Description

The invention relates to an optical apparatus for writing and/or reading recording tracks in a recording surface of a record carrier by means of a radiation beam which is produced by a radiation source for instance, for scanning video and/or audio recording tracks in a reflecting recording surface of a rotary video or audio disc by means of a light beam, which apparatus comprises: a frame; an objective for concentrating the radiation beam to form a radiation spot in a focussing plane, which objective has an upper end which, during operation, faces the recording surface of a record carrier, and a lower end which is remote from the recording surface and comprises a lens system with an optical axis; a combined bearing arrangement for the objective, which arrangement is a combination of, firstly, a focussing bearing-arrangement which is adapted to permit focussing movements of the objective between a rest position and an operating position and relative to the frame in a direction which at least substantially coincides with the optical axis, so as to enable any deviations of the recording surface of the record carrier from a mean position in a direction perpendicular to the recording surface to be followed by the focussing plane, and, secondly, a pivotal bearing arrangement which is adapted to permit pivotal movements of the objective relative to the frame about an axis substantially perpendicular to the optical axis of the lens system, so as to enable any deviations of the recording tracks from a mean position in directions extending in the recording surface to be followed by the radiation spot; electrically controllable focussing means for electrically effecting and controlling the focussing movements of the objective; and electrically controllable pivoting means for electrically effecting and controlling the pivotal movements of the objective.

Such an optical apparatus is known from United States Patent Specification 4,135,206. In this known apparatus the objective is mounted near its lower end in a corrugated loudspeaker diaphragm made of impregnated fabric fibre, which diaphragm allows the various movements of the objective. The lens system is located near the upper end of the objective and is mounted in a tubular sleeve. The diaphragm is connected to the lower end of the sleeve, near a cylindrical coil for the focussing movements. For the pivotal movements there are provided coils which are connected to the objective near the upper end and which move in air gaps of associated permanent-magnet stators which are rigidly mounted on the frame.

It is found that an important source of undesired noises in optical disc players such as video disc players is formed by the focussing movements of the objective. The video disc rotates with a frequency of rotation of 50 or 60 Hz, depending on the local mains frequency. Irregularities in the disc surface give rise to focussing movements of the objective with a fundamental frequency of 50 or 60 Hz and, moreover, to harmonics with frequencies of up to approximately 5 or 6 kHz. The sound waves produced by the moving objective therefore have frequencies which are situated in the very frequency range to which the human ear is highly sensitive. For this reason it is useful to minimise the projection of all parts which move along with the objective onto a plane perpendicular to the optical axis of the lens system, in order to obtain a minimal sound pressure during focussing movements. Therefore, the use of a diaphragm for journalling the objective is to be regarded as less satisfactory in view of the reduction of annoying sounds. Moreover, a currogated diaphragm made of fabric fibre does not present a high resistance to transverse movements of the objective, so that under certain conditions, apart from the desired focussing movements and pivotal movements; the objective may also perform translational movements transversely of the optical axis. The diaphragm, which should be rigidly connected to the objective and to the frame, furthermore militates against a rapid and easy replacement of the objective.

It is the object of the invention to provide an optical apparatus of the type mentioned in the opening paragraph, which enables a smaller sound pressure to be produced, which presents a considerable resistance to translational movements of the objective transversely of the optical axis, and which permits rapid and simple replacement of the objective. To this end the invention is characterized in that the combined bearing arrangement for the objective comprises a sliding bearing arrangement comprising a stationary bearing member which is connected to the frame and which has an outer bearing surface, or a plurality of outer bearing surfaces, which is arranged symmetrically around the optical axis of the objective, and which bearing surface, or each of which bearing surfaces, is convexly curved about axes perpendicular to said optical axis, as well as a movable bearing member which is connected to the objective and has an inner bearing surface, or surfaces, which cooperates, or cooperate, with the convex outer bearing surface, or surfaces, of the stationary bearing member in a sliding and pivoting manner. In the present patent, "cylinder" is to be understood to mean any three-dimensional body having a constant cross-section perpendicular to a given axis through the body, which cross-section is bounded by a closed curve, and the cylindrical surface of the body being produced by a generative which extends parallel to said axis through the closed curve. Thus, in accordance with said definition a cross-section of a cylinder need not be a circle. Should this be the case, the cylinder will be termed a "circular cylinder". In the present patent, "cylindrical" is to be

understood to mean, relating to a cylinder in accordance with the foregoing definition.

If, as in the previously described known optical apparatus, the lens system is arranged at the upper end of the objective and the combined bearing arrangement is disposed near the lower end of the objective, the objective comprising a sleeve in which the lens system is mounted, an embodiment of the invention is of advantage which is characterized in that the sleeve is open at the lower end of the objective, the frame is provided with a bearing support which extends into the sleeve through the open lower end and has a free end which is directed towards the lens system, the stationary bearing member is located on the bearing support, and the movable bearing member is constituted by a portion of a wall of the sleeve. The absence of a diaphragm which moves with the objective enables the sound pressure to be reduced. The higher resistance of the bearing to transverse movements of the objective is obtained by connecting the bearing support rigidly to the frame and by giving the bearing support a high rigidity of its own. The bearing clearance between the stationary and the movable bearing members can be comparatively small, for example of the order of magnitude of 10 microns, by the use of precision manufacturing methods. The objective can readily be removed in the axial direction of the stationary bearing member and is therefore readily interchangeable.

An interesting embodiment of the invention is one in which the bearing support is at least partly hollow and is open at its free end, and in which the hollow part of the bearing support constitutes a housing for one or more optical and/or opto-electrical components which cooperate with the radiation beam. The hollow part of the bearing support may also accommodate a radiation source, so that an optical device of very compact construction can be obtained, which comprises the radiation source and the optical parts of the light path as well as the electronic means for the necessary servo controls and for electrically coupling out the high-frequency signal which is modulated by the information on the record carrier.

A further embodiment of the invention is characterized in that near its free end the bearing support comprises a cylindrical stop portion which is substantially coaxial with the optical axis of the objective, and in that the sleeve of the objective has an inner wall which surrounds said cylindrical stop portion with clearance in order to limit the pivotal movements of the objective relative to the bearing support. This precludes excessive pivotal movements of the objective, which could give rise to problems in the servo control for the pivotal movements. Furthermore, in an important embodiment of the invention the bearing support and the sleeve of the objective are provided with seating surfaces which cooperate with each other in the rest position of the objective and which are inclined relative to the optical axis of the objective, in order to obtain a well-defined, substantially non-inclined rest position for the objective. During operation the objective is maintained in position by electromagnetic forces. However it is important that in the rest position also the objective occupies a well-defined position, so that when the apparatus is put into operation the objective can start from said well-defined position thereby allowing the servo controls to lock-in immediately after the seating surfaces are disengaged. This is to be understood to mean that immediately upon putting the apparatus into operation the objective occupies a geometrical position such that the servo controls which automatically control the position of the objective during operation are not saturated.

In a known optical apparatus said electrically controllable focussing means and pivoting means comprise moving electrodynamic means which are connected to the objective as well as stationary electrodynamic means which are connected to the frame and which comprise a plurality of electric control coils and which cooperate magnetically with the moving electrodynamic means, so that by the application of electric control currents to the control coils electromagnetic forces can be exerted on the objective in order to effect focussing movements and pivotal movements thereof. In the case of an optical apparatus in accordance with the invention whose construction in this respect is similar to the known apparatus an embodiment of the invention is of significance which is characterized in that the moving electrodynamic means are situated at the sides of the sleeve and near its lower end and the moving electrodynamic means are oriented in such a way relative to the sleeve that the electromagnetic forces on the objective substantially extend through a common point on the optical axis of the lens system and said point substantially coincides with the centre of percussion of the objective. In theoretical mechanics the centre of percussion of a physical body is to be understood to mean the imaginary point on or in the body which, upon the application of an energy impulse to the body in a specific direction of percussion, performs a solely translational movement in the direction off percussion relative to an external frame of reference. An energy impulse applied to the centre of percussion causes the entire physical body to move only translationally. An energy impulse applied to a different point causes the body to perform a combined motion, the centre of percussion moving translationally and all other points moreover rotating about the centre of percussion.

Thus, the last-mentioned embodiment of the invention has the advantage that the combined bearing arrangement is not subject to forces which merely serve to counteract undesired

pivotal movements. The moving electrodynamic means may suitably comprise control coils with turns which are situated in planes perpendicular to an imaginary connecting line between the centre of the coil and the centre of percussion. During focussing movements of the objective such coils exert only a small sound pressure, because their projected area on a plane perpendicular to the optical axis is small. The said stationary electrodynamic means may comprise an annular axially magnetised magnet which surrounds the bearing support, which annular magnet may be included in a magnetic circuit with polepieces which extend axially into the control coils and which are secured to the annular magnet. For securing the control coils to the objective an embodiment is of interest which contributes to a reduction of the sound pressure and which is characterized in that externally of the sleeve there is provided a plurality of fins having free ends, which are disposed in planes substantially parallel to the optical axis of the lens system, and in that the moving electrodynamic means are arranged on the free ends of the fins.

In general it will be desirable to prevent or limit rotational movements of the objective about the optical axis, because these could give rise to contact between the moving and the stationary parts of the apparatus. This could lead to undesired wear and to the movements of the objective being impaired. An embodiment of the invention in which rotary movements of the objective about the optical axis are not possible is characterized in that the stationary bearing member comprises a first and a second pair of outer bearing surfaces, the first pair of surfaces comprising two part-cylindrical surfaces which are at least substantially disposed diametrically opposite one another on an imaginary first circular cylinder with a first diameter and a first axis which is substantially perpendicular to the optical axis of the lens system, and the second pair of surfaces comprising two part-cylindrical surfaces which are at least substantially disposed diametrically opposite one another on an imaginary second circular cylinder with a second diameter and a second axis which is substantially perpendicular to the optical axis of the lens system and also substantially perpendicular to the first axis and in that the bore of the sleeve at the location of the movable bearing member is of rectangular cross-section, with opposed sides spaced from each other by distances which are equal to the first and second diameters plus a clearance for the bearing.

The invention will now be described in more detail with reference to the drawings, which relate to some embodiments of the invention and in which:

Fig. 1 is a perspective view showing partly in section an optical apparatus in accordance with the invention which is suitable for a video disc player;

Figure 2 is a sectional view taken on the optical axis of the apparatus shown in Fig. 1,

Fig. 3 is a plan view of the optical apparatus shown in Figs. 1 and 2,

Fig. 4 is a sectional view, similar to that of Fig. 2, of a modified embodiment of the invention, and

Fig. 5 is a perspective view of the bearing arrangement of an optical apparatus of yet another embodiment.

The optical apparatus *1* shown in Fig. 1 is suitable for writing and/or reading recording tracks in a reflecting recording surface of a rotary video disc 3 by means of a radiation beam 2, produced by a radiation source, not shown. Said disc is rotatable about an axis of rotation 4 by means of a drive arrangement, not shown, which falls beyond the scope of the invention and is not discussed in more detail. The optical apparatus *1* comprises a frame 5, relative to which an objective 6 is movable. Said objective serves for concentrating the radiation beam 2 to form a radiation spot 7 in a focussing plane. The upper end 8 of the objective faces the recording surface of the video disc 3, its lower end 9 being remote from said disc, and the objective comprises a symbolically represented lens system 10 having an optical axis 11.

For the movements of the objective 6 there is provided a combined bearing arrangement which is a combination of, firstly, a focussing bearing arrangement which is adapted to permit focussing movements 12 of the objective in direction which substantially coincides with the direction of the optical axis 11 so as to enable any deviations of the recording surface of the video disc 3 from a mean position in directions perpendicular to the recording surface to be followed by the focussing plane, and secondly, a pivotal bearing arrangement which is adapted to permit pivotal movements of the objective 6 relative to the frame 5 in directions 13 and 14 about axes 15 and 16 substantially perpendicular to the optical axis 11 of the lens system 10, so as to enable any deviations of the recording track from a mean position in directions extending in the plane of the recording surface to be followed by the radiation spot 7. The pivotal movements 13 about the pivotal axis 15 serve to enable radial excursions of the track to be followed by the radiation spot 7. Pivotal movements 14 about the pivotal axis 16 serve to permit time-error corrections in tangential directions. In principle pivotal movements about any pivotal axis passing through the intersection S of the optical axis 11 and the two pivotal axes 15 and 16 and disposed in the plane defined by the axes 15 and 16 are possible. However, such pivotal movements about pivotal axes other than said two pivotal axes may always be regarded as a combination of two pivotal movements about the said

pivotal axes. The electrically controllable focussing means for electrically effecting and controlling the pivotal movements 13 and 14 of the objective will be discussed in more detail hereinafter.

The combined bearing arrangement for the objective *6* comprises a plain bearing arrangement which comprises a stationary bearing member 17 which is substantially coaxial with the optical axis 11 of the objective and is connected to frame 5 and which has an outer bearing surface 18 which is convexly curved about axes perpendicular to the optical axis 11, as well as a movable bearing member 19 which is connected to the objective *6* and has a cylindrical inner bearing surface 20 which cooperates with the convex outer bearing surface 18 of the stationary bearing member 17, in a sliding and pivoting manner and with a certain bearing clearance.

In the optical apparatus *1* shown in Figs. 1 to 3 the lens system 10 is situated near the upper end 8 of the objective *6*. The combined bearing arrangement is situated near the lower end 9 of the objective and the objective comprises a sleeve 22 in which the lens system is mounted. At its upper end said sleeve, as is apparent from Fig. 1, has a portion with a circular-cylindrical outer wall and a portion with plane outer walls. Internally the sleeve is circular-cylindrical throughout its length, a portion 23 near the lower end having a slightly greater diameter than the upper portion of the sleeve. At the lower end 9 the objective is open. The frame 5 is provided with a bearing support 21, which extends into the portion 23 of the sleeve 22 through the open lower end and which has a free end 24 which is directed towards the lens system 10. The stationary bearing member 17 is disposed on the bearing support 21 and the movable bearing member 19 is constituted by a portion off the wall of the sleeve portion 23. The stationary bearing member 17 is constituted by an annular portion of the bearing support 21 and is integral with the support 21.

The bearing support 21 is hollow over its entire length and is open at the free end 24. A portion of the hollow bearing support constitutes a housing for an optical component 25, which cooperates with the radiation beam 2. Said component is a glass component with a ground reflecting surface 26 and is glued in the bearing support 21. In its side wall the bearing support 21 has an opening 27 for the passage of the light beam 2. By means of the reflecting surface 26 the beam 2, which enters the space inside the bearing support 21 through the opening 27, is reflected through 90° in the direction of the lens system 10. The light beam which is reflected by the video disc 3 is also reflected by the reflecting surface 26 and emerges through the opening 27.

Near the free end 24 the bearing support 21 comprises a cylindrical stop portion 28 which is substantially coaxial with the optical axis 11 of the lens system 10. The sleeve 22 of the objective has an inner wall 29 which surrounds said cylindrical stop portion with some clearance in order to limit the pivotal movements of the objective relative to the bearing support 21.

The bearing support 21 and the sleeve 22 of the objective are provided with conical seating surfaces 30 and 31 which, in the rest position of the objective, cooperate with each other and which are inclined relative to the optical axis 11 of the lens system. The drawing shows the objective in the operating position, so that there is clearance between the seating surfaces. Said surfaces serve to provide a well-defined and substantially non-inclined rest position of the objective relative to the bearing support 21.

In the optical apparatus *1* as shown in Figs. 1 to 3 the electrically controllable focussing means and pivoting means comprise magnetically cooperating electrodynamic means. Said means comprise moving electrodynamic means which are connected to the objective *6* and are constituted by four control coils 32 to 35, and stationary electrodynamic means which are connected to the frame 5 and comprise an axially magnetised annular magnet 36 which surrounds the bearing support 21. Said magnet is included in a magnetic circuit with polepieces 37 to 40 which each extend into a respective one of the control coils 32 to 35 through an end thereof and which are glued to the annular magnet 36. Each of the polepieces comprises two separate portions, which are designated A and B, between which a small air gap is formed. The magnetic circuit further comprises an iron base plate 41, four iron supports 42, and four iron yoke portions 43 to 46 which complete the permanent circuit. The base plate 41, the supports 42 and the yoke portions 43 to 46 are connected to each other by means of bolts 47.

With the aid of the electrodynamic means it is possible, by applying electric control currents to the control coils 32 to 35, to exert electromagnetic forces on the objective 6 for effecting the focussing movements 12 and the pivotal movements 14 and 15. The control coils are situated at the sides of the sleeve 22, near the lower end 9 of said sleeve. They are oriented in such a way relative to the sleeve that the electrodynamic forces F on the objective 6 substantially pass through a common point C on the optical axis 11 of the lens system. Said point substantially coincides with the centre of percussion of the objective 6.

The turns of each of the control coils 32 to 35 are disposed in planes which are perpendicular to an imaginary connecting line (see the lines 48 and 49 in Fig. 2) between the centre of the respective coil and the centre of percussion C. Externally of the tube 22 there are provided a plurality of fins 50A, 50B to 53A, 53B arranged in pairs in planes which are substantially parallel to the optical axis 11, which fins have free ends on which the control coils 32 to 35

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are mounted. In order to reinforce the assembly the fins are interconnected by means of thin connecting portions 54 between adjacent pairs of fins and a connecting portion 55 between the two fins of each pair of fins.

In the embodiment shown in Figs. 1—3 the sleeve 22 and the fins 50A, B to 53A, B, the connecting portions 54 and the connecting portions 55 all form part of a single integral component *56* which is made of a suitable material. The material should be selected so that the objective *6* combines a minimal weight with a maximal rigidity, whilst obviously considerations of manufacturing technology also play a part in the choice of the material. One possibility is a diecast product of an aluminium alloy or an injection-moulded product of a high-quality plastics. The coils 32 to 35 are glued to the magnet 36. The fins and the connecting portions have a minimal thickness in order to minimise the sound pressure of the component *56* during the movements 12.

The embodiment of Fig. 4 is an optical apparatus 101 which, except for some modifications, is identical to the optical apparatus 1 of Figs. 1 to 3. The details of the apparatus 101 which correspond to details of the apparatus 1 will therefore not be discussed any further, and components to which reference is necessary for the description of the modifications and which correspond to components in the optical apparatus 1, are designated by reference numerals which are increased by 100 in comparison with the reference numerals of said corresponding parts. The lower end portion of the hollow bearing support 121 accommodates a semiconductor laser 157, which is mounted on a support 158 on a base 159. The diverging light beam 102 emitted by the semiconductor laser is formed into a parallel beam by means of an optical system 160, which beam is directed towards the lens system 110 *via* the optical element 125, whose reflecting surface 126 is now semi-transparent. Upon reflection by the video disc 103 a part of the light beam, after reflection at the reflecting surface 126, is reflected outwards through the opening 127 in the wall of the bearing support 121 and is concentrated at a semiconductor-diode cell 163 by means of lenses 161 and 162 (which are only represented symbolically and are auxiliary to the optical apparatus). It is also possible to design a light path which is entirely situated inside the bearing support 121, in which case the opening 127 in the bearing support 121 is not needed. An optical apparatus provided with such a light path is for example known from United States Patent Specification No. 4,135,083. The optical apparatus in accordance with the previously mentioned United States Patent Specification No. 4,135,206 is also intended for such a light path.

Fig. 5 relates to a detail of a modified optical apparatus which, except for the bearing arrangement, may be identical to the apparatus *1* or the apparatus *101*. The Figure shows a bearing support 221 to which a stationary bearing member 217 is secured. This bearing member comprises a first and a second pair of convex outer bearing surfaces. The first pair of surfaces 218A, 218B comprises two part-cylindrical surfaces which are disposed diametrically opposite one another on an imaginary first circular cylinder 270 (shown in broken lines) having a first axis 215 which is substantially perpendicular to the optical axis 211 of the lens system, not shown. The second pair of surfaces 218C and 218D comprises two part-cylindrical surfaces which are disposed diametrically opposite one another on an imaginary second circular cylinder 271 having a second axis 216, which is also substantially perpendicular to the optical axis 211, and having a diameter equal to that of the first circular cylinder 270. At the location of the movable bearing member 219 the sleeve 223 has a bore of square cross-section so that the inner wall 220 is constituted by plane surfaces which are perpendicular to each other. These plane surfaces surround the convex surfaces 218A to D with some bearing clearance, so that the imaginary cylinders 270 and 271 are each situated between opposing plane surfaces with some clearance. The sleeve 223 can thus perform focussing movements 212 along the optical axis 211 and pivotal movements 214 about the axis 215 of the first circular cylinder 270 as well as pivotal movements 214 about the axis 216 of the circular cylinder 271. In principle other movements are not possible, apart from the very small movements which may be allowed by the bearing clearance.

Claims

1. An optical apparatus for writing and/or reading recording tracks in a recording surface of a record carrier by means of a radiation beam which is produced by a radiation source, for instance, for scanning video and/or audio recording tracks in a reflecting recording surface of a rotary video or audio disc by means of a light beam, which apparatus comprises:

— a frame;
— an objective for concentrating the radiation beam to form a radiation spot in a focussing plane, which objective has an upper end which, during operation, faces the recording surface of a record carrier, and a lower end which is remote from the recording surface and comprises a lens system with an optical axis;
— a combined bearing arrangement for the objective, which arrangement is a combination of, firstly, a focussing bearing arrangement which is adapted to permit focussing movements of the objective between a rest position and an operating position and relative to the frame in a direction

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are mounted. In order to reinforce the assembly the fins are interconnected by means of thin connecting portions 54 between adjacent pairs of fins and a connecting portion 55 between the two fins of each pair of fins.

In the embodiment shown in Figs. 1—3 the sleeve 22 and the fins 50A, B to 53A, B, the connecting portions 54 and the connecting portions 55 all form part of a single integral component *56* which is made of a suitable material. The material should be selected so that the objective *6* combines a minimal weight with a maximal rigidity, whilst obviously considerations of manufacturing technology also play a part in the choice of the material. One possibility is a diecast product of an aluminium alloy or an injection-moulded product of a high-quality plastics. The coils 32 to 35 are glued to the magnet 36. The fins and the connecting portions have a minimal thickness in order to minimise the sound pressure of the component *56* during the movements 12.

The embodiment of Fig. 4 is an optical apparatus 101 which, except for some modifications, is identical to the optical apparatus 1 of Figs. 1 to 3. The details of the apparatus 101 which correspond to details of the apparatus 1 will therefore not be discussed any further, and components to which reference is necessary for the description of the modifications and which correspond to components in the optical apparatus 1, are designated by reference numerals which are increased by 100 in comparison with the reference numerals of said corresponding parts. The lower end portion of the hollow bearing support 121 accommodates a semiconductor laser 157, which is mounted on a support 158 on a base 159. The diverging light beam 102 emitted by the semiconductor laser is formed into a parallel beam by means of an optical system 160, which beam is directed towards the lens system 110 *via* the optical element 125, whose reflecting surface 126 is now semi-transparent. Upon reflection by the video disc 103 a part of the light beam, after reflection at the reflecting surface 126, is reflected outwards through the opening 127 in the wall of the bearing support 121 and is concentrated at a semiconductor-diode cell 163 by means of lenses 161 and 162 (which are only represented symbolically and are auxiliary to the optical apparatus). It is also possible to design a light path which is entirely situated inside the bearing support 121, in which case the opening 127 in the bearing support 121 is not needed. An optical apparatus provided with such a light path is for example known from United States Patent Specification No. 4,135,083. The optical apparatus in accordance with the previously mentioned United States Patent Specification No. 4,135,206 is also intended for such a light path.

Fig. 5 relates to a detail of a modified optical apparatus which, except for the bearing arrangement, may be identical to the apparatus *1* or the apparatus *101*. The Figure shows a bearing support 221 to which a stationary bearing member 217 is secured. This bearing member comprises a first and a second pair of convex outer bearing surfaces. The first pair of surfaces 218A, 218B comprises two part-cylindrical surfaces which are disposed diametrically opposite one another on an imaginary first circular cylinder 270 (shown in broken lines) having a first axis 215 which is substantially perpendicular to the optical axis 211 of the lens system, not shown. The second pair of surfaces 218C and 218D comprises two part-cylindrical surfaces which are disposed diametrically opposite one another on an imaginary second circular cylinder 271 having a second axis 216, which is also substantially perpendicular to the optical axis 211, and having a diameter equal to that of the first circular cylinder 270. At the location of the movable bearing member 219 the sleeve 223 has a bore of square cross-section so that the inner wall 220 is constituted by plane surfaces which are perpendicular to each other. These plane surfaces surround the convex surfaces 218A to D with some bearing clearance, so that the imaginary cylinders 270 and 271 are each situated between opposing plane surfaces with some clearance. The sleeve 223 can thus perform focussing movements 212 along the optical axis 211 and pivotal movements 214 about the axis 215 of the first circular cylinder 270 as well as pivotal movements 214 about the axis 216 of the circular cylinder 271. In principle other movements are not possible, apart from the very small movements which may be allowed by the bearing clearance.

Claims

1. An optical apparatus for writing and/or reading recording tracks in a recording surface of a record carrier by means of a radiation beam which is produced by a radiation source, for instance, for scanning video and/or audio recording tracks in a reflecting recording surface of a rotary video or audio disc by means of a light beam, which apparatus comprises:

— a frame;
— an objective for concentrating the radiation beam to form a radiation spot in a focussing plane, which objective has an upper end which, during operation, faces the recording surface of a record carrier, and a lower end which is remote from the recording surface and comprises a lens system with an optical axis;
— a combined bearing arrangement for the objective, which arrangement is a combination of, firstly, a focussing bearing arrangement which is adapted to permit focussing movements of the objective between a rest position and an operating position and relative to the frame in a direction

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which at least substantially coincides with the optical axis, so as to enable any deviations of the recording surface of the record carrier from a mean position in a direction perpendicular to the recording surface to be followed by the focussing plane, and, secondly, a pivotal bearing arrangement which is adapted to permit pivotal movements of the objective relative to the frame about an axis substantially perpendicular to the optical axis of the lens system, so as to enable any deviations of the recording track from a mean position in the directions extending in the recording surface to be followed by the radiation spot;

— electrically controllable focussing means (for electrically effecting and controlling the focussing movements of the objective; and
— electrically controllable pivoting means for electrically effecting and controlling the pivotal movements of the objective,

characterized in that the combined bearing arrangement for the objective comprises a sliding bearing arrangement comprising a stationary bearing member which is connected to the frame and which has an outer bearing surface, or a plurality of outer bearing surfaces, which is arranged around the optical axis of the objective, and which bearing surface, or each of which bearing surfaces, is convexely curved about axes perpendicular to said optical axis, as well as a movable bearing member which is connected to the objective and has an inner bearing surface, or surfaces, which cooperates, or cooperate, with the convex outer bearing surface or surfaces, of the stationary bearing member in a sliding and pivoting manner.

2. An optical apparatus as claimed in Claim 1, the lens system being mounted at the upper end of the objective and the combined bearing arrangement being situated near the lower end of the objective, the objective comprising a sleeve in which the lens system is mounted, characterized in that,

— the sleeve is open at the lower end of the objective,
— the frame is provided with a bearing support which extends into the sleeve through the open lower end and has a free end which is directed towards the lens system,
— the stationary bearing member is situated on the bearing support, and
— the movable bearing member is constituted by a portion of a wall of the sleeve.

3. An optical apparatus as claimed in Claim 2, characterized in that the bearing support is at least partly hollow and is open at its free end, the hollow part of the bearing support constituting a housing for one or more optical and/or opto-electrical components which cooperate with the radiation beam.

4. An optical apparatus as claimed in Claim 3, characterized in that the hollow portion of the bearing support also accommodates a radiation source.

5. An optical apparatus as claimed in any of Claims 2 to 4, characterized in that near its free end the bearing support comprises a cylindrical stop portion which is substantially coaxial with the optical axis of the objective, and in that the sleeve of the objective has an inner wall which surrounds said cylindrical stop portion with clearance in order to limit the pivotal movements of the objective relative to the bearing support.

6. An optical apparatus as claimed in any of Claims 2 to 5, characterized in that the bearing support and the sleeve of the objective are provided with seating surfaces which cooperate with each other in the rest position of the objective and which are inclined relative to the optical axis of the objective.

7. An optical apparatus as claimed in any of Claims 2 to 6, the electrically controllable focussing means and pivoting means comprising moving electrodynamic means which are connected to the objective as well as stationary electrodynamic means which are connected to the frame and which comprise a plurality of electric control coils and which cooperate magnetically with the moving electrodynamic means, so that by the application of electric control currents to the control coils electromagnetic forces can be exerted on the objective in order to effect focussing movements and pivotal movements thereof, characterized in that,

— the moving electrodynamic means are disposed at the sides of the sleeve and near its lower end and
— the moving electrodynamic means are oriented in such a way relative to the sleeve that the electromagnetic forces on the objective substantially extend through a common point on the optical axis of the lens system and said point substantially coincides with the centre of percussion of the objective.

8. An optical apparatus as claimed in Claim 7, characterized in that the moving electrodynamic means comprise control coils with turns which are situated in planes perpendicular to an imaginary connecting line between the centre of the respective coil and the centre of percussion.

9. An optical apparatus as claimed in Claim 7 or 8, characterized in that the stationary electrodynamic means comprise an annular axially magnetised magnet which surrounds the bearing support, the annular magnet being included in a magnetic circuit with polepieces which each extend into one of the control coils through an end thereof and which are secured to the annular magnet.

10. An optical apparatus as claimed in any of

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Claims 7 to 9, characterized in that externally of the sleeve there is provided a plurality of fins having free ends, which fins are disposed in planes substantially parallel to the optical axis of the lens system, and in that the moving electrodynamic means are arranged on the free ends of the fins.

11. An optical apparatus as claimed in any of Claims 2 to 10, characterized in that,

- the stationary bearing member comprises a first and a second pair of outer bearing surfaces, the first pair of surfaces comprising two part-cylindrical surfaces which are at least substantially disposed diametrically opposite one another on an imaginary first circular cylinder with a first diameter and a first axis which is substantially perpendicular to the optical axis of the lens system, and the second pair of surfaces comprising two part-cylindrical surfaces which are at least substantially disposed diametrically opposite one another on an imaginary second circular cylinder with a second diameter and a second axis which is substantially perpendicular to the optical axis of the lens system and also substantially perpendicular to the first axis, and
- the bore of the sleeve at the location of the movable bearing member is of rectangular cross-section, with opposed sides spaced from each other by distances which are equal to the first and second diameters plus a clearance for the bearing.

Revendications

1. Appareil optique pour l'enregistrement et/ou la reproduction de pistes d'information dans une surface d'enregistrement d'un porteur d'enregistrement à l'aide d'un faisceau de rayonnement formé par une source de rayonnement, par exemple pour le balayage de pistes d'enregistrement vidéo et/ou audio dans une surface d'enregistrement réflectrice d'un disque vidéo ou audio en rotation à l'aide d'un faisceau lumineux, appareil qui comporte:

- un châssis,
- un objectif pour la concentration du faisceau de rayonnement afin de former une tache de rayonnement dans une face de focalisation, objectif qui présente une extrémité supérieure qui, lors du fonctionnement, est opposée à la surface d'enregistrement d'un porteur d'enregistrement, et une extrémité inférieure qui est située à l'opposé de la surface d'enregistrement et qui comporte un système de lentilles présentant un axe optique,
- un système de support combiné pour l'objectif, qui est une combinaison d'abord d'un système de support de focalisation permettant des mouvements de focalisation de l'objectif entre une position de repos et une position de fonctionnement et par rapport au châssis dans une direction qui coïncide, au moins pratiquement, avec l'axe optique afin que la face de focalisation puisse suivre tout écart de la surface d'enregistrement du porteur d-enregistrement par rapport à une position principale dans une direction perpendiculaire à la surface d'enregistrement et, en second lieu, un système de support de basculement permettant des mouvements de basculement de l'objectif par rapport au châssis autour d'un axe pratiquement perpendiculaire à l'axe optique du système de lentilles, afin que la tache de rayonnement puisse suivre tout écart de la piste d'enregistrement par rapport à une position principale dans des directions s'étendant dans la surface d'enregistrement,
- des moyens de focalisation à réglage électrique permettant d'effectuer et de régler électriquement les mouvements de focalisation de l'objectif,
- et des moyens de basculement à réglage électrique pour effectuer et régler électriquement les basculements,

caractérisé en ce que le système de support combiné pour l'objectif comporte un système de palier lisse comportant un organe de palier stationnaire qui est relié au châssis et qui présente une surface de support extérieure, ou une pluralité de surfaces de support extérieures, qui est prévu symétriquement autour de l'axe optique de l'objectif, cette surface de palier ou chacune des surfaces de palier est courbée de façon convexe autour des axes perpendiculaires audit axe optique, ainsi qu'un organe de support mobile, qui est relié à l'objectif et qui présente une surface de palier intérieure ou des surfaces de palier intérieures, qui coopère(nt) avec la surface ou les surfaces de palier extérieure(s) de l'organe de palier stationnaire d'une façon à pouvoir glisser et basculer.

2. Appareil optique selon la revendication 1, dont le système de lentilles est monté à l'extrémité supérieure de l'objectif et le système de support, l'objectif comportant une douille dans laquelle est monté le système de lentilles, caractérisé en ce que

- la douille est ouverte à l'extrémité inférieure de l'objectif,
- le châssis est muni d'un support de palier, qui s'étend dans la douille à travers l'extrémité inférieure ouverte et qui présente une extrémité libre qui s'étend vers le système de lentilles,
- l'organe de palier stationnaire se situe sur le support de palier, et
- l'organe de support mobile est constitué par une partie d'une paroi de la douille.

3. Appareil optique selon la revendication 2, caractérisé en ce que le support de palier est au

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moins partiellement creux et est ouvert à son extrémité libre, la partie creuse de support de palier constituant un boîtier pour au moins un composant optique et/ou opto-électrique, qui coopère avec le faisceau de rayons.

4. Appareil optique selon la revendication 3, caractérisé en ce que la partie creuse de support de palier contient également une source de rayonnement.

5. Appareil optique selon l'une des revendications 2 à 4, caractérisé en ce que près de son extrémité libre, le support de palier comporte une partie d'arrêt cylindrique, qui est pratiquement coaxiale par rapport à l'axe optique de l'objectif, et que la douille de l'objectif présente une paroi intérieure, qui entoure ladite partie d'arrêt cylindrique avec quelque jeu afin de limiter le basculement de l'objectif par rapport au support de palier.

6. Appareil optique selon l'une des revendications 2 à 5, caractérisé en ce que le support de palier et la douille de l'objectif sont munis de surfaces de siège, qui coopèrant l'une avec l'autre dans la position de repos de l'objectif et qui sont inclinées par rapport à l'axe optique de l'objectif.

7. Appareil optique selon l'une des revendications 2 à 6, les moyens de focalisation de réglage électrique et les moyens de basculement comportant des moyens électrodynamiques mobiles qui sont reliés à l'objectif aussi bien que des moyens électrodynamiques stationnaires qui sont reliés au châssis et qui comportent plusieurs bobines de réglage électriques et qui coopèrent magnétiquement avec les moyens électrodynamiques mobiles de façon que, par application de courants de réglage électrique aux bobines de réglage, des forces électromagnétiques puissent être exercées sur l'objectif afin d'effectuer des mouvements de focalisation et des basculements de celui-ci, caractérisé en ce que

— les moyens électrodynamiques mobiles sont disposés latéralement de la douille et près de son extrémité inférieure et
— les moyens électrodynamiques mobiles sont orientés par rapport à la douille de façon que les forces électromagnétiques exercées sur l'objectif s'étendent essentiellement à travers un point commun sur l'axe optique (11) du système de lentilles et ledit point coïncide pratiquement avec le centre de percussion de l'objectif.

8. Appareil optique selon la revendication 7, caractérisé en ce que les moyens électrodynamiques mobiles comportent des bobines de réglage, dont les spires se situent dans le plan perpendiculaire à une ligne de liaison imaginaire entre le centre de la bobine respective et le centre de percussion.

9. Appareil optique selon la revendication 7 ou 8, caractérisé en ce que les moyens électrodynamiques stationnaires comportent un aimant aimanté axialement annulaire qui entoure le support de palier, l'aimant annulaire étant inséré dans un circuit magnétique présentant des pièces polaires qui s'étendent chacune dans l'une des bobines de réglage à travers une extrémité de ces dernières et qui sont fixées à l'aimant annulaire.

10. Appareil optique selon l'une des revendications 7 à 9, caractérisé en ce que à l'extérieur de la douille est appliquée une pluralité d'ailes présentant des extrémités libres, ailes qui sont disposées dans les plans pratiquement parallèles à l'axe optique du système de lentilles, et que les moyens électrodynamiques mobiles sont disposées aux extrémités libres des ailes.

11. Appareil optique selon l'une des revendications 2 à 10, caractérisé en ce que

— l'organe de support stationnaire comporte des première et seconde paires de surfaces de support extérieures, la première paire de surfaces présentant deux surfaces partiellement cylindriques, qui sont disposées, au moins en majeure partie de façon diamétralement opposée, l'une par rapport à l'autre, sur un premier cylindre de révolution imaginaire présentant un premier diamètre et un premier axe qui est pratiquement perpendiculaire à l'axe optique du système de lentilles, et que la deuxième paire de surfaces comporte deux surfaces partiellement cylindrique, qui sont disposées, au moins en majeure partie, de façon diamétralement opposée, l'une par rapport à l'autre, sur un second cylindre imaginaire présentant un second diamètre et un second axe qui est pratiquement perpendiculaire à l'axe optique du système de lentilles et également perpendiculaire au premier axe et,
— l'ouverture de la douille à l'endroit de l'organe de palier mobile présente une section transversale rectangulaire présentant des faces opposées les unes aux autres, espacées par des distances, qui sont égales aux premier et second diamètres augmentés d'un jeu pour le palier.

Patentansprüche

1. Optische Vorrichtung zum mit Hilfe eines Strahlungsbündels, das von einer Strahlungsquelle herrührt, im Betrieb Einschreiben und/oder Auslesen von Aufzeichnungsspuren in einer Aufzeichnungsfläche eines Aufzeichnungsträgers und insbesondere zum mit Hilfe eines Lichtbündels Abtasten von Video- und/oder Audioaufzeichnungsspuren in einer reflektierenden Aufzeichnungsfläche einer sich drehenden Video- oder Audioplatte mit:

— einem Gestell,
— einem Objektiv zum Konzentrieren des Strahlungsbündels zu einem Stralungs-

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flecken in einer Fokussierebene und mit einer Oberseite, die im Betrieb der Aufzeichnungsfläche eines Aufzeichnungsträgers zugewandt ist und mit einer Unterseite, die von der Aufzeichnungsfläche abgewandt ist und mit einem Linsensystem mit einer optischen Achse,

— einer kombinierten Lagervorrichtung für das Objektiv, die eine Kombination von erstens einer Fokussierlagervorrichtung zur Ermöglichung von Fokussierbewegungen des Objektivs zwischen einer Ruhelage und einer Betriebslage und gegenüber dem Gestell in einer Richtung, die wenigstens im wesentlichen mit der optischen Achse zusammenfällt, um mit der Fokussierfläche etwaigen Abweichungen von einer ungefähren Lage der Aufzeichnungsfläche des Aufzeichnungsträgers in einer Richtung senkrecht zur Aufzeichnungsfläche folgen zu können und zweitens einer Kipplagervorrichtung zur Ermöglichung von Kippbewegungen des Objektivs gegenüber dem Gestell um eine Achse im wesentlichen senkrecht zu der optischen Achse des Linsensystems, um mit dem Strahlungsflecken etwaigen Abweichungen von einer ungefähren Lage der Aufzeichnungsspur in Richtungen in der Aufzeichnungsfläche folgen zu könne;
— elektrisch steuerbaren Fokussiermitteln zum auf elektrischem Wege Bewerken und Steuern von Fokussierbewegungen des Objektivs;
— sowie elektrisch steuerbaren Kippmitteln zum auf elektrischem Wege Bewirken und Steuern der Kippbewegungen des Objektivs,

dadurch gekennzeichnet, dass die kombinierte Lagervorrichtung für das Objektiv eine Gleitlagervorrichtung enthält, die ein ortsfestes Lagerelement aufweist, das mit dem Gestell verbunden ist und eine äussere Lagerfläche hat oder eine Anzahl äusserer Lagerflächen die symmetrisch um die optische Achse des Objektivs angeordnet ist bzw. sind und welche Lagerfläche oder jede der Lagerflächen konvex um Achsen senkrecht zu der optischen Achse liegt, sowie ein bewegliches Lagerelement das mit dem Objektiv verbunden ist und eine innere Lagerfläche oder innere Lagerflächen hat, die mit der (den) konvexen äusseren Lagerfläche(n) des ortsfesten Lagerelementes glittend und kippend zusammenarbeitet oder zusammenarbeiten.

2. Optische Vorrichtung nach Anspruch 1, wobei das Linsensystem auf der Oberseite des Objektivs angeordnet ist und die kombinierte Lagervorrichtung sich in der Nähe der Unterseite des Objektivs befindet, wobei das Objektiv einen rohrförmigen Tubus aufweist, in dem das Linsensystem angeordnet ist, dadurch gekennzeichnet,

— dass der Tubus auf der Unterseite des objektivs offen ist,
— dass das Gestell mit einer Lagerunterstützung versehen ist, die durch die offene Unterseite in den Tubus ragt und eine dem Linsensystem zugewandtes freies Ende aufweist,
— dass der ortsfeste Lagerteil sich auf der Lagerunterstützung befindet und
— dass der bewegliche Lagerteil durch einen Teil einer Wand des Tubus gebildet wird.

3. Optische Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, dass die Lagerunterstützung wenigstens teilweise hohl und an dem freien Ende offen ist und wobei der Hohlteil der Lagerunterstützung ein Gehäuse für ein oder mehrere optische und/oder optoelektrische, mit dem Strahlungsbündel zusammenarbeitende Elemente bildet.

4. Optische Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, das der Hohlteil der Lagerunterstützung zugleich als Gehäuse für eine Strahlungsquelle dient.

5. Optische Vorrichtung nach einem der Ansprüche 2 bis 4, dadurch gekennzeichnet, dass die Lagerunterstützung in der Nähe des freien Endes einen zu der optischen Achse des Objektivs im wesentlichen koaxialen zylinderförmigen Anschlagteil aufweist und dass der Tubus des Objektivs eine Innenwand aufweist, die den genannten zylinderförmigen Anschlagteil mit Spielraum umgibt, damit die Kippbewegungen des Objektivs gegenüber der Lagerunterstützung beschränkt werden.

6. Optische Vorrichtung nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, dass die Lagerunterstützung und der Tubus des Objektivs mit in Ruhelage des Objektivs miteinander zusammenarbeitenden, gegenüber der optischen Achse des Objektivs schräg stehenden ruheflächen versehen sind.

7. Optische Vorrichtung nach einem der Ansprüche 2 bis 6, wobei die elektrisch steuerbaren Fokussiermittel und Kippmittel miteinander magnetisch zusammenarbeitende und mit dem Objektiv verbundene bewegliche, sowie mit dem Gestell (5) verbundene ortsfeste elektrodynamische Mittel enthalten und eine Anzahl elektrischer Steuerspulen umfassen, so dass durch Zuführen elektrischer Steuerströme zu den Steuerspulen auf das Objektiv elektromagnetische Kräfte ausgeübt werden können zum Erzeugen von Fokussierbewegungen und Kippbewegungen dadurch gekennzeichnet,

— dass die beweglichen elektrodynamischen Mittel sich seitlich des Tubus und in der Nähe dessen Unterseite befinden und
— dass die beweglichen elektrodynamischen Mittel derart gegenüber dem Tubus ausgerichtet sind, dass die elektromagnetischen Kräfte auf das Objektiv um wesentlichen durch einen gemeinsamen Punkt auf der optischen Achse des Linsensystems gehen

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und dass der genannte Punkt im wesentlichen mit dem Stosspunkt des Objektivs zusammenfällt.

8. Optische Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, dass die beweglichen elektrodynamischen Mittel Steuerspulen mit Windungen enthalten, die in Ebenen senkrecht zu einer imaginären Verbindungslinie zwischen der Mitte der Spule und dem Stosspunkt gehen.

9. Optische Vorrichtung nach Anspruch 7 oder 8, dadurch gekennzeichnet, dass die ortsfesten elektrodynamischen Mittel einen die Lagerunterstützung umgebenden und axial magnetisierten Ringmagneten umfassen, wobei der Ringmagnet in einen Magnetkreis mit axial in die Steuerspulen ragenden und auf dem Ringmagneten befestigten Polschuhen aufgenommen ist.

10. Optische Vorrichtung nach einem der Ansprüche 7 bis 9, dadurch gekennzeichnet, dass sich auf der Aussenseite des Tubus eine Anzahl Flossen befinden in Ebenen im wesentlichen parallel zu der optischen Achse des Linsensystems und mit freien Enden und dass die beweglichen elektrodynamischen Mittel an den freien Enden der Flossen angeordnet sind.

11. Optische Vorrichtung nach einem der Ansprüche 2 bis 10, dadurch gekennzeichnet,

— dass das ortsfeste Lagerteil ein erstes und ein zweites Paar äusserer Lagerflächen umfasst, wobei das erste paar Oberflächen zwei wenigstens nahezu gegenübereinander befindliche Oberflächen auf einem imaginären ersten Kreiszylinder liegend mit einem ersten Durchmesser und einer ersten Achse im wesentlichen senkrecht zu der optischen Achse des Linsensystems und wobei das zweite Paar Oberflächen zwei gegenübereinander liegenden Oberflächen hat wenigstens nahezu auf einem zweiten imaginären Kreiszylinder liegend mit einem zweiten Durchmesser und einer zweiten Achse im wesentlichen senkrecht zu der optischen Achse de Linsensystems und zugleich im wesentlichen senkrecht zu der ersten Achse und

— dass die Öffnung in dem Tubus an der Stelle des beweglichen Lagerteils einen rechtwinkligen Querschnitt aufweist mit Seiten gleich den ersten und zweiten Durchmessern vermehrt um einen Spielraumabstand für das Lager.

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