction angle which is related to the direction of the normal to the surface 9 of the video disc at a location where the optical axis 19 of the objective intersects the surface 9 of the video disc. The first correction means define a desired correction angle which is solely a function of the positional deviation of the objective, during focussing, relative to the neutral objective position shown. The mounting bush 17 and the bearing rings 22A and 22B guide the objective in such a way that during focussing movements along the optical axis 19 it follows a slightly curved path. The degree of curvature of the path is determined by the choice of the angle φ between the central axes 24A and 24B of the bearing rings 22A and 22B and the optical axis 19. The correction means comprise said mechanical guide means and the second correction means, which tilt the objective through the desired correction angle, comprise the previously mentioned focussing actuator comprising the electric coil 18 and the magnet system. The up and down movement of the objective by means of the focussing coil 18 thus automatically results in the objective being tilted through an angle determined by the bearing means.

The embodiment of the invention shown in Figure 3 is based on the same principle. The electro-optical apparatus comprises a sleeve 26, a semiconductor-diode laser 27, two stationary lenses 28 and 29, a movable objective 30, a double prism 31, and a radiation-sensitive electrical output unit 32.

The objective 30 is mounted on a frame 33 having a bush 34 which is slid over the sleeve 26. The objective 30 is connected to said frame by a pivotal device. The pivotal device, the objective 30 and the frame together constitute a system which behaves as a quadrangular linkage. The objective 30 and the part 35 of the frame form the opposite sides of the quadrangular linkage. Two leaf springs 36A and 36B form the two other sides of the quadrangular linkage. Said last mentioned sides are at an angle of approximately 6° with each other. The objective 30 is connected to the two leafsprings 36A and 36B by means of a nut 37, which also retains a cylindrical permanent magnet system 38 and a spacer ring 39. A focussing coil 40 attached to frame 33 is arranged concentrically around the magnet system 38 and forms a focussing actuator with said system. During said focussing movements a certain pivotal movement is imparted to the objective about a pivotal axis perpendicular to the plane of drawing at the location of the line of intersection of the extensions of the leaf springs 36A and 36B.

Figure 6 schematically illustrates an embodiment of the invention which also employs mechanical guides means, comprising a first bearing arrangement and a second bearing arrangement for an objective 42 having an optical axis 43. Said two bearing arrangements, viewed along the optical axis of the objective, are axially spaced from each other by a distance d. The first bearing arrangement comprises two guide rods 44, disposed one behind the other in a direction perpendicular to the plane of drawing, and sleeve bearings 45 which slide along said rods. The second bearing arrangement comprises a guide rod 46 and a sleeve bearing 47. The bearings 45 and 47 may for example be of precious stone and the guide rods may be drawn from silver steel.

Claims

1. An electro-optical apparatus for recording and/or reading recording tracks in a reflecting recording surface of an optical disc by means of a radiation beam, which disc has a transparent protective layer having a plane surface over the entire area of the recording surface, the radiation beam being incident on the disc surface, traversing the transparent layer, and being reflected by the recording surface, after which the reflected radiation beam again traverses the transparent layer and subsequently emerges from the disc surface, which electro-optical apparatus comprises:
- a frame,
- an objective having an optical axis and a lens system for concentrating the radiation beam to form a radiation spot,
- an objective bearing arrangement which permits limited pivotal movements of the optical axis of the objective in a plane substantially radial to the disc
- an electrical focussing actuator for moving the objective along the optical axis in order to focus the radiation spot on the recording surface,

characterized in that there are provided automatic correction means for continually and automatically correcting the position of the optical axis during recording and/or reading of the recording tracks by tilting the objective within said plane through a correction angle which is related to the direction of the normal to the surface of the optical disc at the location where the optical axis of the objective intersects the optical-disc surface, so as to reduce the angle between the optical axis and the normal in the case of an oblique position of the surface, which automatic correction means belong to the objective bearing arrangement and comprise mechanical guide means for guiding the objective along a curved path during its focussing movements.

2. An electro-optical device as claimed in Claim 1, characterized in that
- the objective bearing arrangement connects the objective (30) to the frame (35) by means of a pivotal device (36A, 36B),
- the pivotal device, the objective and the frame together form a quadrangular linkage, the objective and the frame forming opposite sides of the quadrangular linkage and the other two sides belonging to the pivotal device, and
- said two other sides form an acute angle with each other.

3. An electro-optical apparatus as claimed in Claim 2, characterized in that said other two sides of the quadrangular linkage comprise two spaced leaf springs which are rigidly connected to the objective and to the frame.

4. An apparatus as claimed in Claim 1, characterized in that
- the mechanical guide means comprise a first bearing arrangement (44, 45) and a second bearing arrangement (46, 47) for the objective,
- the first and the second bearing arrangement guide the objective at locations which, viewed along the optical axis of the objective, are axially spaced from each other, and
- the first and the second bearing arrangement guide the objective in a first and a second direction, respectively, which directs make an angle with each other.

5. An apparatus as claimed in Claim 4, characterized in that the first and second bearing arrangements each comprise:
- at least one straight guide rod which is rigidly connected to the frame, and
- a sleeve bearing which is connected to the objective and which slides along the associated guide rod.

Patentansprüche

1. Elektrooptische Anordnung zum mit einem Strahlungsbündel Einschreiben und/oder Auslesen von Aufzeichnungsspuren in einer reflektierenden Aufzeichnungsfläche einer optischen Platte, die mit einer transparenten Deckschicht mit einer ebenen Oberfläche über die Aufzeichnungsfläche versehen ist, wobei das Strahlungsbündel die Oberfläche der Platte trifft, sich durch die transparente Schicht fortpflanzt und von der Aufzeichnungsfläche reflektiert wird, wonach das reflektierte Strahlungsbündel sich wieder durch die transparente Schicht fortpflanzt und daraufhin die Platte an der Oberfläche verlässt, wobei die elektrooptische Anordnung folgende Elemente umfasst:
- ein Gestell;
- ein Objektiv mit einer optischen Achse und einem Linsensystem zum Konzentrieren des Strahlungsbündels zu einem Strahlungsflecken;
- eine Objektivlagerung, die beschränkte Kippbewegungen der optischen Achse des Objektivs in einer gegenüber der Platte nahezu radialen Ebene zulässt;
- ein elektrisches Fokussierungsbetätigungsglied zum Bewegen des Objektivs längs der optischen Achse um den Strahlungsflecken auf die Aufzeichnungsfläche zu fokussieren,

dadurch gekennzeichnet, dass automatische Korrekturmittel vorhanden sind zum beim Einschreiben und/oder Auslesen von Aufzeichnungsspuren ständigen automatischen Korrigieren der Lage der optischen Achse durch Kippung des Objektivs innerhalb der genannten Ebene über einen Korrekturwinkel, der zu der Richtung der Normale auf der Oberfläche der optischen Platte an der Stelle des Schnittpunktes der Oberfläche der optischen Platte und der optischen Achse des Objektivs in Beziehung steht, damit bei einer Schieflage der Oberfläche der Winkel zwischen der optischen Achse under Normale verringert wird, wobei die automatischen Korrekturmittel der Objektivlagerung zugeordnet sind und mechanische Führungsmittel aufweisen zum Führen des Objektivs über eine Kurvestrecke während der Fokussierbewegungen.

2. Elektrooptische Anordnung nach Anspruch 1,

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dadurch gekennzeichnet,
— dass die Objektivlagerung das Objektiv (30) mit dem Gestell (35) verbindet und zwar mit einer Scharniervorrichtung (36A, 36B);
— dass die Scharniervorrichtung, das Objektiv und das Gestell zusammen ein viereckiges Hebelwerk bilden, wobei das Objektiv und das Gestell gegenüberliegende Seiten des viereckigen Hebelwerkes bilden und die übrigen zwei Seiten zu der Scharniervorrichtung gehören und
— dass die genannten zwei übrigen Seiten einen scharfen Winkel miteinander einschliessen.

3. Elektrooptische Anordnung nach Anspruch 2, dadurch gekennzeichnet, dass die genannten übrigen zwei Seiten des viereckigen Hebelwerkes durch zwei in einem Abstand voneinander liegende und mit dem Objektiv sowie mit dem Gestell ortsfest verbundene Blattfedern gebildet werden.

4. Anordnung nach Anspruch 1, dadurch gekennzeichnet,
— dass die mechanischen Führungsmittel eine erste Lagerung (44, 45) und eine zweite Lagerung (46, 47) für das Objektiv aufweisen;
— dass die erste und die zweite Lagerung das Objektiv an Stellen führen, die entsprechend der optischen Achse des Objektivs axial in einem Abstand voneinander liegen und
— dass die erste und die zweite Lagerung das Objektiv in einer ersten bzw. zweiten Richtung führen, wobei diese Richtungen einen Winkel miteinander einschliessen.

5. Anordnung nach Anspruch 4, dadurch gekennzeichnet, dass die ersten und zweiten Lagerungen je folgende Elemente umfassen:
— mindestens eine mit dem Gestell ortsfest verbundene gerade Führungsstange und
— ein mit dem Objektiv verbundenes und längs der zugehörenden Führungsstange gleitendes Gleitlager.

Revendications

1. Appareil électro-optique pour enregistrer et/ou lire des pistes d'enregistrement dans une surface d'enregistrement réfléchissante d'un disque optique au moyen d'un faisceau de rayonnement, disque qui est muni d'une couche de protection transparente ayant une surface plane sur toute l'étendue de la surface d'enregistrement, alors que le faisceau de rayonnement est incident à la surface du disque, traverse la couche transparente et est réfléchi par la surface d'enregistrement, après quoi le faisceau de rayonnement réfléchi traverse à nouveau la couche transparente et sort ensuite de la surface de disque, appareil électro-optique qui comporte:
— un châssis,
— un objectif ayant un axe optique et un système de lentilles pour concentrer le faisceau de rayonnement de façon à former un spot de rayonnement,
— un dispositif d'appui de l'objectif permettant des mouvements pivotants limités de l'axe optique de l'objectif dans un plan sensiblement radial par rapport au disque et
— un actionneur électrique de focalisation pour déplacer l'objectif suivant l'axe optique de façon à focaliser le spot de rayonnement sur la surface d'enregistrement,

caractérisé en ce qu'il est prévu des moyens de correction automatiques pour corriger continûment et automatiquement la position de l'axe optique au cours de l'enregistrement et/ou de la lecture des pistes d'enregistrement par renversement de l'objectif dans ledit plan sous un angle de correction qui est lié à la direction de la normale à la surface du disque optique à l'endroit où l'axe optique de l'objectif coupe la surface du disque optique, afin de réduire, dans le cas d'une position oblique de la surface, l'angle que fait l'axe optique avec la normale, moyens de correction automatiques qui appartiennent au dispositif d'appui de l'objectif et comportent des moyens de guidage mécaniques pour guider l'objectif dans un trajet courbe au cours de ses mouvements de focalisation.

2. Dispositif électro-optique selon la revendication 1, caractérisé en ce que
— le dispositif d'appui de l'objectif réunit l'objectif (30) au châssis (45) au moyen d'un dispositif pivotant (36A, 36B),
— le dispositif pivotant, l'objectif et le châssis forment ensemble un mécanisme de liaison quadrangulaire, l'objectif et le châssis formant des côtés opposés du mécanisme de liaison quadrangulaire et les deux autres côtés appartenant au dispositif pivotant et,
— lesdits deux autres côtés font un angle aigu l'un avec l'autre.

3. Appareil électro-optique selon la revendication 2, caractérisé en ce que lesdits deux autres côtés du mécanisme de liaison quadrangulaire sont constitués par deux ressorts-lame séparés par un espace et liés rigidement à l'objectif et au châssis.

4. Appareil selon la revendication 1, caractérisé en ce que
— les moyens de guidage mécaniques comportent un premier dispositif d'appui (44, 45) et un second dispositif d'appui (46, 47) pour l'objectif,
— les premier et second dispositifs d'appui guident l'objectif à des endroits qui, vus suivant l'axe optique de l'objectif, sont séparés par un espace dans le sens axial et
— les premier et second dispositifs d'appui guident l'objectif respectivement dans des première et seconde directions qui font un angle l'une avec l'autre.

5. Appareil selon la revendication 4, caractérisé en ce que les premier et second dispositifs d'appui comportent chacun:
— au moins une tige de guidage droite qui est liée rigidiment au châssis et
— un palier lisse réuni à l'objectif et glissant le long de la tige de guidage associée.

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