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OPTICAL PICKUP DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to improvements of an optical pickup device for recording and reproducing information on an optical disc or an optical magnetic disc or the likes, and particularly relates to an optical pickup device capable of maintaining securely a posture of an objective lens of the optical pickup even when a shock or an acceleration is added thereto from an outside.

Description of the Related Art:

It is well known that in an optical disc such as a compact disc (CD), a video disc (VD), a CD-ROM (Read Only Memory) or an optical magnetic disc, an information signal such as sound information, picture information or letter information is converted into a series of pits, and the series of pits is spirally or concentrically recorded on the optical disc.

There are employed many kinds of structures in the optical pickup device to focus-control an objective lens along an optical axis thereof and to track-control it in a radial direction of a recording or recorded track so as to irradiate a light beam spot precisely on the recording or recorded track of the optical disc. In Japanese Laid-open Patent Publication 62-40627/1987, there is disclosed an

optical pickup device where the light beam spot from objective lens never fails to trace on the recorded track even when a shock or an acceleration is added in a tracking direction of the optical disc.

Fig. 1 is an exploded perspective view of an optical pickup in the prior art;

Fig. 2 (A) is a plan view of Fig. 1; and

Fig. 2 (B) is a side sectional view of Fig. 2 (A).

Optical pickup device 100 shown in Fig. 1 and Figs. 2 (A) to 2 (B) is disclosed in the Japanese Laid-open Patent Publication 62-40627/1987, and the description thereof is simply given here.

In the optical pickup device 100 shown in Fig. 1, a base substrate 101 is made in a plate shape. On a center of the base substrate 101, an opening 101a is extendedly provided along a front and rear direction of the base substrate 101. Further, a platform 101b is protrudingly provided upward on the base substrate 101 between an distal end of the opening 101a and a distal end of the base substrate 101. A pair of inner yorks 101c, 101c facing each other, is protrudingly provided upward adjacent to side walls of the opening 101a interposed between the pair of inner yorks 101c, 101c, and a pair of outer yorks 101d, 101d is provided outside the pair of inner yorks 101c, 101c, each facing the inner york 101c leaving a predetermined interval. A pair of magnets 102, 102 is fixed to the inner walls of the pair of outer yorks 101d, 101d, each facing the inner york 101c.

A support arm 103 for swingably supporting a movable

member 106 mentioned hereinafter is fixed on the platform 101b by using bolts 104, 104. The support arm 103 is integrally made of an elastic resin capable of elastically deforming.

The support arm 103 is comprised of a base 103a, a pair of elastic members 103b, 103b thinly made of an elastic resin connected to upper and lower ends of the base 103a, which pair of elastic members 103b, 103b is allowed to be swingably displaced in a focusing direction, i.e., upward and downward, shown with a double-headed arrow Y, a pair of parallel links 103c, 103c respectively provided on distal ends of the pair of the elastic members 103b, 103b, and an H-shaped hinge 103d having a thin member 103d1 provided on ends of the pair of parallel links 103c, 103c, which thin member 103d1 allows the movable member 106 to swingably displace in a tracking direction shown with a double-headed arrows X.

Here, a center line 103d2 passing through a center point of the H-shaped hinge 103d is designed to coincide with a center of gravity G of the movable member 106 shown in Fig. 2(A).

The movable member 106 for mounting an objective lens 105 is formed to have a height as large as that of the H-shaped hinge 103d. The movable member 106 is integrally made of a base member 106a and a pair of arms 106d, 106d extendedly provided backward at an end of the base member 106a. And, there are defined a lens hole 106b on a top surface of the base member 106a for mounting an objective

lens 105, a balance hole 106c defined under a bottom of base member 106a for providing a ring balancer 107, a pair of hinge grooves 106e, 106e for being engaged with the H-shaped hinge 103d of the support arm 103, and a pair of balance holes 106f, 106f defined at one ends of the pair of arms 106d, 106d for supporting a pole balancer 108 interposed therebetween.

Further, driving coils 109, 109 are respectively fixed on both sides of the movable member 106. Each of driving coils 109, 109 is composed of a focusing coil 109a and a tracking coil 109b provided on an outer side of the focusing coil 109a. Each of the focusing coils 109a, 109a is loosely fitted with the inner york 101c as shown in Fig. 2 (A) without contact therewith.

As shown in Figs. 2 (A) and 2 (B), upon focusing control operation of the optical pickup device 100 in the prior art, a focusing control signal is applied to the pair of focusing coils 109a, 109a from a focusing control signal supply section (not shown). Thus, the pair of parallel link 103c, 103c of the support arm 103 is displaced in the focusing direction shown with the arrow Y (upward or downward) caused by magnetic fields formed between the magnets 102, 102 and the inner yorks 101c, 101c. Thereby, a light beam spot from the objective lens 105 is controlled so as to be focused on a recording track of an optical disc D along the optical axis of the objective lens 105 by elastic deformation of the elastic members 103b, 103b of the pair of parallel links 103c, 103c.

Further, upon tracking control operation, a tracking control signal is applied to the pair of tracking coils 109b, 109b from a tracking control signal supply section (not shown). Thus, the pair of parallel rink 103c, 103c of the support arm 103 is displaced in the tracking direction X caused by magnetic fields formed between the magnets 102, 102 and the inner yorks 101c, 101c. Thereby, the light beam spot from the objective lens 105 is controlled so as to be displaced in the radial direction of the optical disc D by an elastic deformation of the H-shaped hinge 103d of the support arm 103, so that the light beam spot from the objective lens 105 is controlled to trace on a desired recorded track in the tracking direction X.

In the optical pickup device 100 of the prior art, the center point of the H-shaped hinge 103d is designed so as to coincide with the line passing through the center of gravity G of the movable member 106 so that the objective lens 105 is not easily deviated from the recorded track by the shock or the acceleration added from the outside thereof.

However, the optical pickup device 100 of the prior art has a drawback that it is difficult to reduce the dimensions thereof.

Specifically, as shown in Fig. 2 (B), it is necessary to provide a mirror M being inclined at an angle of 45° to the optical axis of the objective lens 105 under the ring balancer 107 of the movable member 106. The mirror M reflects a light beam emitted from a semiconductor laser L in the direction of the optical disc D through the objective

lens 105, and the light beam reflected by the optical disc D is directed to a photo-detector F reflected at a right angle by the mirror M through the objective lens 105.

Accordingly, when the ring balancer 107 is provided under the objective lens 105, it is impossible to locate the mirror M adjacent to the objective lens 105, resulting in difficulty of reducing the dimension of the optical pickup device 100 in a height direction thereof.

When the ring balancer 107 is removed from the above construction of the optical pickup device 100 to reduce the dimension thereof, the optical pickup device 100 loses its balance, resulting in a rolling of the optical pickup device due to the shock or the acceleration from the outside.

This optical pickup device without the ring balancer 107 can not be applied to a portable type or a car use type.

SUMMARY OF THE INVENTION

Accordingly, a general object of the present invention is to provide an optical pickup device in which the above disadvantages have been eliminated.

A specific object of the present invention is to provide an optical pickup device capable of maintaining securely a posture of an objective lens of the optical pickup even when a shock or an acceleration is added thereto from an outside.

Another specific object of the present invention is to provide an optical pickup device capable of reducing a thickness of the optical pickup device by installing a

reflecting mirror adjacent to the objective lens in the pickup device.

Another more specific object of the present invention is to provide an optical pickup device for recording/ reproducing a signal on/from a track of a recording disc by using a light beam spot comprising: a base substrate; a movable section for mounting an objective lens for focusing the light beam spot on the tack of the optical disc; a suspension base fixed on the base substrate; and an upper pair and a lower pair of suspension wires for connecting the movable section to the suspension base in such a manner that the movable section is allowed to be displaced in a focusing direction of the objective lens, wherein the upper pair and lower pair of suspension wires are disposed unsymmetric with respect to a center of gravity of the movable section in a height direction of the movable section, and the suspension base further comprises a spring section for connecting one ends of the upper pair and the lower pair of suspension wires, and the spring section comprises a first spring part located upper than the center of gravity of the movable section and a second spring part located lower than the center of gravity thereof in the height direction of the movable section, and a first spring constant of the first spring part is made to be different from a second spring constant of the second spring part to prevent the movable section from rolling caused by an external force.

Other objects and further features of the present

invention will be apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective view of an optical pickup in the prior art;

Fig. 2 (A) is a plan view of Fig. 1;

Fig. 2 (B) is a side sectional view of Fig. 2 (A);

Fig. 3 is an exploded perspective view for explaining a construction of a first embodiment of an optical pickup device according to the present invention;

Fig. 4 (A) is a plan view of the first embodiment of the optical pickup device;

Fig. 4 (B) is a side view of Fig. 4 (A);

Fig. 4 (C) is a back view of Fig. 4 (A);

Fig. 5 is a perspective view of the first embodiment of the optical pickup device in the present invention;

Fig. 6(A) is a perspective view of a suspension base shown in Fig. 3;

Fig. 6 (B) is a plan view of Fig. 6 (A);

Fig. 6 (C) is a back view of Fig. 6 (A);

Fig. 7 (A) is a schematic side view for explaining an operation of a suspension wire and the suspension base of the first embodiment of the optical pickup device;

Fig. 7 (B) is a schematic back view of Fig. 7 (A);

Fig. 7 (C) is a schematic view for explaining the operation of the suspension wire and the suspension base of

the first embodiment of the optical pickup device;

Fig. 8 (A) is a plan view of a first embodiment of the optical pickup device;

Fig. 8 (B) is a side view of Fig. 8 (A);

Fig. 8 (C) is a back view of Fig. 8 (A);

Fig. 9(A) is a perspective view of a suspension base shown in Figs. 8 (A) to 8(C);

Fig. 9 (B) is a plan view of Fig. 9 (A);

Fig. 9 (C) is a back view of Fig. 9 (A);

Fig. 10 (A) is a schematic side view for explaining an operation of a suspension wire and the suspension base of the second embodiment of the optical pickup device;

Fig. 10 (B) is a schematic back view of Fig. 10 (A); and

Fig. 10 (C) is a schematic view for explaining the Fig. 10 (A).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Description will be given to first and second embodiments according to the present invention accompanying drawings of Figs 3 to 10 (C).

Fig. 3 is an exploded perspective view for explaining a construction of a first embodiment of an optical pickup device according to the present invention;

Fig. 4 (A) is a plan view of the first embodiment of the optical pickup device;

Fig. 4 (B) is a side view of Fig. 4 (A);

Fig. 4 (C) is a back view of Fig. 4 (A);

Fig. 5 is a perspective view of the first embodiment of the optical pickup device in the present invention;

Fig. 6(A) is a perspective view of a suspension base shown in Fig. 3;

Fig. 6 (B) is a plan view of Fig. 6 (A);

Fig. 6 (C) is a back view of Fig. 6 (A);

Fig. 7 (A) is a schematic side view for explaining the operation of suspension wires and the suspension base of the first embodiment of the optical pickup device;

Fig. 7 (B) is a schematic back view of Fig. 7 (A); and

Fig. 7 (C) is a schematic view for explaining the operation of the suspension wires and the suspension base of the first embodiment of the optical pickup device.

Referring to Fig. 3, in an optical pickup device 1A of a first embodiment of the present invention, a base substrate 2 is integrally formed as a rigid frame structure by using a soft magnetic material. On a center of the base substrate 2, an opening 2a is extendedly provided along front and rear direction. This opening 2a is used as an optical path of a light beam reflected by a mirror M through an objective lens 5 mentioned hereinafter.

Further, a bridge board 2b is protrudingly provided upward over the opening 2a between a left wall and a right wall of the opening 2a at a front end thereof to allow the mirror M to be located under the bridge board 2b.

A pair of support bases 2c, 2c is protrudingly provided upward facing each other on a top surface of the base substrate 2 between an end of the opening 2a and a rear end

of the base substrate 2. A pair of notches 2c1, 2c1 is provided on top surfaces of the pair of the support bases 2c, 2c to allow a suspension base 11A mentioned hereinafter to be mounted or supported in the notches 2c1, 2c1.

Further, a pair of inner yorks 2d, 2d facing each other, is protrudingly provided upward adjacent to the left and right walls of the opening 2a, and a pair of outer yorks 2e, 2e is provided on the base substrate 2 outside the inner yorks 2d, 2d so as to face the outer yorks 2e, 2e with a predetermined interval. A pair of magnets 3, 3 is fixed to walls of the inner yorks 2d, 2d so as to be interposed between the inner york 2d and the outer york 2e.

Further, a pair of attachment bases 2f, 2f facing each other protrudes upward from side walls of the base substrate 2, each interposed between the bridge board 2b and the outer york 2e. A pair of projections 2f1, 2f1 protrudes from tops of the pair of the attachment bases 2f, 2f in an outside direction of the base substrate 2. The pair of projections 2f1, 2f1 is supported by a pair of notches Iv, (Iv) each provided on a top of a transfer plate I as clearly shown in Fig. 5.

Next the description is given of a movable section 4 for mounting the objective lens 5.

The movable section 4 comprises the objective lens 5, a lens holder 6 for mounting the objective lens 5, a pair of driving coils 8, 8 and two pairs of suspension wires 9, i.e., a pair of upper suspension wires (9a, 9a) provided on a top surface of the lens holder 6 and a pair of lower

suspension wires (9b, 9b) provided on a bottom of the lens holder 6 for resiliently supporting the lens holder 6, and a pair of printed circuit boards 10 provided on the top surface and the bottom of the lens holder (one on the bottom is not shown) for connecting ends of driving coils 8, 8 and fixing one ends of the upper and lower suspension wires (9a, 9a), (9b, 9b). Another ends of the upper and lower suspension wires (9a, 9a), (9b, 9b) are fixed on a suspension base 11A. The two pairs of wires 9 are provided to allow the movable section 4 to be displaced in the focusing direction as mentioned hereinafter.

The lens holder 6 is generally comprised of a front section 6a, a rear section 6c and an intermediate section 6b forming a pair of concaves interposed between the front and rear sections 6a, 6c for allowing the pair of driving coils 8, 8 to be provided therein. In the front section 6a, there are coaxially provided a lens hole 6a1 on the top surface thereof for mounting the objective lens 5 and a through hole 6a2 under the lens hole 6a1 for forming an optical path of a light beam reflected by the mirror M through the objective lens 5.

Further, the driving coils 8, 8 are respectively fixed on both sides of the movable section 4. Each of the driving coils 8, 8 is composed of a focusing coil 8a and a tracking coil 8b provided on an outer side of the focusing coil 8a. Each of the focusing coils 8a, 8a is loosely fitted with the inner york 2d without a contact therewith as shown in Fig. 4(A).

On a top surface of the rear section 6c of the lens holder 6, a balancer 7 for balancing itself with the objective lens 5 is provided at a center thereof. On the top surface and the bottom of the rear section 6c, two pairs of grooves 6c1, 6c1 (one on the bottom surface is not shown) are respectively formed to provide the upper and lower suspension wires (9a, 9a), (9b, 9b) therethrough in a radial manner adjacent to the balancer 7 interposed between the pair of grooves 6c1, 6c1.

In the pair of concaves of the intermediate section 6b, there is fixedly provided the pair of driving coils 8, 8 facing each other as mentioned in the foregoing.

On top and bottom surfaces of the intermediate section 6b, there are provided the printed circuit boards 10 for connecting ends of driving coils 8 and fixing the ends of the four suspension wires 9 as mentioned in the foregoing.

Next, a description is given of a suspension base 11A for swingably supporting the movable section 4 through the suspension wires 9, which is one of the main features of the first embodiment of the present invention.

The suspension base 11A is integrally formed with a resin capable of deforming elastically.

As shown in Figs. 6 (A) to 6 (C) being enlarged, a rectangular base 11a is formed at a center of the suspension base 11A. The rectangular base 11a has a pair of wing plates 11a1, 11a1 at sides thereof, and is provided with a pair of projections 11b (11b) protruding in front and rear directions shown with arrows from front and rear ends

thereof so that the suspension base 11A is allowed to mount on the base substrate 2 by causing the pair of projections 11b (11b) to engage with the pair of notches 2c1, 2c1 of the support bases 2c, 2c provided on the base substrate 2. On the top surfaces and the bottoms of the pair of wing plates 11a1, 11a1, two pairs of grooves 11c, 11c (one pair on the bottom is not shown) are respectively formed to insert the upper and lower suspension wires (9a, 9a), (9b, 9b) therethrough in a radial manner along extended lines of the two pairs of grooves 6c1, 6c1 of the lens holder 6.

Further, the suspension base 11A has a spring section S including a pair of first plate springs 11d, 11d and a pair of second plate springs 11e, 11e.

The pair of first plate springs 11d, 11d having a thin thickness is elastically formed in a track direction shown with arrow X at left and right sides of the rectangular base 11a. A height H1 of each of the first plate springs 11d, 11d is formed to be small and symmetrical with respect to a plane of gravity Gm defined as a plane including the center of gravity G of the movable section 4 and parallel to the top surface of the lens holder 6.

The pair of second plate springs 11e, 11e is connected to one ends of the pair of first plate springs 11d, 11d so that a height H2 of each of the second plate springs 11e, 11e is larger than the height H1 of the first plate springs 11d, 11d. On top and bottom surfaces of the pair of second plate springs 11e, 11e, there are provided two pairs of guide grooves, i.e., a pair of upper guide grooves (11e1,

11e1) and a pair of lower guide grooves (11e2, 11e2), in the radius manner along extended lines of the two pairs of grooves 6c1, 6c1 of the lens holder 6 so that the two pairs of suspension wires 9 are positioned at the same height. Further, there are provided a pair of upper notches (11e11, 11e11), and a pair of lower notches (11e21, 11e21) on left and right sides of the pair of second plate springs 11e, 11e to be as high as those of the two pairs of guide grooves (11e1, 11e1), (11e2, 11e2).

And, another ends of the pair of upper suspension wires (9a, 9a) are fixed in the pair of guide grooves (11e1, 11e1) and distal ends thereof are pinched by the pair of upper notches 11e11, 11e11, and another ends of the pair of lower suspension wires (9b, 9b) are fixed in the pair of guide grooves (11e2, 11e2) and distal ends thereof are pinched by the pair of lower notches 11e21, 11e21.

As shown in Fig. 6 (C), a distance K1 defined from the bottoms of both the upper guide groove 11e1 and the upper notch 11e11 to the plane of gravity Gm is made shorter than a distance K2 defined from the bottoms of both the lower guide groove 11e2 and the lower notch 11e21 to the plane of gravity Gm. Thus, the distance K1 and the distance K2 are made unsymmetrical with respect to the plane of gravity Gm. As a result, the upper suspension wires 9a, 9a and the lower suspension wires 9b, 9b are disposed unsymmetrical with respect to the plane of gravity Gm.

In the first embodiment, if the distance K2 is made as small as the distance K1 so that both the distance K1 and

the distance K2 are symmetrical to the plane of gravity Gm, a total distance K = K1 + K2 becomes much smaller. This small total distance K causes not only the suspension wires 9 to support the movable section 4 unstably, but also a degradation of dimensional precision of the optical pickup device 1A.

Accordingly, in the first embodiment, the total distance K is large enough so that the suspension wires 9 support the movable section 4 stably by making the distance k2 larger than the distance K1, i.e., by making the distance K1 and the distance K2 unsymmetrical to the plane of gravity Gm, resulting in a stable support of the movable section 4 by the suspension wires 9.

Here, the description is given of the suspension wires 9.

Referring to Fig. 3 again, as mentioned in the foregoing, one ends of the four suspension wires 9 are fixed on the printed circuit boards 10 of the lens holder 6, and another ends of the four suspension wires 9 are fixed on the guide grooves (11e1, 11e1), (11e2, 11e2) with the wires 9 being extended through the grooves 6c1, 6c1 of the lens holder 6 and the guide grooves 11c, 11c of the wing plates 11a1, 11a1 of the rectangular base 11a.

Accordingly, two extended lines of the pair of upper suspension wires (9a, 9a) intersect at a first virtual point O1 to each other on the upper printed circuit board 10 and two extended lines of the pair of lower suspension wires (9b, 9b) intersect at a second virtual point O2 (not shown)

to each other on the lower printed circuit board 10 as well. A line passing through the first and second virtual points O1, O2 is defined as a virtual center line O. And the center of gravity G of the movable section 4 shown in Fig.4 (B) and Figs. 7 (A) to 7 (C), is made to be approximately situated on this virtual center line O.

The suspension base 11A is mounted on the base substrate 2 by causing the projections 11b (11b) of the suspension base 11A to engage with the notches 2c1, 2c1 of the support base 2c. Then, the suspension base 11A and the base substrate 2 are integrally supported at the surface of the suspension base 11A and the bottom of the base substrate 2 by being pressed and interposed between spring arms 12a, 12b of a support spring 12. Then, the objective lens of the movable section 4 is covered by a cover 13, resulting in the optical pickup device 1A as shown in Fig. 5.

Next, the description is given of a focusing operation and a tracking operation of the optical pickup device 1A of the first embodiment referring to Figs. 4 (A) to 4(C).

First, when a focus control signal is inputted to the pair of focusing coils 8a, 8a, the pair of focusing coils 8a, 8a receives a magnetic force in a focus direction shown with arrow Y caused by a pair of magnetic fields between the pair of yorks (2d, 2d), and the pair of magnets 3, 3. Thus, the movable section 4 supported by the four suspension wires 9 is swingably moved in the upper or lower directions. Thereby, the objective lens 5 mounted on the movable section 4 is focus-controlled along its optical axis, and a light

spot from the objective lens 5 is focused on a recorded track of the optical disc D.

Further, when a track control signal is inputted to the pair of tracking coils 8b, 8b, the pair of tracking coils 8b, 8b receives a magnetic force in a track direction shown with arrow X caused by a pair of magnetic fields between the pair of yorks (2d, 2d), and the pair of magnets 3, 3. Thus, the movable section 4 supported by the four suspension wires 9 is swingably moved in the left or right direction at the virtual line O. Thereby, the objective lens 5 mounted on the movable section 4 is track-controlled along the radius direction of the tracks, and the light spot from the objective lens 5 can be traced on any one of the recorded tracks of the optical disc D.

Next, a description is given of operations of the suspension wires 9 and the suspension base 11A referring to Figs. 7 (A) to 7 (C).

As shown in Figs. 7 (A) and 7 (B), the objective lens 5 is provided on the front section 6a of the lens holder 6, and a part of the lens holder 6 under the front section 6a is cut away to allow the mirror M to be provided under the objective lens 5. On the other hand, there is provided the balancer 7 on an upper surface of the rear section 6c of the lens holder 6. And, the center of gravity G of the movable section 4 provided with the objective lens 5 and the balancer 7 is determined to be located slightly below the upper surface of the lens holder 6 along the virtual line O. As a result, the center of the gravity G thereof is

determined to be located at a higher position than a positional center C of the movable section 4 in a height direction thereof.

Further, the movable section 4 can be elastically moved against the base substrate 2 by the two pairs of suspension wires 9 (9a, 9a), (9b, 9b) of which one ends are connected to the top and bottom surfaces of the movable section 4 and the other ends are connected to the top and bottom surfaces of the suspension base 11A.

As mentioned in the foregoing, the distance K between the upper suspension wires (9a, 9a) and the lower suspension wires (9b, 9b) are made large enough to support the movable section 4 securely, however, the center of gravity G of the movable section 4 is located above the positional center C of the movable member 4, and the positional center C thereof approximately coincides with a center of an interval between the upper and lower suspension wires (9a, 9a), (9b, 9b) in the upper and lower directions. In other words, the the upper and lower suspension wires (9a, 9a), (9b, 9b) are provided to be unsymmetrical to the center of gravity G in the height direction.

Thus, it will be understood that this state is unstable against a shock and an acceleration added from an outside, resulting in a rolling movement of the movable section 4 in a direction shown with a double-headed arrow R with causing the positional center C to be a center of rolling because the center of gravity G of the movable section 4 is located above the positional center C thereof.

Accordingly, in the first embodiment as shown in Figs. 7(B) and 7(C), in order to compensate the drawback of the unsymmetrical disposition of the suspension wires 9 to the plane of gravity Gm of the movable section 4, the plate spring section S is divided into two parts, a first spring part S1 located above the plane of gravity Gm and a second spring part S2 located below the plane of gravity Gm. Specifically, the first spring part S1 is composed of a part of the first plate springs (11d, 11d) which is located above the plane of gravity Gm and the suspension wires 9a, 9b, and the second spring part S2 is composed a part of the first plate springs (11d, 11d) which is located below the plane of gravity Gm and the second plate springs (11e, 11e) located below the plane of gravity Gm and the suspension wires 9b, 9b. In the present invention, the first spring part S1 has a first spring constant S1c different from a second spring constant S2c of the second spring part S2, for instance, by changing the thicknesses of the first and second plate springs (11d, 11d), (11e, 11e).

Specifically, the first spring constant S1c of the first spring part S1 is made larger than the second spring constant S2c of the second spring part S2c in accordance with a distance difference between the distances K1 and K2 as mentioned hereinafter.

As shown in Fig. 7 (C), assuming that an external force f is added to the center of gravity G of the movable section 4 in a direction shown with an arrow from a side of the movable section 4, it is effective to suppress the rolling

of the movable section 4 to determine the first and second spring constants S1c, S2c of the first and second spring parts S1, S2 so that a displacement X of the first spring part S1 is the same as that of the second spring parts S2. A balance condition of this state is determined by the relation between moments as follows:

$$f1 \times k1 = f2 \times k2 \quad \cdots\cdots\cdots (1)$$

Wherein f1 or f2 denotes a force component of the force f added to the first or second spring part S1 or S2. (f = f1 + f2)

Further, formulas (2) and (3), each showing the relation between the displacement X and the force component f1 or f2 are obtained as follows:

$$f1 = S1c \times X \quad \cdots\cdots\cdots (2)$$

$$f2 = S2c \times X \quad \cdots\cdots\cdots (3)$$

From the above formulas (1), (2) and (3), a formula (4) is obtained as follows:

$$S1c/S2c = k2/k1 \quad (S1c = Sc2 \times (k2/k1)) \cdots\cdots\cdots (4)$$

As seen from the formula (4), wherein k2 > K1 as mentioned in the foregoing, it is possible to suppress the

rolling of the movable section 4 in the direction shown with arrow R against an external force or acceleration by causing the first spring constant S1c of the first spring part S1 larger than the second spring constant S2c of the second spring part S2c in proportion to the ratio of k2/k1.

Thereby, an aberration of the objective lens 5 due to an inclination thereof can be effectively prevented, resulting in an elimination of tracking-off of the objective lens 5.

Further, it is possible to locate the objective lens 5 close to the mirror M thereunder by providing the first and second spring parts S1, S2 on the suspension base 11A, resulting in a reduction of the thickness of the optical pickup 1A.

Further, it is possible to provide the first plate springs 11d, 11d to be unsymmetric with respect to a center line passing through the center of gravity G of the movable section 4 because the respective spring constants of the first left and right plate springs 11d, 11d are optionally changeable by changing the thicknesses thereof in the upper and lower directions to the plane of gravity Gm.

[Second embodiment]

Fig. 8 (A) is a plan view of the second embodiment of the optical pickup device;

Fig. 8 (B) is a side view of Fig. 8 (A);

Fig. 8 (C) is a back view of Fig. 8 (A);

Fig. 9(A) is a perspective view of a suspension base shown in Figs. 8 (A) to 8(C);

Fig. 9 (B) is a plan view of Fig. 9 (A);

Fig. 9 (C) is a back view of Fig. 9 (A);

Fig. 10 (A) is a schematic side view for explaining an operation of a suspension wire and the suspension base of the second embodiment of the optical pickup device;

Fig. 10 (B) is a schematic back view of Fig. 10 (A); and

Fig. 10 (C) is a schematic view for explaining the Fig. 10 (A).

In an optical pickup device 1B of a second embodiment of the present invention, a shape of a suspension base 11B is partially different from that of the suspension base 11A explained in the first embodiment. Thus, the like parts are denoted with the like reference characters used in the first embodiment and the detailed description thereof is omitted here for simplicity, and new constructive components in the second embodiment are denoted with new reference characters.

As shown in Figs. 9 (A) to 9 (B) being enlarged, the suspension base 11B used in the second embodiment comprises the rectangular base 11a formed at a center thereof, a pair of spring plates 11f, 11f provided at the left and right sides of the rectangular base 11a so as to be swingably displaced in a tracking direction (directions shown with arrows X) by their elastic forces. The spring plates 11f, 11f are respectively divided into two parts i.e., upper first plate springs 11f1, 11f1 and lower second plate springs 11f2, 11f2, at a proportion of 3 : 1 in a height direction by thin slits 11g, 11g.

Further, on the top surfaces of the upper first plate

springs 11f1, 11f1, there are provided upper guide grooves 11f11 and 11f11 so that their bottoms are approximately flush with the bottoms of the guide grooves 11c, 11c, and on the side surfaces of the upper first plate springs 11f1, 11f1, there are provided notches 11f12, 11f12 so that their bottoms are approximately flush with the bottoms of the upper guide grooves 11f11 and 11f11.

Similar to the above, on the bottoms of the lower second plate springs 11f2, 11f2, there are provided lower guide grooves 11f21 and 11f21 so that their bottoms are approximately flush with the bottoms of the guide grooves 11c, 11c (not shown), and on the side surfaces of the lower second plate springs 11f2, 11f2, there are provided notches 11f22, 11f22 so that their bottoms are approximately flush with the bottoms of the lower guide grooves 11f21 and 11f21.

And, one ends of the pair of upper suspension wires 9a, 9a are respectively fixed in the pair of upper guide grooves 11f11, 11f11 and distal ends thereof are pinched by the pair of upper notches 11f12, 11f12, and one ends of the pair of lower suspension wires 9b, 9b are respectively fixed in the pair of lower guide grooves 11f21, 11f21 and distal ends thereof are pinched by the pair of lower notches 11f22, 11f22.

As shown in Figs. 9 (C) and 10 (C), a distance K1 defined from bottoms of the upper guide grooves 11f11, 11f11 and the upper notches 11f12, 11f12 to the plane of gravity Gm mentioned in the foregoing is made shorter than a distance defined from the bottoms of the lower guide grooves

11f21, 11f21 and the lower notches 11f22, 11f22 to the plane of gravity Gm. Thus, the distance K1 and the distance K2 are made unsymmetrical with respect to the plane of gravity Gm. As a result, the upper suspension wires 9a, 9a and the lower suspension wires 9b, 9b are made unsymmetric with respect to the plane of gravity Gm in the upper and lower directions.

In the second embodiment as well, if the distance K2 is made as small as the distance K1 so that both the distance K1 and the distance K2 are symmetrical with respect to the plane of gravity Gm, a total distance K = K1 + K2 becomes much smaller. This small total distance causes the the suspension wires 9 to unstably support the movable section 4, and a degradation of dimensional precision of the optical pickup device 1A.

Accordingly, in the second embodiment, the distance K1 and the distance K2 are made unsymmetrical with respect to the plane of gravity Gm by causing the distance k2 to be larger than the distance K1, resulting in a stable support of the movable section 4 by the suspension wires 9 as well as the first embodiment.

Next, the description is given of the operations of the suspension wires 9 supporting the movable section 4 and the suspension base 11B, referring to Figs. 9 (A) to 10 (C).

In the second embodiment as shown in Figs. 9(A) to 10(C), in order to compensate the drawback of the unsymmetrical disposition of the suspension wires 9 with respect to the plane of gravity Gm of the movable section 4, the plate spring section S' is divided into two parts, a

first spring part S1 located above the plane of gravity Gm and a second spring part S2 located below the plane of gravity Gm. Specifically, the first spring part S1 is composed of a part of the first plate springs (11f1, 11f1) which is located above the plane Gm and the suspension wires 9a, 9a, and the second spring part S2 is composed a part of the first plate springs (11f1, 11f1) which is located below the plane Gm and the second plate springs (11f2, 11f2) located below the plane Gm and the suspension wires 9b, 9b. In the present invention, the first spring part S1 has a first spring constant S1c different from a second spring constant S2c of the second spring part S2, for instance, by changing the thicknesses of the first and second plate springs (11f1, 11f1), (11f2, 11f2).

Specifically, the first spring constant S1c of the first spring part S1 is made larger than the second spring constant S2c of the second spring part S2c in accordance with a distance difference between the distances K1 and K2 as mentioned in the foregoing.

These facts can be analyzed in the same manner as mentioned in the first embodiment by using the formulas (1) to (4). As a result, it is possible to suppress the rolling of the movable section 4 in the directions shown with an arrow R against the external force or acceleration by causing the first spring constant S1c of the first spring part S1 larger than the second spring constant S2c of the second synthetic spring S2 as well as the first embodiment.

Specifically, this is realized by causing, for instance,

the spring constant of the first plate springs (11f1, 11f1) to be larger than that of the second plate spring (11f2, 11f2) which is located below the center of gravity G as well as the first embodiment.

Thereby, an aberration of the objective lens 5 due to an inclination thereof can be effectively prevented, resulting in an elimination of tracking-off of the objective lens 5.

Further, it is possible to locate the objective lens 5 close to the mirror M thereunder by providing the first and second plate springs 11f1, 11f2 on the suspension base 11B, resulting in a reduction of the thickness of the optical pickup 1A.



WHAT IS CLAIMED IS:

1. An optical pickup device for recording/reproducing a signal on/from a track of a recording disc by using a light beam spot comprising:

a base substrate;

a movable section for mounting an objective lens for focusing the light beam spot on the track of the optical disc;

a suspension base fixed on the base substrate; and

an upper pair and a lower pair of suspension wires for connecting the movable section to the suspension base in such a manner that the movable section is allowed to be displaced in a focusing direction of the objective lens,

wherein the upper pair and lower pair of suspension wires are disposed unsymmetric with respective to a center of gravity of the movable section in a height direction of the movable section, and the suspension base further comprises a spring section for connecting one ends of the upper pair and the lower pair of suspension wires, and the spring section comprises a first spring part located upper than the center of gravity of the movable section and a second spring part located lower than the center of gravity thereof in the height direction of the movable section, and a first spring constant of the first spring part is made to be different from a second spring constant of the second spring part to prevent the movable section from rolling caused by an external force.

2. An optical pickup device as claimed in claim 1, wherein a first distance defined between the first spring part of the spring section and the center of gravity of the movable section in the height direction of the movable section is made to be smaller than a second distance defined between the second spring part and the center of gravity of the movable section.

3. An optical pickup device as claimed in claim 1, wherein the first spring constant of the first spring part is made to be larger that the second spring constant of the second spring part.