

PATENT SPECIFICATION (11)

1 580 384/

1 580 384

- (21) Application No. 19291/77/ (22) Filed 9 May 1977/ (19)
 (31) Convention Application No. 7 605 043 (32) Filed 12 May 1976 in
 (33) Netherlands (NL)
 (44) Complete Specification published 3 Dec. 1980
 (51) INT. CL.⁸ G02B 7/08 27/17
 (52) Index at acceptance

G2J 23X B7W

G1A A3 D10 D4 G1 G4 G7 G8 P10 P11 P12 P14 P15
 P17 PG R7 S4 T14 T26 T3 T4 T8



(54) OPTICAL SCANNING DEVICE

(71) We, N.V. PHILIPS' GLOEILAMPEN-FABRIEKEN, a limited liability company, organised and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an optical scanning device which is suitable for scanning video and/or audio tracks on a reflecting surface of a rotating disc with the aid of a light beam, said device comprising: a frame, upon which is movably mounted an objective lens system suitable for concentrating the beam of radiation to a scanning spot in a focussing plane, a focussing bearing-arrangement for allowing focussing movements of the objective relative to the frame in a direction which at least substantially coincides with the optical axis of the objective, so as to enable incidental deviations from a datum position of the recording plane of the record carrier in a direction perpendicular to the recording plane to be followed with the focussing plane, and electrically controllable means for electrically effecting the focussing movements of the objective.

Such an optical scanning device, intended for use in a video disc player, is known. In a series of articles concerning the Philips VLP video disc system in the magazine "Philips Technical Review", Vol. 33, 1973, No. 7, pages 178-193, a scanning device is described in which said electrically controllable focussing means for controlling the focussing movements comprise a magnetic circuit with a centrally apertured axially magnetized permanent magnet with apertured soft-iron end plates at the two axial ends and a hollow cylindrical soft-iron core which is disposed in the central aperture. A cylindrical coil arrangement which is coaxially disposed around the soft-iron

core, and which is also rigidly connected to the objective, is axially movable in an annular air gap around the soft-iron core. The focussing bearing arrangement of the objective employs a number of leaf springs which each are connected to the objective with their one ends and to the frame with their other ends so that limited motion of the objective in an axial direction is possible, but movements in a radial direction are substantially prevented.

For playing a video disc it is necessary that in addition to means for focussing the beam of radiation onto the recording track, means are also provided for radially moving the very small scanning spot which is projected onto the disc by the objective so that the spot continuously follows the spiral track. Oscillations in a radial direction of the track are produced owing to irregularities in the recording process and owing to axial and radial movements of the disc during its rotation. Therefore, in addition to a focussing bearing-arrangement for the purpose of focussing perpendicularly to the record surface, provisions are necessary for accurately following the track of the disc in the radial direction. This may for example be effected, as is also described in the previously cited magazine, with the aid of a movable mirror which is disposed in the radiation path of a laser beam. The mirror can be controlled under the influence of a control signal which is related to the deviation of the scanning spot relative to the track on the disc. Such mirrors can deflect the laser beam through a small angle, so that the objective should also be capable of handling and focussing laser beams which do not enter the objective perfectly along the optical axis and which moreover may be slightly eccentric. This demands a lens system which is of good quality over a certain "field". For said known objective a circular field with a diameter of approx. 400 microns is needed.

Realizing a field of such dimensions is a

stringent optical requirement for a lens system which must be capable of focussing a laser beam to a read spot with a diameter of approximately 0.9 micron. It is an object of the invention to provide an optical scanning device of the type mentioned in the preamble which imposes less stringent requirements on the lens system of the objective (in particular in respect of the field dimensions) and which, depending on the embodiment, may also have further advantages.

The invention provides an optical scanning device which is suitable for scanning video and/or audio tracks on a reflecting surface of a rotating disc with the aid of a light beam said device comprising: a frame upon which is movably mounted an objective lens system suitable for concentrating the beam of radiation to a scanning spot in a focussing plane, a focussing bearing arrangement for allowing focussing movements of the objective lens system relative to the frame in a direction which at least substantially coincides with the optical axis of the objective, so as to enable incidental deviations from a datum position of the recording plane of the record carrier in a direction perpendicular to the recording plane to be followed with the focussing plane, and electrically controllable means for electrically effecting the focussing movements of the objective lens system, a tracking bearing arrangement for allowing tracking movements of the objective lens system relative to the frame in a direction transverse to the direction of the focussing movement, so as to enable incidental deviations from a datum position of the recording track in a direction normal to the recording plane to be followed with the scanning spot, and electrically controllable means for electrically effecting the tracking movement of the objective lens system. Hereinafter, for brevity, the objective lens system will frequently be referred to as the objective.

In such a scanning device it is possible to ensure by means of the said electrically controllable transverse tracking means that the optical axis of the objective always follows the recording track. As a result of this a smaller field is needed with a diameter of, for example, approximately 100 microns instead of a diameter of, for example, 400 microns. Such a field dimension remains necessary in view of manufacturing tolerances and play between components. Thus, the cost price of the objective is favourably influenced in two manners. In the first place the optical specifications can be made less stringent; in the second place the requirements imposed on the accurate alignment of the lenses in the lens system may

be less stringent, though this will be at the expense of a part of the available field.

The invention enables a more compact construction of the means required for scanning a record carrier to be obtained and, in addition, the objective lens system may include further optical elements and/or radiation sensitive electronic elements which are needed in the radiation path of the radiation beam. For example, when a low-power radiation source of small size (such as a laser diode) suffices, it is possible to include the radiation source itself in the objective. In the case of a radiation source of higher power and larger size (such as a gas laser) the radiation source may be situated outside the objective and a filamentary flexible radiation guide or optic fibre may be used to connect the objective optically with the radiation source. An advantage of this arrangement is that although the radiation source is disposed outside the objective and may be rigidly connected to the stationary parts of a video player or similar apparatus, no movable mirror, electrically controlled via a control circuit, is necessary and that furthermore the point of origin of the radiation beam relative to the lens system is invariable. This results in minimal requirements with respect to the required field of the lens system. The optic fibre then serves as a flexible connection between the objective and the radiation source. Modern optic fibres of glass or plastic can combine a high efficiency with sufficient flexibility to ensure that no undesired forces are exerted on the moving objective.

In view of the generally long narrow structure of the objective it is difficult in the last two embodiments to find a suitable solution for receiving the radiation beam which is reflected by the record carrier and aiming this beam at the appropriate radiation sensitive electronic elements. It may be advantageous to employ an arrangement in which, in the objective and outside the path of radiation from the radiation source to the lens system, one or more reflecting surfaces are provided for reflecting the radiation beam reflected by the record carrier (for example in the transverse direction). In this respect it may be advantageous in view of the small space which is generally available, to utilize an arrangement wherein the reflecting surfaces consist of the surface of a single mirror which has a radiation transmitting portion (for example a hole) for transmitting the part of the radiation beam which is directed to the lens system.

The focussing bearing arrangement may comprise a parallel guide arrangement substantially parallel to the optical axis of the objective and the tracking bearing arrangement may comprise a pivot-bearing arrange-

10

ment which enables a limited pivoting movement of the objective relative to the frame about a pivoting axis which is transverse to its optical axis.

5 The optical axis of the objective may then follow the transverse positional deviations of the track by pivoting movements of the complete objective. It is apparent that a suitable location of the pivoting axis will have to be selected. The most suitable location depends on the design of the apparatus in which the scanning device is to be incorporated. However, unless the radiation beam has an orientation which is stable relative to the lens system such as when the radiation source is integrated in the objective or connected to it through an optic fibre, there is obviously no point in arranging the pivoting axis in the principal plane of the lens system. As is known from theoretical optics the principal plane is to be understood to mean a plane which may be assumed to contain a single imaginary lens which has the same properties as the actual lens system. Limited pivoting movements of the lens system relative to a stationary radiation source about a pivoting axis in the principal plane do not result in movements of the scanning spot.

30 As previously stated, a scanning device is known in which the electrically controllable means for electrically effecting the focussing movements of the objective comprise: a permanent magnetic circuit provided by a centrally apertured axially magnetized permanent magnet with apertured soft-iron end plates at the two axial ends, a hollow cylindrical soft-iron core fitted in the central aperture, and a cylindrical coil construction, comprising the focussing drive coils, which is rigidly connected to the objective and is disposed coaxially around the soft-iron core, which construction is axially movable in an annular air gap around the soft-iron core. The invention may be embodied in an apparatus wherein the focussing bearing arrangement comprises a sleeve bearing bush which is pivotably connected to the frame by means of the tracking bearing arrangement and a second bearing bush which is connected to the objective and which is movable relative to the first bearing bush, and the said coil construction comprising two coils which are disposed symmetrically one on each side of the pivoting axis of the tracking bearing arrangement. Preferably to obtain a high efficiency of the coil construction, the annular air gap may comprise two gaps one each between each of the two apertured soft-iron end plates and the cylindrical soft-iron core and one part of the turns of each tracking coil being disposed in the one air gap and another part of the turns in the other air gap, in such

a way that the said parts of the turns provide an equally directed contribution to an electrically generated pivoting torque.

Another method of pivoting the objective is possible with an embodiment of the invention wherein the focussing bearing-arrangement consists of a parallel guide and the tracking bearing arrangement consists of a pivot bearing for enabling a limited pivoting movement of the objective lens system relative to the frame about a pivoting axis which is disposed parallel to and at some distance from the optical axis of the objective lens system. By means of this embodiment it is possible, as shown in the drawings, to realize a scanning device in which the radiation source is rigidly connected to the frame and focussing and tracking are effected exclusively by movements of the objective without the use of other optical elements or a light guide.

A suitable and simple construction can be obtained if the objective is mounted in an objective support, the focussing bearing arrangement movably connecting the objective support to the frame for movement parallel to the objective axis, and the tracking bearing arrangement movably connecting the objective to the objective support for movement transverse to the objective axis.

In particular when the bandwidth of the scanning device need not comply with excessively stringent requirements, for example when the device serves for scanning audio recording tracks of an optically readable audio disc, the focussing bearing arrangement may comprise a number of identical and parallel leaf springs with their planes transverse to the objective axis and which are spaced from each other, which springs with one of their ends are connected to the frame and with their other ends to the objective support, and the tracking bearing arrangement may comprise a number of identical leaf springs with their planes parallel to the objective axis and which springs with one of their ends are connected to the objective support and with their other ends to the objective in crossed pairs to form a spring hinge having a hinge axis parallel to the objective axis. These steps result in a simple robust construction which requires little maintenance. In order to avoid unnecessary loss of power and parasitic resonances the electrically controllable means for effecting focussing preferably consist of a cylindrical axially magnetized permanent magnet which is connected to the frame, and an annular focussing coil which is connected to the objective support and which is disposed concentrically around said magnet, said magnet and coil both being coaxial with the objective.

Further, the electrically controllable

means for effecting tracking may consist of an assembly of two cylindrical axially magnetized permanent magnets, which assembly is connected to the objective support, which magnets are mounted against each other with ends of like polarity facing one another, and of an annular coil which is connected to the objective and which is concentrically arranged around said assembly, the line of motion of these means being transverse to the optical axis of the objective and offset from and opposite to the pivoting axis of the tracking bearing arrangement.

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

Figure 1 shows a part of a video disc player,

Figure 2 is a cross-section of a scanning device in which the objective is pivotable about a pivoting axis which is perpendicular to its optical axis and is journaled in a movable bearing bush,

Figure 3 is a plan view of the scanning device of Figure 2 with the cover partly removed,

Figure 4 is a cross-section of a part of the scanning device of Figure 2,

Figure 5 illustrates the principle of a similar scanning device mainly in cross-section, but in which the objective is movable in a bearing bush which bush in its turn is pivotably connected to the frame,

Figure 6 shows in perspective the shape and the position relative to the pivoting axis of two tracking coils for controlling the pivoting movements of the scanning device of Figure 5,

Figure 7 is a cross-section of a scanning device in which the objective is pivotable about a pivoting axis parallel to its optical axis and in which both the focussing bearing arrangement and the tracking bearing arrangement employ leaf springs,

Figure 8 is a cross-section in accordance with the line VIII-VIII in Figure 7,

Figure 9 is a plan view of the scanning device of Figure 7, and

Figure 10 is a cross-section along the line X-X in Figure 9.

In Figure 1 an optical scanning device bears the general reference numeral 1. It comprises a frame 2, on which is movably mounted an objective 3. The scanning device forms part of a video disc player which is suitable for playing a video disc 4 which is disposed on a rotating spindle 5. The video disc consists of a transparent part 6 as well as a protective coating 7 (which need not be transparent) between which a recording surface with an extremely thin reflecting layer 8 which is provided with the

video information in tracks in the form of small recesses and/or raised portions. The frame 2 of the scanning device is movably mounted on a base plate 9 of the video player. It is movable in a slot 10 with the aid of an electric motor 11 which via two conical gear wheels 12 and 13, of which the last mentioned gear wheel contains an internal nut, moves a lead screw 14. The recording track on the video disc 4 takes the form of a spiral the consecutive turns of the spiral being situated very near to each other at a distance of the order of magnitude of a few microns.

With the aid of a gas laser 15 a powerful radiation beam is produced which via a flexible radiation guide 16 is led to the underside of the objective 3, the end of guide 16 being fixed rigidly thereto. Such radiation guides are generally known in optics, and they consist of a transparent core surrounded by a transparent cladding of a material with a lower refractive index to that of the core, so that radiation travelling along the core cannot emerge via the cladding. The part of the radiation beam which emerges from the objective is shown in the drawing and bears the reference numeral 17. It is one of the functions of the scanning device to focus this part of the radiation beam onto the layer 8, in other words to ensure that the focussing plane of the objective and the recording plane coincide as far as possible whilst the disc is being played. For this purpose the objective is movable to and fro in the direction of its optical axis. In the drawing this is symbolically represented by a double headed arrow with the reference numeral 18. The objective is moreover pivotable about an axis which is perpendicular to the plane of the drawing, which pivoting movement is indicated by the curved double headed arrow 19. This pivoting movement serves to keep the scanning spot 20 of the radiation beam 17 constantly aimed at the recording track of the video disc. During the rotation of the video disc the track will oscillate in a direction transverse to the axis of rotation 22 of the spindle 5 owing to irregularities in the course of the track on the disc and owing to the eccentricity of the central opening 21 and of the spindle 5. These oscillations are generally referred to as "radial oscillations", whilst following these oscillations with the radiation spot 20 is generally referred to by the term "radial tracking". The objective is included in two control circuits to realize focussing and radial tracking. These circuits will not be described in more detail in the present application, because they are irrelevant for the invention. However, for information in respect of focussing and radial tracking techniques which may be used, reference is

made to the article in the previously mentioned magazine.

The objective 3 accommodates all the optical elements as well as the electronic radiation sensitive elements which are necessary for detecting the position of the scanning spot and for scanning the video and audio information contained in the layer 8. The objective 3 and the frame 2 have electromagnetically driven focussing and tracking means which co-operate with each other for moving the objective to and fro and pivoting it in an electrically controlled fashion. Via a multi-pole connector 23 the electrical connections with the electronic elements in the objective and with the said electromagnetic means are connected to electronic circuits which are accommodated in the video player and which are symbolically represented in the drawing as a box 24. Via a multi-core electrical conductor 25 and a multipole connector 26 the connector 23 is connected to the box 24. Via an electrical conductor 27 and the connectors 28 and 29 the motor 11 is also connected to the box 24. The motor 11 may be controlled so that the focussing-tracking device 1 is constantly moved with a speed which corresponds to the average pitch of the track on the video disc 4. It is alternatively possible to move the focussing tracking device intermittently, tracking being effected by means of the pivoting movement of the objective 3 during the time that said device is stationary.

Figures 2, 3 and 4 show how a scanning device may be constructed. The frame of this scanning device comprises an axially magnetized annular permanent magnet 30, two soft-iron end plates 31 and 32 at the two axial ends, one on each side of the magnet, as well as a hollow cylindrical soft-iron core 33 which is fitted in the central opening 34 of the permanent magnet. Between the upper end plate 32 and the core 33 an annular air-gap 35 is formed. In this gap a cylindrical coil construction 37 is movable which construction is rigidly connected to the objective 36 and is coaxially disposed around the soft iron core 33. The construction 37 is connected to a bearing bush 39 which with the objective is movable in the direction of its optical axis 38, which bush together with a bush 40 which is rigidly connected to the frame serves for the parallel guidance of the objective and constitutes the focussing bearing-arrangement.

On top of the end plate 32 a plastics cover 41 is disposed to which a rubber cuff 42 is attached. This cuff has concentric corrugations 43 and 44 and is connected to the objective 36. The shape of the cuff is so that it ensures that movements in the direc-

tion of the optical axis 38 and small pivoting movements are only slightly impeded.

Around the coil construction 37 an annular disc 45 is mounted which at two opposite sides, also see Figure 3, has local notches 46. These notches co-operate with locally formed ridges 47 of the cover 41, thus preventing the objective 36 together with the bearing bush 39 as a whole from rotating about its optical axis 38.

The objective is pivotable relative to the bearing bush 39 about a pivoting axis 48. For this purpose a pivot bearing arrangement is provided which comprises two bearing pins 49 as well as two bearing bushes 50. For controlling the pivoting movements of the objective two annular tracking coils 51 are mounted underneath on the bottom 53 of the objective with the aid of supports 52, also see Figure 4. The coils 51 are arranged around two cylindrical axially magnetized permanent magnets 54 and 55 with a clearance for movement. The poles of these permanent magnets are located at their ends. They are mounted with like poles facing each other and against each other; their other ends are mounted in a soft iron ring 56. This method of mounting results in a radially directed permanent magnetic field at the location where the like poles of the magnets 54 and 55 adjoin each other, so that upon energization of the coils 51 these are subjected to a force in the direction of the axis of the cylindrical magnets. The direction of the current then determines the direction of pivoting.

In the bottom 53 a light guide 59 is clamped with the aid of a threaded cap 57 and a deformable plastics ring 58. This light guide is mounted in the centre of the bottom 53 and directs a radiation beam towards the other end of the objective 36 concentric with the optical axis 38. At this end a lens system is located which consists of a single aspherical lens 60, which by means of a threaded cap 61 is fitted in a lens mount 62. In addition to this lens a number of further optical elements are accommodated in the objective, namely a quarter wave length plate 63, a Wollaston prism 64, as well as a mirror 66 in which an opening 65 is formed. This mirror is provided with a reflecting surface 67. Furthermore, the objective accommodates a stop plate 68 which stops out half the radiation beam which emerges from the light guide 59, as well as two radiation-sensitive diodes 69 and 70 which serve for converting a light-beam modulation into high frequency video and audio information and into information about the position of the focussing plane relative to the recording plane.

The electrical connections of the coils 51, the diodes 69, 70 and the coil 37 are not

(14)

shown in the drawing. However, the connecting wires of the coils 51 and the diodes 69 and 70 are preferably led upwards and through the wall of the bearing bush 39 near the bearing pins 49, so that they can be attached to mounting pins 71 (see Figure 3) which are fitted in the cover 41.

The optical elements 63, 64 and 66, the diodes 69, 70 as well as the stop plate 68 accommodated in the objective 36 together constitute a device for reading optical information described in Patent Specification No. 1,532,247, Patent Application No. 46373/75 (PHN7810), which is thus assumed to form part of the present disclosure. Said Application also describes how automatic focussing of the objective 36 is effected. For automatic tracking use is made of a system as described in the Netherlands Patent Application 7,401,470, which has been laid open for public inspection. This system employs a periodic small amplitude oscillation of the information track on the record carrier, as a result of which a signal of small amplitude is superimposed on the light beam modulation. This superimposed signal contains information about the position of the scanning spot relative to the recording track.

Referring now to Figure 5, the objective of an alternative embodiment of the scanning device bears the reference numeral 72. The permanent magnet circuit has an axially magnetized permanent magnet 73 with a central opening 74 and two soft iron end plates 75 and 76 at the two axial ends. A hollow soft-iron core 77 is mounted in the central opening 74. A cylindrical coil construction 78 which is coaxially arranged around the soft iron core 77 is fixed to the objective 72 and is axially movable in the annular air gap 79 between the end plate 75 and the core 77 and a second annular air gap 80 between end plate 76 and the core 77. The focussing bearing arrangement is a sleeve bearing arrangement for the parallel guidance of the objective 72 and comprises a first bearing bush 81 which is connected to the frame and a second bearing bush 82 which is connected to the objective and which is axially movable relative to the bearing bush 81. The bearing bush 81 is pivotally connected to the core 77 with the aid of two bearing pins 83. These bearing pins are rigidly mounted in the core 77, whilst two bearing bushes 84, which are rigidly mounted in the bearing bush 81, are pivotable on the pins. In the present embodiment the bearing bush 82, as previously stated, is rigidly connected to the objective 72 and movable in the bearing bush 81. Of course, the outer wall of the objective 72 itself may alternatively be used as a part of the sleeve bearing arrangement.

The major advantage of the construction

in accordance with Figure 5 is that the objective 72 is movable in both the direction of its optical axis 85 and, for the tracking movement, about the pivoting axis 86, with the aid of only a single electro-magnetic system, the permanent magnet 73 performing a dual function. In comparison with the embodiment of Figure 2 the mass to be moved in the direction of the optical axis 85 is thus reduced. The coil construction 78 is provided with two coils 87 which are symmetrically disposed one on each side of the pivoting axis 86, also see Figure 6, which coils serve both for focussing and for tracking. With the aid of a mounting plate 88; see Figure 5, on which the cylindrical soft iron core 77 is mounted, a construction is obtained which is such that between each of the end plates 75 and 76 and the core 77 an annular air gap is formed, namely the air gaps 79 and 80. Thus, a high efficiency of the electro-magnetic means for the axial movement and for pivoting the objective 72 can be obtained. Of each coil 87 a part 89 of the turns, see Figure 6, extend into the air gap 79 and another part 90 into the air gap 80. These parts 89 and 90 are situated so that they provide an equally directed contribution to an electrically generated torque about the pivoting axis 86.

The electromagnetic forces which are exerted on the parts 89 and 90 of the coils 87 are directed axially. Focussing movements can be effected if the current directions through the corresponding parts 89 and 90 of the two coils are selected so that the axial forces have the same direction and are equal. If this is not the case a pivoting movement of the objective is obtained, which may be used for the purpose of tracking.

Figures 7 to 10 relate to a scanning device in which an objective 91 is pivotable about a pivoting axis 92 parallel to the optical axis 93 of the objective. A movable support 94 is connected to a frame 99 by means of a focussing bearing arrangement 95 consisting of two leaf springs 96 which are arranged parallel to each other and with the aid of screws 97 and clamping plates 98. This frame consists of a base plate 100 on which a support 101 is secured with bolts 102.

The tracking bearing arrangement 103 connects the objective 91 movably to the objective support 94 and consists of four identical leaf springs 104 with their planes parallel to the objective axis, which springs are fixed to the objective support 94 with one of their ends and are fixed to the objective 91 with their other ends in crossed pairs to form a spring hinge having a hinge axis parallel to the objective axis.

The electrically controllable focussing

drive means 105 consists of an axially magnetized permanent magnet 106 which is fixed to the frame 99, and an annular focusing coil 107 which is arranged concentrically around said magnet and is fixed to the objective support 94. Both the magnet and the coil are coaxial with the objective 91 and in the magnet 106 a hole 108 is formed for the passage of a light guide to convey radiation obtained from a stationary radiation source, not shown, to the bottom of the objective. The electrically controllable tracking drive means 109 consists of an assembly of two cylindrical axially magnetized permanent magnets 110 connected to the objective support 94, which magnets are mounted against each other with ends of like polarity, and of an annular coil 111 which is concentrically arranged around this assembly and connected to the objective 91. The axis 112 of this tracking drive means crosses the optical axis 93 of the objective 91 at some distance and opposite the pivoting axis 92 of the tracking bearing arrangement 103.

To fix the two permanent magnets 110 to the objective support 94 this support is provided with two tabs 113. The two magnets have a bore through which a bolt 114 is passed which clamps the magnets between the tabs 113.

The coil 111 is fixed in a holder 115 which is fixed to a sleeve 116 in which the objective 91 is fitted. The leaf springs 104 are connected to the objective via this sleeve.

WHAT WE CLAIM IS:—

1. An optical scanning device which is suitable for scanning video and/or audio tracks on a reflecting surface of a rotating disc with the aid of a light beam said device comprising: a frame upon which is movably mounted an objective lens system suitable for concentrating the beam of radiation to a scanning spot in a focussing plane, a focussing bearing arrangement for allowing focussing movements of the objective lens system relative to the frame in a direction which at least substantially coincides with the optical axis of the objective lens system, so as to enable incidental deviations from a datum position of the recording plane of the record carrier in a direction perpendicular to the recording plane to be followed with the focussing plane, electrically controllable means for electrically effecting the focussing movements of the objective lens system, a tracking bearing arrangement for allowing tracking movements of the objective lens system relative to the frame in a direction transverse to the direction of the focussing movement, so as to enable incidental deviations from a datum position of the recording track in a direction nor-

mal to the recording track and disposed in the recording plane to be followed with the scanning spot, and electrically controllable means for electrically effecting the tracking movement of the objective lens system.

2. An optical scanning device as claimed in Claim 1, wherein the objective lens system includes further optical elements and/or radiation sensitive electronic elements which are needed in the radiation path of the radiator beam.

3. An optical scanning device as claimed in Claim 2, wherein the objective lens system includes the radiation source.

4. An optical scanning device as claimed in Claim 2, wherein the radiation source is situated outside the objective lens system and a filamentary flexible radiation guide is connected to the objective lens system with one of its ends and to the radiation source with its other end.

5. An optical scanning device as claimed in Claim 2, wherein, in the objective lens system and outside the path of radiation from the radiation source through the lens of the objective lens system, one or more surfaces are provided for reflecting modulated radiation, returned into the objective lens system by a record carrier, onto one or more radiation sensitive electronic elements.

6. An optical scanning device as claimed in Claim 5, wherein the reflecting surfaces are part of the surface of a single mirror which has a radiation transmitting portion for transmitting the part of the radiation beam which is directed through the lens.

7. An optical scanning device as claimed in Claim 1, wherein the focussing bearing arrangement comprises a guide arrangement substantially parallel to the optical axis of the objective lens system, and the tracking bearing arrangement comprises a pivot bearing arrangement for enabling a limited pivoting movement of the objective lens system relative to the frame about a pivoting axis which is transverse to its optical axis.

8. An optical scanning device as claimed in Claim 7, in which the electrically controllable means for electrically effecting the focussing and tracking movements of the objective lens system comprise; a permanent magnetic circuit provided by a centrally apertured axially magnetized permanent magnet with apertured soft iron end plates at the two axial ends, a hollow cylindrical soft-iron core fitted in the central aperture, and a cylindrical coil construction, comprising the focussing and tracking drive coils, which is rigidly connected to the objective lens system and which is disposed coaxially around the soft iron core, which construction is movable in an annular air



1,580,384

7

7

drive means 105 consists of an axially magnetized permanent magnet 106 which is fixed to the frame 99, and an annular focussing coil 107 which is arranged concentrically around said magnet and is fixed to the objective support 94. Both the magnet and the coil are coaxial with the objective 91 and in the magnet 106 a hole 108 is formed for the passage of a light guide to convey radiation obtained from a stationary radiation source, not shown, to the bottom of the objective. The electrically controllable tracking drive means 109 consists of an assembly of two cylindrical axially magnetized permanent magnets 110 connected to the objective support 94, which magnets are mounted against each other with ends of like polarity, and of an annular coil 111 which is concentrically arranged around this assembly and connected to the objective 91. The axis 112 of this tracking drive means crosses the optical axis 93 of the objective 91 at some distance and opposite the pivoting axis 92 of the tracking bearing arrangement 103.

To fix the two permanent magnets 110 to the objective support 94 this support is provided with two tabs 113. The two magnets have a bore through which a bolt 114 is passed which clamps the magnets between the tabs 113.

The coil 111 is fixed in a holder 115 which is fixed to a sleeve 116 in which the objective 91 is fitted. The leaf springs 104 are connected to the objective via this sleeve.

WHAT WE CLAIM IS:—

1. An optical scanning device which is suitable for scanning video and/or audio tracks on a reflecting surface of a rotating disc with the aid of a light beam said device comprising: a frame upon which is movably mounted an objective lens system suitable for concentrating the beam of radiation to a scanning spot in a focussing plane, a focussing bearing arrangement for allowing focussing movements of the objective lens system relative to the frame in a direction which at least substantially coincides with the optical axis of the objective lens system, so as to enable incidental deviations from a datum position of the recording plane of the record carrier in a direction perpendicular to the recording plane to be followed with the focussing plane, electrically controllable means for electrically effecting the focussing movements of the objective lens system, a tracking bearing arrangement for allowing tracking movements of the objective lens system relative to the frame in a direction transverse to the direction of the focussing movement, so as to enable incidental deviations from a datum position of the recording track in a direction nor-

mal to the recording track and disposed in the recording plane to be followed with the scanning spot, and electrically controllable means for electrically effecting the tracking movement of the objective lens system.

2. An optical scanning device as claimed in Claim 1, wherein the objective lens system includes further optical elements and/or radiation sensitive electronic elements which are needed in the radiation path of the radiator beam.

3. An optical scanning device as claimed in Claim 2, wherein the objective lens system includes the radiation source.

4. An optical scanning device as claimed in Claim 2, wherein the radiation source is situated outside the objective lens system and a filamentary flexible radiation guide is connected to the objective lens system with one of its ends and to the radiation source with its other end.

5. An optical scanning device as claimed in Claim 2, wherein, in the objective lens system and outside the path of radiation from the radiation source through the lens of the objective lens system, one or more surfaces are provided for reflecting modulated radiation, returned into the objective lens system by a record carrier, onto one or more radiation sensitive electronic elements.

6. An optical scanning device as claimed in Claim 5, wherein the reflecting surfaces are part of the surface of a single mirror which has a radiation transmitting portion for transmitting the part of the radiation beam which is directed through the lens.

7. An optical scanning device as claimed in Claim 1, wherein the focussing bearing arrangement comprises a guide arrangement substantially parallel to the optical axis of the objective lens system, and the tracking bearing arrangement comprises a pivot bearing arrangement for enabling a limited pivoting movement of the objective lens system relative to the frame about a pivoting axis which is transverse to its optical axis.

8. An optical scanning device as claimed in Claim 7, in which the electrically controllable means for electrically effecting the focussing and tracking movements of the objective lens system comprise; a permanent magnetic circuit provided by a centrally apertured axially magnetized permanent magnet with apertured soft iron end plates at the two axial ends, a hollow cylindrical soft-iron core fitted in the central aperture, and a cylindrical coil construction, comprising the focussing and tracking drive coils, which is rigidly connected to the objective lens system and which is disposed coaxially around the soft iron core, which construction is movable in an annular air



gap around the soft-iron core, the focussing bearing arrangement comprising a sleeve bearing comprising a first bearing bush which is pivotably connected to the frame by means of the tracking bearing arrangement and a second bearing bush which is connected to the objective lens system and which is movable relative to the first bearing bush, and said coil construction comprising two coils which are disposed symmetrically one on each side of the pivoting axis of the tracking bearing arrangement.

9. An optical scanning device as claimed in Claim 8, wherein the annular air gap comprises two gaps one each between each of the two apertured soft iron end plates and the cylindrical soft iron core, and wherein one part of the turns of each tracking coil is disposed in the one air gap and another part of the turns in the other air gap, in such a way that the said parts of the turns provide an equally directed contribution to an electrically generated pivoting torque.

10. An optical scanning device as claimed in Claim 1, wherein the focussing bearing arrangement consists of a parallel guide, and the tracking bearing arrangement consists of a pivot bearing for enabling a limited pivoting movement of the objective lens system relative to the frame about a pivoting axis which is disposed parallel to and at some distance from the optical axis of the objective lens system.

11. An optical scanning device as claimed in Claim 10, wherein, the objective lens system is mounted in an objective support, the focussing bearing arrangement movably connecting the objective support to the frame for movement parallel to the objective axis, and the tracking bearing arrangement movably connecting the objective lens system to the objective support for movement transverse to the objective axis.

12. An optical scanning device as claimed in Claim 11, wherein the focussing bearing arrangement comprises a number of identical and parallel leaf springs with their planes transverse to the objective axis and which are spaced from each other, which springs with one of their ends are connected

to the frame and with their other ends to the objective support, and wherein the tracking bearing arrangement comprises a number of identical leaf springs with their planes parallel to the objective axis and which springs with one of their ends are connected to the objective support and with their other ends to the objective lens system in crossed pairs to form a spring hinge having a hinge axis parallel to the objective axis.

13. An optical scanning device as claimed in Claim 12, wherein the electrically controllable means for effecting focussing comprise a cylindrical axially magnetized permanent magnet which is connected to the frame and an annular focussing coil which is connected to the objective support and which is disposed concentrically around said magnet, said magnet and coil both being coaxial with the objective lens system.

14. An optical scanning device as claimed in Claim 12, wherein the electrically controllable means for effecting tracking comprise an assembly of two cylindrical axial magnetized permanent magnets, which assembly is connected to the objective support and which magnets are mounted against each other with ends of like polarity facing each other, and an annular coil which is disposed concentrically around said assembly and which is connected to the objective lens system, and wherein the line of motion of said means is transverse to the optical axis of the objective lens system and offset from and opposite to the pivoting axis of the tracking bearing arrangement.

15. An optical scanning device substantially as described with reference to Figures 1, 2, 3 and 4 of the accompanying drawings.

16. An optical scanning device substantially as described with reference to Figures 5 and 6 of the accompanying drawings.

17. An optical scanning device substantially as described with reference to Figures 7, 8, 9 and 10 of the accompanying drawings.

R. J. BOXALL,
Chartered Patent Agent,
Mullard House,
Torrington Place,
London WC1E 7HD.
Agent for the Applicants.