Description

Background of the invention

Field of the invention

The present invention relates to a fluid bearing head for use in information recording and/or retrieval apparatus, and more particularly, to a method and means for supporting an optical read or write head to maintain a constant spacing between the head and a moving information storage medium.

Description of the prior art

In the design and construction of an optical record and/or playback system, it is necessary to maintain a constant spacing between the read or write head and the recording medium in order to, in turn, maintain proper focus of the light beam impinging the surface of the medium. In a videodisc system, for example, information is recorded on a disc as a series of irregularities, each approximately 0.6 microns in width, and arranged in a spiral track with adjacent tracks being spaced apart by approximately 1.5 microns center to center. As noted in U.S. Patent No. 3,914,541, issued October 21, 1975 to James E. Elliott, the problem of optically resolving irregularities of such dimensions requires that the focus of the optical system be maintained so as to keep the diameter of the focused spot to within a fraction of a micron.

One method of maintaining a constant disc-to-head spacing for an optical read head is described in U.S. Patent No. 3,894,180, issued July 8, 1975 to Lawrence S. Canino. As described in the Canino patent, the reading of information recorded on a disc is through the use of a transducer head assembly placed adjacent the disc and which, along with the disc, is immersed in a fluid, (typically air) thus creating a fluid bearing between the assembly and the disc. As is further described in the Canino patent, the spacing maintained between the assembly and the disc can be kept substantially constant by means of a source of fluid at a variable controllable pressure, and a pressure regulator including a fluid flow restrictor which responds to changes in separation between the assembly and the disc and modifies the fluid pressure applied to the head.

Another Canino U.S. Patent No. 4,006,294, issued February 1, 1977 describes an improved transducer head assembly having a pair of expandable chambers which are coupled to each other through a fluid restrictor and which carries the transducer head, the expandable chambers being sensitive to pressure changes and causing the transducer head to move toward and away from the surface in response to such changes to correct the fluid flow pressure.

In both Canino patents, the forces exerted on the read head by the pressures within the chambers act directly on the entire resiliently suspended read head. This results in substantial mass and weight for such a read head reducing the ability of the head to respond to quick spacing changes between the head and the disc surface.

Other systems providing fluid bearings which afford a noncontact support for the entire disc and a read head and which utilize a negative pressure differential in the vicinity of the head may be found by a reference to U.S. Patent No. 3,914,541, issued October 21, 1975 to James E. Elliott, and to U.S. Patent No. 3,947,888, issued March 30, 1976 to Manfred H. Jarsen. In both these patents, the read head is maintained substantially "rigid", while the disc is flexible and deemed "compliant" in maintaining a predetermined spacing between a disc surface and the read head. In such a system, the spacing is maintained by the creation of a hydrodynamic bearing between the videodisc and the foot of the read head. In both the Elliott and Jarsen patents, however, all forces acting to maintain the spacing constant are applied as forces to or are forces which react with the entire read head assembly. Furthermore, such prior art devices are useful only in systems employing "floppy" discs and would not be suitable for recording and/or playing back rigid discs, as in a disc mastering machine which records information on a coated substrate of thick glass. Both Elliott and Jarsen make reference to the need to assure appropriate spacing when dealing with the rigid videodisc or when dealing with a rigid master disc by applying various biasing forces brought to bear upon the read head assembly, urging it toward the surface of the disc.

In one such prior art apparatus known from US—A—3 081 682, a positive pressure is applied to an annular chamber adjacent one end of a lens and housing assembly in which the lens assembly is telescopically mounted relative to the housing, and the positive pressure within the annular chamber acts on a flange provided at the forward end of the long assembly, the air pressure entering the annular chamber being regulated by an air pressure regulator to provide the necessary biasing forces urging the lens assembly toward the videodisc spinning beneath it at 1800 RPM. Such a system has proven useful when recording or reading rigid videodiscs. One of the contributions of such prior art devices lies in the separating of the read head into two telescoping parts, the lens assembly and the housing, thereby making the low mass lens assembly responsive to quick axial adjustments as to better maintain a constant spacing, and therefore constant focus, of the light beam reaching the disc.

In all of the above-referenced patents describing the prior art, some discussion and details have been given as regards to a servo system which responds to out-of-focus conditions and adjusts the biasing forces on the head accordingly. Furthermore, these references teach the need for providing a fluid pressure system responsive to the relative radial location of the read head to vary the pressure differential with

radial location thereby maintaining a constant head-to-disc spacing independent of the relative surface speeds.

The present invention concerns the improvement in the support of the lens assembly relative to the housing, and this description will not dwell on the pneumatic servo system and its cooperation with a radial position sensing device, and it is presumed that one skilled in the art can adapt such subsystems to a recorder or player apparatus incorporating the concepts of the present invention.

A major drawback in the prior art head assemblies incorporating the aforementioned annular chamber concerns the chattering, or radial and axial vibrations, of the lens assembly relative to the housing due to the turbulent airflow in the passageway leading from the annular chamber to the atmosphere. The chattering is caused by the short axial length of the flange relative to the gap between the outer periphery of the flange and the inner periphery of the housing.

To determine the cause of the vibrations set up in the prior art heads, in accelerometer was installed on the lens assembly. It was discovered that excessive vibration in both the axial and radial directions occurred, and the source of the vibrating forces appeared to center around the gap location of the journal bearing. Using known techniques to observe the streamlines of air passing through the gap, it was discovered that a separation layer existed close to the piston wall, and a substantial air turbulence was noted downstream of the gap exit. Apparently, the separation layer attaches and separates itself from the piston wall randomly creating vibration by adding to and subtracting from the pressure of the air source from the regulator.

Attempts at diminishing the turbulent air flow have been directed at lengthening of the flange resulting in a lengthening of the lens assembly, thereby adding undesirable mass and increasing the length of the free end of the lens assembly such that housing support for the lens assembly is a greater distance from such free end causing instability and inaccuracies in maintaining solid radial support for the lens assembly within the housing. Obviously, it is desirable to have the bearing surfaces between the lens assembly and the housing extend the entire length of the lens assembly, and thus there arises a trade-off between axial bearing length and axial flange length, the former needed for solid radial support of the lens assembly and the latter needed for minimizing air turbulence which causes radial and axial vibrations of the flange and the integral lens assembly.

Summary of the invention

The present invention provides an improvement over the aforementioned lens assembly/housing arrangement in which substantial axial support for the lens assembly within the housing is obtainable simultaneously with eliminating the turbulent air flow by increasing the axial width verses gap width ratio, thereby avoiding the instability and vibration problems notable in prior art read head assemblies.

Basically, the invention concerns a method as claimed in claim 1 and an apparatus for supporting an optical head as claimed in claim 4.

Further developments of the invention are subject of subclaims.

In a preferred embodiment, the inner assembly is a lens assembly of an optical read/write head, although the principles of this invention can be applied to a variety of axially movable, fluid bearing heads. Air (or other fluid) is introduced under pressure in the annular gaps between the outer surface of the lens assembly and the inner surface of the housing. Such pressurized air is introduced on each axial side of the annular chamber to produce an air bearing journal between the telescoping members.

Pressure in the annular chamber is maintained at a level lower than that introduced into the annular gaps such that at least a portion of the air introduced into the gap on each axial side of the annular chamber is received by the annular chamber and exhausted therefrom. The regulator thus regulates the exhaust air pressure of the air leaving the annular chamber.

In a further aspect of the preferred embodiment, the housing is maintained in a relatively fixed relationship to the information carrying surface of the storage medium, and a supply of positive air pressure is applied to the space between the read head and the information storage medium to establish a hydrodynamic film creating the aforementioned relatively fixed resilient biasing force against which the force caused by pressure within the annular chamber is exerted.

In the drawings

Figure 1 is a cross sectional view of a prior art fluid read head showing an annular chamber at the end of the assembly;

Figure 2 is a plot of pressure versus mass flow in turbulent and laminar flow environments;

Figure 3 is a cross sectional view of the improved read head according to the present invention showing the placement of the annular chamber at the approximate center axially of the lens assembly and housing;

Figure 4 is a bottom view of the invention shown in Figure 3 detailing some of the fluid ducting and distribution patterns within the read head assembly; and

Figure 5 shows a graphical representation of the pressure at axial points along a corresponding schematic model of the invention according to the invention.

Detailed description of the preferred embodiments

Figure 1 shows a typical prior art mastering recording head 2 for recording information on the light responsive coating 5 of a videodisc 4. As critical as it is to maintain proper focus of a light

beam on the information carrying surface of a prerecorded videodisc by a read head, even more critical tolerance limitations are placed on the record head assembly which originates the submicron width tracks in the light responsive coating 5 (typically a thin metal coating, an ablative plastic coating, or photoresist coating), deposited on the near surface of a glass substrate 4. In order to minimize frictional drag of the objective lens assembly relative to its housing, it has been found advantageous to pneumatically support the lens assembly and to incorporate pneumatic principles in effecting proper focus of the light beam on the videodisc surface.

In the prior art example of Figure 1, for example, three different pneumatic systems acting in concert are shown.

An inner objective lens casing 6, carrying the objective optics represented by lens 8, is coupled to an outer objective lens casing 10 by screw-threads 12. The inner casing 6 is screwed into outer casing 10 until a hard rubber ring 14 is firmly sandwiched between flanges at the entrance end of the objective lens. An annular forcing flange 16 extends laterally near the exit end of the objective lens assembly, while an end flange 18 of the outer objective lens casing 10 serves as a mounting structure for receiving foot plate 20 pivotal about pivoting members 22 (one shown) typically in the form of a ball joint contained within recessed pockets in plate-like members 18 and 20. Such pivoting members 22 are placed on opposite sides of the objective lens assembly, being in quadrature to a pair of diametrically opposed air outlets 24 receiving a source of input air 26 through tube 28 mounting bushing 30 and distributing cavity 32. Typically, a fixed air pressure of 310 kPa (45 psi) is sufficient to create a pneumatic thrust bearing between foot plate 20 and the rotating disc substrate 4. The air exiting openings 24 placed on opposite sides of foot plate 20 thus create a relatively fixed resilient biasing force on the lens assembly relative to the housing to urge the lens assembly away from the substrate 4. Any distortions in the flatness of the disc as it passes by the head causes foot plate 20 to pivot about balls 22 and thus maintain constant spacing as the defect passes by.

In a second of the pneumatic systems to be described, an inlet tube 34 receives positive air pressure indicated by arrow 35, the air passing through tube 34, mounting bushing 38, cavity 42, and into the spacing or gap between the objective lens outer casing 10 and housing 19.

Air exiting cavity 42 in housing 19 exits to the atmosphere near the entrance end of the objective lens at a region 50, and flows into an annular cavity 48 located at the exit end of the objective lens. The positive air pressure in gap 46 maintains an extremely low frictional pneumatic air bearing between casing 10 and housing 19.

Finally, a third of the pneumatic systems employed in the read head of Figure 1 involves a tube 56 receiving positive air pressure indicated by arrow 58 leading to air pressure regulator 54. The air exiting regulator 54 is routed through tube 36, through mounting bushing 40, cavity 44, and into annular cavity 48 formed between flange 16 and housing 19. Adjusting the pressure regulator 54 changes the internal pressure within annular chamber 48, and this pressure acting between the fixed walls of housing 19 and the movable flange 16 defines a forcing piston arrangement for varying the axial position of the lens assembly within housing 19.

While the above-described prior art optical head is functional, the many drawbacks inumerated earlier are quite evident from Figure 1. First, in a typical design, the width W of flange 16 is on the order of 16.25 mm (0.640 inches), while the gap G has a span of 0.025 mm (.001 inches). As is well known in the art of fluid mechanics, the ratio of the gap dimension divided by the axial length of the gap (W in the device of Figure 1) determines whether or not the fluid passing through the gap will exit the gap in laminar or turbulent flow. Analytical calculations can be made using what is referred to as the Reynolds criterion to produce a number above which substantially turbulent flow will result and another number below which substantially laminar flow will result. Reynolds numbers are dependent also on the viscosity and density of the fluid involved in the system, and since the present invention is concerned with the use of air as an operative fluid, and since the dimension of the gap G will naturally be made as small as possible without danger of flange 16 touching the inner wall of housing 19 due to manufacturing tolerances and uncontrollable radial vibrations of the lens assembly, only the dimension W is variable to change the Reynolds number so as to obtain a smallest Reynolds number possible within the design constraint of the system. The Reynolds number equation in its simplest form can be stated as:

$$Re = \frac{v}{d} \cdot \frac{G}{W},$$

where V and d are, respectively, the viscosity and density of the fluid involved, G is the gap span, and W is the axial length of the gap.

Attempts in the prior art to increase W, while advantageously reducing the Reynolds number, produces other, deleterious effects. First, by making W larger, a substantial amount of weight is added to the movable lens assembly reducing its responsiveness to quick changes called for by the focus servo system. Secondly, by increasing W, the amount of journal bearing surface between outer casing 10 and housing 19 is lessened, allowing the free end of the lens assembly to project further and further from the housing resulting in an obvious reduction in stability of the pneumatic journal bearing.

Furthermore, with the type of geometry involved in the head assembly of the type to which this invention is related requires a ratio of

W to G to be on the order of 500 or more. Experiments have shown that a ratio of W to G over 1000 results in substantially laminar flow, while ratios of W to G under 100 result in substantially turbulent flow. This can be appreciated by reference to Figure 2 where it is indicated that, in a turbulent flow environment increased mass flow varies as the square of the pressure (i.e. $M \sim P^2$). On the other hand, in a liminar flow (L) environment, increased mass flow varies as the square root of the pressure. Accordingly, in order to avoid a turbulent situation at exit of the gap G in Figure 1, the ratio of W to G must exceed 100, and preferably should exceed 500. In a typical prior art device, the ratio of W to G is 40. Thus, to increase the width of flange 16 to obtain a ratio of 500 or more, practicality precludes the making of W large enough to produce a W to G ratio of 500 or more.

It is surmised that the reason for putting the gap and piston at the end of the lens assembly in the prior art is that it is easier to design and produce a straight bore for an air bearing, since the jounal bearing gaps are held to extremely tight tolerances to produce a gap 46 on the order of 0,0076 mm (.0003 inches).

The construction of an optical head in accordance with the principles of the present invention can be appreciated by reference to Figures 3 and 4. In Figure 3, the lens assembly is similarly constructed to that shown in Figure 1. That is, an inner lens casing 106 carries objective lens 108, and is threadedly received by outer casing 110. The two casings are locked together by a retainer bushing 115 having a lateral flange 114 bearing against the entrance end of the outer lens casing 110. Outer casing 110 has an end flange 118 facing a surface of foot plate 120 pivotally mounted with respect to end flange 118 about axis 117 on balls 122. A central land portion 121 surrounds the objective lens 108 leaving the remainder of the outer surface of foot plate 120 with a recessed area within which air indicated by arrows 123 in Figure 4 exit an opening 124 in the manner described in connection with the same function of the thrust bearing of Figure 1.

As in Figure 1, a source of positive air pressure indicated by arrow 126 enters a tube 128 through mounting bushing 130 and through a distribution cavity 132 in foot plate 120. The function and operation of the thrust bearing is prior art knowledge and will not be detailed in this description.

One important aspect of the invention lies in the provision of the annular chamber 148 near the axial center of the head assembly. Locating chamber 148 to the center of the assembly is not a mere extension of the placement of the chamber 48 in Figure 1, since other considerations, such as the aforementioned loss of journal bearing surface, are involved. Thus, to accommodate the central placement of chamber 148, the outer peripheral surface of the lens casing 110 and the inner peripheral surface of the housing 119 are provided with shoulders making the parts of both the lens assembly and housing on either side of the annular chamber 148 of different diameters. This combination of modifications results in a pair of pneumatic journal bearings, 146, 146' one on either side of chamber 148, thereby preserving the integrity of the journal bearing by keeping it a substantial length relative to the length of the lens assembly. Simultaneously, as can be appreciated by reference to Figure 3, the lens 108, i.e. the free end of the lens assembly, is positioned much closer to the end of the housing 119 so as to provide support for the lens assembly for substantially the entire length of the housing.

Moreover, and more importantly, placing the annular chamber 148 in the center of the optical head results in a high value for the ratio of W to G. First, since G is the dimension of the pneumatic journal bearing, this dimension is small, on the order of 0,0076 mm (.0003 inches), and the axial length W and W' (Figure 3) of the gap may be on the order of 25,4 mm (1 inch) or more. Accordingly, W to G ratios exceeding 3000 are possible, and even with a 0,025 mm (.001 inch) gap, W to G ratios exceeding 1000 can be realized without sacrificing good design principles. As mentioned earlier, W to G ratios exceeding 1000 result in a laminar flow at the exit ends of the gap, thereby totally eliminating the chattering of the lens assembly common with prior art structures.

With reference to Figures 3 and 4, sources of positive air pressure indicated by arrows 135 and 135' force air through tubes 134 and 134', through mounting bushings 138 and 138', through distribution cavities 142 and 142', and into the housing 119. All of the external connections and routing of air to housing 119 are shown in Figure 3 to take place within manifold 125.

Air under positive pressure in passageways 142 and 142' is distributed to the central portion of the gaps G and G' as seen in Figure 3. After entering gaps G, G', the air providing a pneumatic journal bearing within gaps 146, 146', exit both ends of the gap, one end of each gap being exhausted to the atmosphere shown at 150 and 152, and other end of the gap exhausting into annular chamber 148. Contrary to the design of prior art head assemblies, the air in chamber 148 is maintained at a pressure lower than that provided for the journal bearing, such that a pressure regulator 154 regulates the exhaust air pressure and maintains the appropriate forces acting between the housing 119 and casing 110 in the fashion of a pneumatic forcing piston to balance the oppositely directed forces against the lens assembly provided by the pneumatic thrust bearing between foot plate 120 and substrate 4. The exhaust air leaving chamber 148 is routed through distribution passageway 144, through mounting bushing 140, pipe 136, regulator 154, exit pipe 156, and to the atmosphere as shown at arrow 158.

Figure 4 is drawn to show one possible routing arrangement for the air passageways supplying gaps 146 and 146', annular chamber 148, and passageways 132 for the thrust bearing. In order to avoid confusion, not all of the air passageways

are shown in Figure 4. An example of air distribution around the periphery of gaps 146 and 146' is illustrated in Figure 4 by the provision of radially directed passageways 145 and 145' and feeder lines 143 and 143'.

While only a simplified air distribution system for the pneumatic journal bearing has been described, an improvement in the mechanism for distributing air into the bearing passageway may be provided in the manner described by U.S. Patent No. 4,339,814, issued July 13, 1982 to Lawrence S. Canino. The Canino '814 patent describes a pneumatic journal bearing in which pressurized air is supplied through a plurality of slotted flow paths to the support interface between the journal and a spindle housing for supporting the journal for relatively high speed rotation on a cushion of air.

Figure 5 shows a schematic representation of the principles of the invention at the bottom half thereof and a graph of the pressure at the corresponding axial locations along the head assembly in the upper half of Figure 5. As can be readily observed, air exiting the ends of the assembly at 150 and 152 are at atmospheric pressure (P_{AT}), while the peak pressures in the system occur in the points in gaps 146 and 146' where input pressure (P_{IN}) enter passageways 142 and 142'. At the axial location of the annular chamber 148, the pressure in the system drops to the value determined by the setting of pressure regulator 154. This is shown in Figure 5 as the pressure dip point 151 of waveform 147. The graph of Figure 5 illustrates the higher pressure 149, 149' of the journal bearing air pressure sources relative to the pressure maintained within chamber 148 and, of course, atmospheric pressure at the ends of the assembly.

In a typical operational assembly, input pressure in passageways 142 and 142' may be on the order of 193 kPa (28 psi), while the exhaust pressure adjusted by regulator 154 maintains a pressure in chamber 148 of approximately 68 kPa (10 psi) resulting in a net force against the lens assembly relative to the housing of about 4,4 N (1 pound).

Claims

1. A method for supporting an optical head (102) for use in information recording and/or retrieval systems in spaced relationships to a moving information storage medium (4, 5), the head having a lens assembly (106, 108, 110) movable within a housing (119), said method comprising the steps of:

supporting the lens assembly telescopically slidable within the housing, an annular chamber (148) being provided between the ends of said housing (119), one axially extending wall and one radially extending wall of the annular chamber being integral with the lens assembly (106, 108, 110), and the opposite axially extending wall and opposite radially extending wall of the annular chamber (148) being integral with the housing (119);

providing a relatively fixed resilient biasing force on the lens assembly (106, 108, 110) relative to the housing to urge the lens assembly away from the storage medium (4, 5); and

regulating the air pressure in the annular chamber (148) to provide a variable biasing force on the lens assembly relative to the housing in a direction opposite that of said relatively fixed biasing force;

characterized in that:

said supporting step includes introducing air under pressure (135, 135') in annular gaps (146, 146') between the outer surface of the lens assembly (106, 108, 110) and the inner surface of the housing (119) on each side of the annular chamber (148) to produce an air bearing journal between the telescoping members; and

maintaining the pressure in the annular chamber (145) at a pressure lower than the pressure introduced into said annular gaps (146, 146') and that at least a portion of the air introduced to said gap (146, 146') on each axial side of the annular chamber (145) is received by the annular chamber and exhausted therefrom; with the exhaust air pressure of the air leaving the annular chamber being regulated.

2. The method as claimed in Claim 1, including the step of maintaining the housing (119) in a fixed relationship relative to the information carrying surface of the storage medium (4, 5) and wherein a source of positive air pressure (135, 135') supplies pressurized air to the space between the head (102) and the information storage medium (4, 5) to produce said relatively fixed resilient biasing force.

3. The method as claimed in Claim 1, wherein the ratio of the axial length of each annular gap to the width of the gap is maintained at a value greater than 500.

4. Apparatus for supporting an optical head (102) for use in information recording and/or retrieval systems in spaced relationship to a moving information storage medium (4, 5) comprising:

a lens assembly (106, 108, 110) through which a beam of light may be focused onto the information carrying surface of the storage medium (4, 5);

a lens assembly housing (119) supporting said lens assembly in slidable telescopic relationship thereto;

wall means defining an annular chamber (148) between the ends of said housing (119), said wall means including a first axially extending wall and first radially extending wall integral with said lens assembly (106, 108, 110), and a second axially extending wall and second radially extending wall, opposite said first axially and radially extending walls, integral with said housing (119);

biasing means (123, 124) for providing a relatively fixed resilient biasing force on said lens assembly (106, 108, 110) relative to said housing (119) to urge said lens assembly away from the storage medium (4, 5) and air pressure regulating means (154) for regulating the air pressure in said annular chamber (148), thereby providing a variable biasing force on said lens assembly relative to

are shown in Figure 4. An example of air distribution around the periphery of gaps 146 and 146' is illustrated in Figure 4 by the provision of radially directed passageways 145 and 145' and feeder lines 143 and 143'.

While only a simplified air distribution system for the pneumatic journal bearing has been described, an improvement in the mechanism for distributing air into the bearing passageway may be provided in the manner described by U.S. Patent No. 4,339,814, issued July 13, 1982 to Lawrence S. Canino. The Canino '814 patent describes a pneumatic journal bearing in which pressurized air is supplied through a plurality of slotted flow paths to the support interface between the journal and a spindle housing for supporting the journal for relatively high speed rotation on a cushion of air.

Figure 5 shows a schematic representation of the principles of the invention at the bottom half thereof and a graph of the pressure at the corresponding axial locations along the head assembly in the upper half of Figure 5. As can be readily observed, air exiting the ends of the assembly at 150 and 152 are at atmospheric pressure (P_{AT}), while the peak pressures in the system occur in the points in gaps 146 and 146' where input pressure (P_{IN}) enter passageways 142 and 142'. At the axial location of the annular chamber 148, the pressure in the system drops to the value determined by the setting of pressure regulator 154. This is shown in Figure 5 as the pressure dip point 151 of waveform 147. The graph of Figure 5 illustrates the higher pressure 149, 149' of the journal bearing air pressure sources relative to the pressure maintained within chamber 148 and, of course, atmospheric pressure at the ends of the assembly.

In a typical operational assembly, input pressure in passageways 142 and 142' may be on the order of 193 kPa (28 psi), while the exhaust pressure adjusted by regulator 154 maintains a pressure in chamber 148 of approximately 68 kPa (10 psi) resulting in a net force against the lens assembly relative to the housing of about 4,4 N (1 pound).

Claims

1. A method for supporting an optical head (102) for use in information recording and/or retrieval systems in spaced relationships to a moving information storage medium (4, 5), the head having a lens assembly (106, 108, 110) movable within a housing (119), said method comprising the steps of:

supporting the lens assembly telescopically slidable within the housing, an annular chamber (148) being provided between the ends of said housing (119), one axially extending wall and one radially extending wall of the annular chamber being integral with the lens assembly (106, 108, 110), and the opposite axially extending wall and opposite radially extending wall of the annular chamber (148) being integral with the housing (119);

providing a relatively fixed resilient biasing force on the lens assembly (106, 108, 110) relative to the housing to urge the lens assembly away from the storage medium (4, 5); and

regulating the air pressure in the annular chamber (148) to provide a variable biasing force on the lens assembly relative to the housing in a direction opposite that of said relatively fixed biasing force;

characterized in that:

said supporting step includes introducing air under pressure (135, 135') in annular gaps (146, 146') between the outer surface of the lens assembly (106, 108, 110) and the inner surface of the housing (119) on each side of the annular chamber (148) to produce an air bearing journal between the telescoping members; and

maintaining the pressure in the annular chamber (145) at a pressure lower than the pressure introduced into said annular gaps (146, 146') and that at least a portion of the air introduced to said gap (146, 146') on each axial side of the annular chamber (145) is received by the annular chamber and exhausted therefrom; with the exhaust air pressure of the air leaving the annular chamber being regulated.

2. The method as claimed in Claim 1, including the step of maintaining the housing (119) in a fixed relationship relative to the information carrying surface of the storage medium (4, 5) and wherein a source of positive air pressure (135, 135') supplies pressurized air to the space between the head (102) and the information storage medium (4, 5) to produce said relatively fixed resilient biasing force.

3. The method as claimed in Claim 1, wherein the ratio of the axial length of each annular gap to the width of the gap is maintained at a value greater than 500.

4. Apparatus for supporting an optical head (102) for use in information recording and/or retrieval systems in spaced relationship to a moving information storage medium (4, 5) comprising:

a lens assembly (106, 108, 110) through which a beam of light may be focused onto the information carrying surface of the storage medium (4, 5);

a lens assembly housing (119) supporting said lens assembly in slidable telescopic relationship thereto;

wall means defining an annular chamber (148) between the ends of said housing (119), said wall means including a first axially extending wall and first radially extending wall integral with said lens assembly (106, 108, 110), and a second axially extending wall and second radially extending wall, opposite said first axially and radially extending walls, integral with said housing (119);

biasing means (123, 124) for providing a relatively fixed resilient biasing force on said lens assembly (106, 108, 110) relative to said housing (119) to urge said lens assembly away from the storage medium (4, 5) and air pressure regulating means (154) for regulating the air pressure in said annular chamber (148), thereby providing a variable biasing force on said lens assembly relative to

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said housing in a direction opposite that of said relatively fixed biasing force,

characterized in that

annular gaps (146, 146') are defined on either side of said annular chamber (148) between the outer surface of said lens assembly (106, 108, 110) and the inner surface of said housing (119), and that air is introduced under pressure into each said annular gap (146, 146') to produce an air bearing journal between said lens assembly and said housing, and

said air pressure is maintained in said annular chamber (148) at a pressure lower than the pressure introduced into said annular gaps (146, 146'), at least a portion of the air introduced to said gap on each axial side of said annular chamber being received by said annular chamber and exhausted therefrom through said regulating means (154) to regulate the exhaust air pressure of the air leaving said annular chamber.

5. The apparatus as claimed in Claim 4, including: mounting means maintaining said housing (119) in a fixed relationship relative to the information carrying surface of the storage medium; and means (123, 124) for supplying a source of positive air pressure to the space between said head and the information storage medium (4, 5) to produce said relatively fixed resilient biasing force.

6. The apparatus as claimed in Claim 4 wherein the axial lengths of the mating surfaces of the lens assembly (106, 108, 110) and the housing (119) relative to the widths of the corresponding gaps (146, 146') defined thereby on each axial side of said annular chamber (145) are such that the ratio of the axial length of each said annular gap to the width of the gap is maintained at a value greater than 500.

7. The apparatus as claimed in Claim 4, wherein each said gap (146, 146') leads in one axial direction to said annular chamber (145) and in the opposite axial direction to an opening at atmospheric pressure (150, 152).

8. The apparatus as claimed in Claim 4, wherein adjusting the air pressure setting of said air pressure regulating means (154) alters the resultant reactive forces acting on said lens assembly by the relatively fixed biasing force of said biasing means (123, 124) and said variable biasing force, thereby producing a net difference force acting to move said lens assembly (106, 108, 110) axially relative to said housing (119) to affect the focusing of said light beam on the storage medium (4, 5).

9. The apparatus as claimed in Claim 4, wherein said annular chamber (148) is located substantially centrally of said head (102) in the axial direction.

10. The apparatus as claimed in Claim 4, wherein said means for introducing air into each said annular gap (146, 146') is positioned to introduce the pressurized air at approximately the axial center of the respective gap.

11. The apparatus as claimed in Claim 9, wherein the axial lengths of said annular gaps are substantially equal.

12. The apparatus as claimed in Claim 4, wherein said wall means is formed by a first shoulder located between two axial parts of different diameters of said lens assembly (106, 108, 110) and a second shoulder located between two cooperating axial parts of different diameters of said housing (119), said annular chamber (148) being formed by the space between said first and second shoulders.

Patentansprüche

1. Ein Verfahren zum Abstützen eines in Informations-Aufzeichnungs- und/oder Abrufsystemen verwendbaren optischen Kopfes (102), der mit Abstand relativ zu einem sich bewegenden Informations-Aufzeichnungsmedium (4, 5) angeordnet ist, wobei der Kopf eine innerhalb eines Gehäuses (119) bewegbare Linsenanordnung (106, 108, 110) aufweist und im Verfahren eingeschlossen sind die Schritte: des Abstützens der Linsenanordnung teleskopartig verschiebbar innerhalb des Gehäuses, wobei eine ringförmige Kammer (148) zwischen den Enden des genannten Gehäuses (119) vorgesehen ist, eine axial verlaufende Wand und eine radial verlaufende Wand der ringförmigen Kammer einteilig mit der Linsenanordnung (106, 108, 110) sind und die gegenüberliegende, axial verlaufende Wand und gegenüberliegende, radial verlaufende Wand der ringförmigen Kammer (148) einteilig mit dem Gehäuse (119) sind; des Aufbringens einer relativ beständigen, elastischen Vorspannungskraft auf die Linsenanordnung (106, 108, 110) relativ zum Gehäuse, um die Linsenanordnung vom Aufzeichnungsmedium (4, 5) wegzudrängen; und des Regulierens des Luftdruckes in der ringförmigen Kammer (148), um eine veränderliche Vorspannungskraft auf die Linsenanordnung relativ zum Gehäuse in einer Richtung, die derjenigen der genannten relativ beständigen Vorspannungskraft entgegengesetzt ist, aufzubringen; dadurch gekennzeichnet, daß im genannten Abstützschritt enthalten sind das Einleiten von Luft unter Druck (135, 135') in ringförmige Spalte (146, 146') zwischen der Außenfläche der Linsenanordnung (106, 108, 110) und der Innenfläche des Gehäuses (119) an jeder Seite der ringförmigen Kammer (148), um ein Luft-Traglager zwischen den verschiebbaren Elementen zu erzeugen; und das Aufrechterhalten des Druckes in der ringförmigen Kammer (145) auf einem Druck, der niedriger als der in die genannten ringförmigen Spalte (146, 146') eingebrachte Druck ist, und daß wenigstens ein Teil der an jeder axialen Seite der ringförmigen Kammer (145) dem genannten Spalt (146, 146') zugeführten Luft von der ringförmigen Kammer aufgenommen und von dieser abgegeben wird, wobei der Abluftdruck der die ringförmige Kammer verlassenden Luft reguliert wird.

2. Das Verfahren nach Anspruch 1, einschließlich des Schrittes des Haltens des Gehäuses (119) in einem festen Verhältnis relativ zur informationstragenden Oberfläche des Aufzeichnungsmediums (4, 5), und in welchem eine Quelle positiven Luftdrucks (135, 135') unter Druck gesetzte Luft dem Raum zwischen dem Kopf (102) und dem

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Informations-Aufzeichnungsmedium (4, 5) zuliefert, um die genannte relativ beständige, elastische Vorspannungskraft zu erzeugen.

3. Das Verfahren nach Anspruch 1, in welchem das Verhältnis der Axiallänge jedes ringförmigen Spaltes zur Breite des Spaltes auf einem Wert größer als 500 gehalten wird.

4. Vorrichtung zum Abstützen eines in Informations-Aufzeichnungs- und/oder Abrufsystemen verwendbaren optischen Kopfes (102), der mit Abstand relativ zu einem sich bewegenden Informations-Aufzeichnungsmedium (4, 5) angeordnet ist, mit:

einer Linsenanordnung (106, 108, 110), durch die hindurch ein Lichtstrahl auf die informationstragende Oberfläche des Aufzeichnungsmediums (4, 5) fokussiert werden kann;

einem Linsenanordnungsgehäuse (119), das die genannte Linsenanordnung in verschiebbarem, teleskopartigem Verhältnis zum Gehäuse abstützt;

einer Wandeinrichtung, die eine ringförmige Kammer (148) zwischen den Enden des genannten Gehäuses (119) abgrenzt, wobei die genannte Wandeinrichtung eine erste, axial verlaufende Wand und erste, radial verlaufende Wand, die einteilig mit der genannten Linsenanordnung (106, 108, 110) sind, und eine zweite, axial verlaufende Wand und zweite radial verlaufende Wand, die den genannten ersten, axial und radial verlaufenden Wänden gegenüberliegen und einteilig mit dem genannten Gehäuse (119) sind, umfaßt;

einer Vorspannungseinrichtung (123, 124) zum Aufbringen einer relativ beständigen, elastischen Vorspannungskraft auf die genannte Linsenanordnung (106, 108, 110) relativ zum genannten Gehäuse (119), um die genannte Linsenanordnung vom Aufzeichnungsmedium (4, 5) wegzudrängen, und einer Luftdruck-Regulierereinrichtung (154) zum Regulieren des Luftdruckes in der genannten ringförmigen Kammer (148), wodurch eine veränderliche Vorspannungskraft auf die genannte Linsenanordnung relativ zum genannten Gehäuse in einer Richtung aufgebracht wird, die derjenigen der genannten relativ beständigen Vorspannungskraft entgegengesetzt ist;

dadurch gekennzeichnet, daß

ringförmige Spalte (146, 146') an jeder Seite der genannten ringförmigen Kammer (148) zwischen der Außenfläche der genannten Linsenanordnung (106, 108, 110) und der Innenfläche des genannten Gehäuses (119) abgegrenzt wind, und daß Luft unter Druck in jeden genannten ringförmigen Spalt (146, 146') eingeleitet wird, um ein Luft-Traglager zwischen der genannten Linsenanordnung und dem genannten Gehäuse zu erzeugen, und

der genannten Luftdruck in der genannten ringförmigen Kammer (148) auf einem Druck gehalten wird, der niedriger als der in die genannten ringförmigen Spalte (146, 146') eingebrachte Druck ist, wobei wenigstens ein Teil der an jeder axialen Seite der genannten ringförmigen Kammer dem genannten Spalt zugeführten Luft von der genannten ringförmigen Kammer aufgenommen und von dieser durch die genannte Regulierereinrichtung (154) abgegeben wird, um den Abluftdruck der die genannte ringförmige Kammer verlassenden Luft zu regulieren.

5. Die Vorrichtung nach Anspruch 4, mit einer Halterungseinrichtung, die das genannte Gehäuse (119) in einem festen Verhältnis relativ zur informationstragenden Oberfläche des Aufzeichnungsmediums hält, und einer Einrichtung (123, 124) zur Zufuhr einer Quelle positiven Luftdrucks zum Raum zwischen dem genannten Kopf und dem Informations-Aufzeichnungsmedium (4, 5), um die genannte relativ beständige elastische Vorspannungskraft zu erzeugen.

6. Die Vorrichtung nach Anspruch 4, in welcher die Axiallängen der zueinander passenden Flächen der Linsenanordnung (106, 108, 110) und des Gehäuses (119) relativ zu den Breiten der dadurch abgegrenzten entsprechenden Spalte (146, 146') an jeder axialen Seite der genannten ringförmigen Kammer (145) derart sind, daß das Verhältnis der Axiallänge jedes genannten ringförmigen Spaltes zur Breite des Spaltes auf einem Wert größer als 500 gehalten ist.

7. Die Vorrichtung nach Anspruch 4, in welcher jeder genannte Spalt (146, 146') in einer Axialrichtung zur genannten ringförmigen Kammer (145) und in der entgegengesetzten Axialrichtung zu einer öffnung mit atmosphärischem Druck (150, 152) führt.

8. Die Vorrichtung nach Anspruch 4, in welcher das Verstellen der Luftdruckeinstellung der genannten Luftdruck-Regulierereinrichtung (154) die durch die relativ beständige Vorspannungskraft der genannten Vorspannungseinrichtung (123, 124) und die genannte veränderliche Vorspannungskraft auf die genannte Linsenanordnung wirkenden resultierenden Reaktionskräfte verändert, wodurch eine Nutz-Differenzkraft erzeugt wird, die dazu dient, die genannte Linsenanordnung (106, 108, 110) relativ zum genannten Gehäuse (119) axial zu bewegen, um das Fokussieren des genannten Lichtstrahls auf dem Aufzeichnungsmedium (4, 5) zu beeinflussen.

9. Die Vorrichtung nach Anspruch 4, in welcher die genannte ringförmige Kammer (148) in der Axialrichtung im wesentlichen mittig zum genannten Kopf (102) angeordnet ist.

10. Die Vorrichtung nach Anspruch 4, in welcher die genannte Einrichtung zum Einleiten von Luft in jeden genannten ringförmigen Spalt (146, 146') angeordnet ist, die unter Druck gesetzte Luft in etwa in der Axialmitte des jeweiligen Spaltes einzuleiten.

11. Die Vorrichtung nach Anspruch 9, in welcher die Axiallängen der genannten ringförmigen Spalte im wesentlichen gleich sind.

12. Die Vorrichtung nach Anspruch 4, in welcher die genannte Wandeinrichtung von einer ersten, zwischen zwei Axialabschnitten der genannten Linsenanordnung (106, 108, 110) mit unterschiedlichen Durchmessern angeordneten Schulter und einer zweiten, zwischen zwei zusammenwirkenden Axialabschnitten des genannten Gehäuses (119) mit unterschiedlichen Durchmes-

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sern angeordneten Schulter gebildet ist, wobei die genannte ringförmige Kammer (148) durch den Raum zwischen der genannten ersten und zweiten Schulter gebildet ist.

Revendications

1. Procédé pour supporter une tête optique (102) pour une utilisation dans des systèmes d'enregistrement et/ou de reproduction d'information en relation espacée avec un support mobile d'enregistrement d'information (4, 5), la tête ayant un ensemble de lentille (106, 108, 110), mobile à l'intérieur d'un logement (119), ledit procédé comprenant les étapes de: supporter l'ensemble de lentille coulissable par emboîtement à l'intérieur du logement, une chambre annulaire (148) étant prévue entre les extrémités dudit logement (119), une paroi s'étendant axialement et une paroi s'étendant radialement de la chambre annulaire étant solidaires de l'ensemble de lentille (106, 108, 110), et la paroi s'étendant axialement opposée et la paroi s'étendant radialement opposée de la chambre annulaire (148) étant solidaires du logement (119);

fournir une force de sollicitation élastique relativement fixée sur l'ensemble de lentille (106, 108, 110) par rapport au logement pour éloigner l'ensemble de lentille du support d'enregistrement (4, 5); et

réguler la pression d'air dans la chambre annulaire (148) pour fournir une force de sollicitation variable sur l'ensemble de lentille par rapport au logement dans une direction opposée à celle de ladite force de sollicitation relativement fixée;

caractérisé en ce que:

ladite étape de support comprend l'introduction d'air sous pression (135, 135') dans des interstices annulaires (146, 146') entre la surface externe de l'ensemble de lentille (106, 108, 110) et la surface interne du logement (119) de chaque côté de la chambre annulaire (148) pour produire un tourillon à palier à air entre les éléments emboîtés; et

maintenir la pression dans la chambre annulaire (145) à une pression inférieure à la pression introduite dans lesdites interstices annulaires (146, 146') et en ce qu'au moins une partie de l'air introduit dans ledit interstice (146, 146') de chaque côté axial de la chambre annulaire (145) est reçue par la chambre annulaire et évacuée de celle-ci; la pression d'air évacué de l'air quittant la chambre annulaire étant régulée.

2. Procédé selon la revendication 1, comprenant l'étape de maintenir le logement (119) dans une relation fixée par rapport à la surface portant l'information du support d'enregistrement (4, 5), et dans lequel une source de pression d'air positive (135, 135') fournit de l'air sous pression à l'espace entre la tête (102) et le support d'enregistrement d'information (4, 5) pour produire ladite force de sollicitation élastique relativement fixée.

3. Procédé selon la revendication 1, dans lequel le rapport de la longueur axiale de chaque interstice annulaire à la largeur de l'interstice est maintenu à une valeur supérieure à 500.

4. Appareil pour supporter une tête optique (102) pour une utilisation dans des systèmes d'enregistrement et/ou de reproduction d'information en relation espacée avec un support d'enregistrement d'information mobile (4, 5) comprenant:

un ensemble de lentille (106, 108, 110) à travers lequel un faisceau de lumière peut être focalisé sur la surface portant l'information du support d'enregistrement (4, 5);

un logement d'ensemble de lentille (119) supportant ledit ensemble de lentille en relation coulissable par emboîtement avec celui-ci;

des moyens de paroi définissant une chambre annulaire (148) entre les extrémités dudit logement (119), lesdits moyens de paroi comprenant une première paroi s'étendant axialement et une première paroi s'étendant radialement solidaires dudit ensemble de lentille (106, 108, 110), et une seconde paroi s'étendant axialement et une seconde paroi s'étendant radialement, opposées auxdites premières parois s'étendant axialement et s'étendant radialement, solidaires dudit logement (119);

des moyens de sollicitation (123, 124) pour fournir une force de sollicitation élastique relativement fixée sur ledit ensemble de lentille (106, 108, 110) par rapport audit logement (119) pour éloigner ledit ensemble de lentille du support d'enregistrement (4, 5) et un moyen de régulation de la pression d'air (154) pour réguler la pression d'air dans ladite chambre annulaire (148), fournissant ainsi une force de sollicitation variable sur ledit ensemble de lentille par rapport audit logement dans une direction opposée à celle de ladite force de sollicitation relativement fixée, caractérisé en ce que des interstices annulaire (146, 146') sont définis de chaque côté de ladite chambre annulaire (148) entre la surface externe dudit ensemble de lentille (106, 108, 110) et la surface interne dudit logement (119), et en ce que de l'air est introduit sous pression dans chaque interstice annulaire (146, 146') pour produire un tourillon à palier à air entre ledit ensemble de lentille et ledit logement; et

ladite pression d'air est maintenue dans ladite chambre annulaire (148) à une pression inférieure à la pression introduite dans lesdits interstices annulaires (146, 146'), au moins une partie de l'air introduit dans ledit interstice de chaque côté axiale de ladite chambre annulaire étant reçue par ladite chambre annulaire et évacuée de celle-ci par ledit moyen régulateur (154) pour réguler la pression d'air évacué de l'air quittant ladite chambre annulaire.

5. Appareil selon la revendication 4, comprenant:

un moyen de montage maintenant ledit logement (119) dans une relation fixée par rapport à la surface portant l'information du support d'enregistrement; et

des moyens (123, 124) pour fournir une source de pression d'air positive à l'espace entre ladite tête et ledit support d'enregistrement d'information (4, 5) pour produire ladite force de sollicitation élastique relativement fixée.

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6. Appareil selon la revendication 4, dans lequel les longueurs axiales des surfaces de raccordement de l'ensemble de lentille (106, 108, 110) et du logement (119) par rapport aux largeurs des interstices correspondants (146, 146') définis par ceux-ci de chaque côté axial de ladite chambre annulaire (145) sont telles que le rapport de la longueur axiale de chaque interstice annulaire à la largeur de l'interstice est maintenu à une valeur supérieure à 500.

7. Appareil selon la revendication 4, dans lequel chacun desdits interstices (146, 146') conduit dans une direction axiale à ladite chambre annulaire (145) et dans la direction axiale opposée à une ouverture à la pression atmosphérique (150, 152).

8. Appareil selon la revendication 4, dans lequel l'ajustement du réglage de pression d'air dudit moyen régulateur de pression d'air (154) modifie les forces réactives résultantes sur ledit ensemble de lentille par la force de sollicitation relativement fixée desdits moyens de sollicitation (123, 124) et ladite force de sollicitation variable, produisant ainsi une force de différence nette agissant pour déplacer ledit ensemble de lentille (106, 108, 110) axialement par rapport audit logement (119) pour modifier la focalisation dudit faisceau lumineux sur le support d'enregistrement (4, 5).

9. Appareil selon la revendication 4, dans lequel ladite chambre annulaire (148) est située sensiblement au centre de ladite tête (102) dans la direction axiale.

10. Appareil selon la revendication 4, dans lequel ledit moyen introduire de l'air dans chacun desdits interstices annulaires (146, 146') est positionné pour introduire l'air sous pression approximativement au niveau du centre axial de interstices respectif.

11. Appareil selon la revendication 9, dans lequel les longueurs axiales desdits interstices annulaires sont sensiblement égales.

12. Appareil selon la revendication 4, dans lequel ledit moyen de paroi est formé par un premier épaulement situé entre deux parties axiales de diamètres différents dudit ensemble de lentille (106, 108, 110) et un second épaulement situé entre deux parties axiales coopérantes de diamètres différents dudit logement (119), ladite chambre annulaire (148) étant formée par l'espace entre lesdits premiers et seconds épaulements.

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