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TITLE OF THE INVENTION

Head positioner and Information recording or reproducing apparatus

BACKGROUND OF THE INVENTION**Field of the Invention**

The present invention relates to an information recording or reproducing apparatus used for recording or reproducing information, and more particularly, to a head positioner for positioning heads at desired tracks on recording medium.

Description of the Related Art

Recently, as an information recording or reproducing apparatus, apparatuses such as a magnetic disk unit and an optical disk unit have been used widely which employ disk-shaped recording media. Among them, the magnetic disk unit has been widely used as an external storage unit of personal computers by making use of its high-speed data transfer property. A small magnetic disk unit that has been widely used of late has typically such a configuration that allows for recording or reproducing information by positioning magnetic heads by means of a rotary head positioner at desired recording tracks on the magnetic disks, the recording tracks being concentric and formed on magnetic disks.

A conventional magnetic disk unit comprising a rotary head positioner will be explained below with reference to Fig. A 9. Fig.

A9 is a plan view showing a major portion of the conventional magnetic disk unit.

Referring to Fig. A9, the magnetic disk 1 on which concentric recording tracks are formed rotates by means of a spindle motor 3 with constant angular speed. The magnetic head 2 (hereinafter referred to simply as the head) which records and reproduces information on the magnetic disk 1, is supported close to the recording surface of the magnetic disk 1 by means of suspensions 8. The head 2 is transported by means of a head positioner 5 to position in order to oppose a desired record track of the magnetic disk 1.

A carriage 10e of the head positioner 5 is rotatably attached to the shaft 6 secured to a base 4 of the information recording or reproducing apparatus via the ball bearing 7. The carriage 10e comprises a head arm 11 that has a predetermined length from the center of rotation in the radial direction. The head arm 11 is provided, on the distal end portion thereof, with suspension 8. In addition, there is provided a planar coil 21 opposite to the head arm 11 across the center of rotation. There is disposed a permanent magnet 23 opposite to the coil 21 with a predetermined space maintained therebetween, thereby forming an actuation mechanism 20 that is typically called a voice coil motor. Energizing the coil 21 will cause a torque to be generated with the rotational axis on the shaft 6 to allow the carriage

10e to rotate. The point of application of driving force D lies on the straight line "A" that connects the center axis of the shaft 6 to the head 2. Moreover, the drive direction is perpendicular to the straight line "A".

In the conventional magnetic disk unit configured as such, the magnetic head 2 detects servo position information written beforehand on the magnetic disk 1 and the current flowing in the coil 21 is controlled based on the servo position information. This allows for positioning the head 2 at a predetermined recording track on the magnetic disk 1.

In general, it is necessary to improve the accuracy of positioning the magnetic head 2 in order to increase track density. For this purpose, it is required to extend the servo bandwidth of the head positioning control. In the aforementioned conventional magnetic disk unit, the servo bandwidth was limited due to the mechanical resonance of the head positioner 5. That is, the aforementioned head positioning operation performs the positioning control for a rigid mode in which the carriage 10e rotates at center on the shaft 6 as a rigid body. For this reason, the servo bandwidth of the head positioning operation could be extended only to such an extent that the influence of high-order oscillatory modes other than the rigid body mode would not cause instability of the control.

There are two high-order oscillatory modes with large amplitudes in the rotary head positioner 5. One of them is a mode that is derived from the mass of the carriage 10e and the rigidity of the ball bearing 7 and causes the entire carriage 10e to oscillate in the direction perpendicular to the center axis of the shaft 6 (hereinafter referred to as the quasi rigid body mode). The other oscillatory mode causes the head arm 11 to bend in a plane of the surface of the magnetic disk to oscillate (hereinafter referred to as the arm sway mode). Among them, since the quasi rigid body mode appears at a lower frequency than that of the oscillation of the arm sway mode, the quasi rigid body mode was a limiting factor that limited the servo bandwidth in a conventional magnetic disk unit. Fig.A10 is a plot showing the frequency response characteristics of the conventional head positioner 5. Referring to Fig.A10, the abscissa axis represents the frequency, while the ordinate axis represents the displacement of the head 2 per unit current of the coil 21. The peak shown by arrow "a" near 3kHz is derived from the quasi rigid body mode. The servo bandwidth of the head positioner 5 could only be extended to such a frequency (for example, 500Hz) at which the frequency (about 3kHz) of the peak derived from the quasi rigid body mode exerts no influence on the stability of the positioning control.

To extend the servo bandwidth of the head positioner 5,

several configurations to reduce the effect of the quasi rigid body mode have been suggested. As an example, as disclosed in Japanese Laid-Open Patent Publication No. Hei 3-80475, a configuration is available in which a voice coil motor is provided on a side of the carriage to allow the drive force D to be generated on the carriage in the direction substantially perpendicular to the direction of displacement provided at the time of positioning. This head positioner allows the oscillatory direction of the quasi rigid body mode to be substantially orthogonal to the direction of displacement provided at the time of positioning, thereby suppressing influence and providing drastically improved accuracy of the head positioning.

As described above, in the conventional magnetic disk unit comprising a typical rotary head positioner such as shown in Fig. A 9, the resonance of the quasi rigid body mode that is potentially present as a natural vibration mode is excited by the drive force to cause an oscillation with a large amplitude to appear. This resonance limits the servo bandwidth and thus such a problem was presented in that this prevented the positioning accuracy from being improved.

Furthermore, the head positioner of a magnetic head disclosed in Japanese Laid-Open Patent Publication No. Hei 3-80475 cannot necessarily eliminate the influence of the quasi rigid body mode for the following reasons.

In general, it is known that a mechanical structure oscillates only at a particular frequency (natural frequency) irrespective of an external force and in a mode shape (natural vibration mode). This holds true in the head positioner and the carriage has natural frequency and natural vibration mode irrespective of the drive force. The quasi rigid body mode is one of the natural vibration modes and the oscillatory direction is determined only by the configuration of the carriage irrespective of the direction of the drive force provided. Unless each oscillatory direction of the quasi rigid body mode of the head positioner is orthogonal to the direction of head displacement (hereinafter referred to as the head positioning direction) provided at the time of head positioning, the oscillation generated by the drive force will have a component in the head positioning direction and thus exert an effect on the head positioning operation. That is, it is not necessarily possible to remove the effect of the oscillation derived from the quasi rigid body mode only by setting the direction of the drive force to the direction orthogonal to the positioning direction. Therefore, the head positioner disclosed in Japanese Laid-Open Patent Publication No. Hei 3-80475 still has the same problem as the conventional magnetic disk unit.

Furthermore, as disclosed in the Japanese Laid-Open Patent

Publication No. Hel 3-80475, in the case where the carriage has rigidity high enough not to cause elastic deformation to occur and to be regarded substantially as a rigid body at the resonance frequency of the quasi rigid body mode, the carriage would oscillate in a given direction of the drive force. Therefore, it is possible to allow the carriage to oscillate only in the direction of the drive force. In this case, it is necessary to provide the head arm and coil with sufficiently high rigidity, which raised such a problem that this became a serious limiting factor in design and the carriage became heavy enough to cause the inertia to increase.

The object of the present invention is to eliminate the effect of the quasi rigid body mode without imposing strict limitations on the design of the carriage and thus improve the head positioning accuracy by extending the servo bandwidth to a broad frequency bandwidth.

Next, another conventional magnetic disk unit comprising a rotary head positioner (hereinafter referred to as conventional example 1) will be explained below with reference to the drawings. Fig. B16 is a plan view showing a major portion of the magnetic disk unit according to conventional example 1. Fig. B17 is a cross-sectional view showing the vicinity of the head positioner in the magnetic disk unit according to conventional example 1. Fig. B18 is a perspective view showing a carriage of the head positioner in the magnetic disk unit according to conventional

example 1.

Referring to Fig. B16 through Fig. B18, two magnetic disks 1a and 1b, on which concentric recording tracks are formed, rotate by means of a spindle motor 3 with constant angular speed. Four magnetic heads 2a, 2b, 2c, and 2d, which perform recording or reproducing on each of the four recording surfaces of the magnetic disks 1, are supported close to the recording surfaces by means of suspensions 8, respectively. The magnetic heads 2a, 2b, 2c, and 2d are transported by means of a head positioner 5 to position in order to oppose desired recording tracks of the magnetic disks 1.

A carriage 10' of the head positioner 5 is rotatably disposed, at a shaft 6 center, by means of two ball bearings 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. The head carriage 10' is comprised of three head arms 11a, 11b and 11c, which have a predetermined length from the center of rotation in the radial direction. The head arm 11a is provided, on the distal end portion thereof, with a head 2a via the suspensions 8. The head arm 11b is provided, on the distal end portion thereof, with heads 2b and 2c via the suspensions 8. The head arm 11c is provided, on the distal end portion thereof, with a head 2d via the suspensions 8. That is, the head arm 11a disposed above the magnetic disk 1a (when viewed toward the surface of the page of Fig. B17) and the head arm 11c disposed below the magnetic disk 1b (when viewed in the same direction) support one head. On the other hand, the head arm 11b disposed between the two magnetic

disks 1a and 1b supports two heads. Each of the head arms 11a, 11b, and 11c has the same shape such as in thickness and in width. That is, the head arms 11a, 11b, and 11c have the same support rigidity. In addition, the magnetic heads 2a, 2b, 2c, and 2d have the same shape.

There is provided a planar coil 21 opposite to the head arms 11 across the center of rotation of the carriage 10'. There is disposed a permanent magnet 23 opposite to the coil 21 with a predetermined space maintained therebetween, the permanent magnet 23 and the coil 21 forming a drive mechanism 20 that is typically called a voice coil motor. Energizing the coil 21 will cause an electromagnetic force to be generated to provide torque that allows the carriage 10' to rotate with the rotational axis on the shaft 6.

In the conventional magnetic disk unit configured as such, the magnetic heads 2 detect servo position information written beforehand on the magnetic disks 1 and the current flowing in the coil 21 is controlled based on the servo position information in order to position the heads 2 at predetermined tracks on the magnetic disks 1.

Furthermore, it is necessary to improve the accuracy of positioning the magnetic heads 2 in order to increase track density. For this purpose, it is required to extend the servo bandwidth of the head positioning control. In the aforementioned conventional magnetic disk unit, the servo bandwidth was limited

due to the mechanical resonance of the head positioner 5. That is, the aforementioned head positioning operation performs the positioning control for a mode in which the head carriage 10' rotates at the center on the shaft 6 as a rigid body (hereinafter referred to as a rigid body mode). For this reason, the servo bandwidth of the head positioning operation could be extended only to such an extent that the influence of high-order oscillatory modes other than the rigid body mode would not cause instability of the control.

There are three high-order oscillatory modes with large amplitudes in the rotary head positioner 5. A first high-order oscillatory mode causes the entire carriage 10' to oscillate in the direction perpendicular to the axis of the shaft 6 as a substantial rigidbody (hereinafter referred to as the quasi rigid body mode), the mass of the carriage 10' and the rigidity of the ball bearings 7. This has a mode shape in which the entire carriage 10' oscillates in the direction shown by arrow u in Fig. B18.

A second high-order oscillatory mode causes the head arms 11 to deform elastically toward the surface of the magnetic disks to oscillate (hereinafter referred to as the arm sway mode). This has a mode shape in which, when the middle head arm 11b is deformed in the direction shown by arrow q in Fig. B18, the upper and lower head arms 11a and 11c are deformed in the directions shown by arrows p and q in the drawing, respectively, the coil allowed to oscillate in the direction shown by arrow s in the drawing. Fig. B19 is a plan view showing the arm sway mode of the head

positioner in the magnetic disk unit according to conventional example 1. Fig. B19 illustrates schematically the mode shape of the arm sway mode.

A third high-order oscillatory mode is a mode in which an in-plane deformation of the head arms 11 and a translation displacement of the ball bearings 7 are coupled to oscillate (hereinafter referred to as the coupled arm-bearing mode). This has a mode shape in which, when the respective head arms 11a, 11b, and 11c are deformed in the direction shown by arrow q and the coil allowed to oscillate in the direction shown by arrow s in Fig. B18, the ball bearings 7 translate in the direction shown by arrow u in the drawing. That is, this mode is such that the entire carriage 10' is deformed so as to take the shape of a bow across the centerline thereof. In this oscillatory mode, the carriage 10' oscillates in the opposite directions at the center and at both ends thereof, so that one oscillation node appears at each of the sides of the head arms 11 and the coil 21.

These three oscillatory modes were limiting factors that limited the servo bandwidth in a conventional magnetic disk unit. Fig. B20 is a graph showing the frequency response characteristics of the head positioner according to conventional example 1. Referring to Fig. B20, the abscissa axis shows the frequency of a sinusoidal current for driving the head positioner 5, while the ordinate axis shows the displacement of the magnetic heads 2 per unit current of the coil 21 in decibels. The resonance peak

shown by arrow "a" in the drawing near 4.7kHz is derived from the quasi rigid body mode. The resonance peak shown by arrow "b" in the drawing near 5.5kHz is derived from the arm sway mode. In addition, the resonance peak shown by arrow "c" in the drawing near 6.4Hz is derived from the coupled arm-bearing mode. Therefore, the servo bandwidth (gain crossover frequencies) of the head positioning control can be extended only to such a frequency (about 500Hz) at which these resonance peaks exert no influence on the stability of the control.

In view of these circumstances, several techniques to reduce two types of the high-order oscillatory modes among the aforementioned three types of high-order oscillatory modes have been conventionally suggested for extending the servo bandwidth of the head positioner 5. As examples, head positioners are disclosed in USP No. 4,620,252 and Japanese Laid-Open Patent Publication No. Hei-10-162519.

According to the example described in USP No. 4,620,252, such a head positioner (hereinafter referred to as conventional example 2) is disclosed which allows two voice coil motors to be disposed at positions symmetric with respect to a point at the center at the rotational axis of the head carriage and which is driven by the couple, in order to reduce the resonance peak of the quasi rigid body mode. According to this head positioner, since no translation exciting force is applied to the rotational axis, the resonance derived from the quasi rigid body mode is not generated and thus the servo bandwidth can be extended.

On the other hand, according to an example described in Japanese Laid-Open Patent Publication No. Hei-10-162519, such a head positioner is disclosed as is configured to be provided, on the surface opposite to a head arm to which a head is mounted, with a member having the same natural oscillation frequency as that of the head (hereinafter referred to as conventional example 3). According to this head positioner, it is asserted that the resonance peak derived from the bent head mode is reduced to extend the servo bandwidth.

However, it is necessary in the conventional example 2 to arrange two coils at positions symmetric with respect to the center axis of rotation of the head carriage. In addition, magnetic circuits need to be provided on bases opposed thereto, respectively. Such a specification to a geometrical position of a drive force providing-portion of the head positioner will give a limiting factor to the design of the apparatus. A magnetic disk unit has substantially standardized housing dimensions of magnetic disk units, which are typically called a form factor. However, it is necessary, in the aforementioned conventional rotary head positioner, to place the center axis of rotation of the head carriage greatly apart from the disks in order to avoid a mechanical and a magnetic interaction between the drive force providing portion and the disks. Thus, it is difficult to allow the head positioner to be accommodated within the aforementioned standardized dimensions.

Furthermore, in conventional example 3, it is necessary to provide a dummy member equivalent to the head on the surface opposite to the head arm to which a head is mounted, so that an excessive amount of inertia is to be added to the head carriage. To add an excessive amount of inertia to a position with a large radius of rotation presented such a problem in that this caused the moment of inertia to increase and the speed of positioning was reduced.

Still furthermore, any one of the aforementioned conventional examples was not intended for the coupled arm-bearing mode.

The present invention was developed in view of the aforementioned problems. Its object is to provide an information recording or reproducing apparatus that does not seriously provide limiting factors in the design of the carriage and provides improved head positioning accuracy by eliminating the effects of the high-order oscillations derived from the quasi rigid body mode, the arm sway mode, and the coupled arm-bearing mode to extend the servo bandwidth to a high frequency.

SUMMARY OF THE INVENTION

A 1st. invention of the present invention is a head positioner comprising:

a head supporting means for supporting a head for recording or reproducing information on a recording medium having recording tracks formed thereon,

a rotate support portion for supporting rotatably said head supporting means,

a drive means for providing said head supporting means with a drive force at a predetermined drive point of said head supporting means, wherein

said head supporting means transports said head substantially in a direction orthogonal to said recording tracks around a center of a rotational axis in said rotate support portion to position said head at a predetermined recording track of said recording medium, and

said head supporting means makes an oscillatory direction of said head in at least one natural vibration mode of a plurality of natural vibration modes which said head positioner has, substantially parallel to a direction of a tangent at such position of a predetermined recording track of said recording medium, at said position of which said head can be provided, and for making an oscillatory direction of a drive point at least another one natural vibration mode substantially perpendicular to a direction of said drive force.

According to the head positioner configured as described above, the oscillatory direction of the head in at least one natural vibration mode of a plurality of natural vibration modes in that the head positioner has is made parallel to a direction of a tangent of a provided recording track when said head is at least positioned the provided recording track on the said recording medium, and

for making an oscillatory direction of a drive point at least another one natural vibration mode substantially perpendicular to a direction of said drive force. The natural oscillation in the direction of a head displacement provided at the time of positioning the head can be prevented from being excited by the drive force. In addition, the oscillatory direction of a drive point in at least another one natural vibration mode is made perpendicular to said direction of the drive force, thereby preventing influence due to the oscillation being exerted on the reproduction signals. Consequently, the servo bandwidth of the head positioner is not limited by this natural vibration mode and thus it is possible to realize a head positioner provided with high head positioning accuracy.

A 2nd. invention of the present invention is a head positioner comprising:

a head supporting means for supporting a head for recording or reproducing information on a recording medium having recording tracks formed thereon,

a rotate support portion for supporting rotatably said head supporting means, and

a drive means for providing said head supporting means with a drive force at a predetermined drive point of said head supporting means,

said head supporting means transporting said head

substantially in a direction orthogonal to said recording tracks around a center of a rotational axis in said rotate support portion to position said head at a predetermined recording track of said recording medium, wherein

said head supporting means has oscillatory direction restricting means for making an oscillatory direction of said head in at least one natural vibration mode of a plurality of natural vibration modes which said head positioner has substantially parallel to a direction of a line connecting a center of said rotate support portion to said head, and for making an oscillatory direction of a drive point at least another one natural vibration mode substantially perpendicular to a direction of said drive force.

According to the head positioner configured as described above, the oscillatory direction of the head in at least one natural vibration mode of a plurality of natural vibration modes in that the head positioner has is made parallel to the direction of a straight line that connects the center of the support portion to the head. The natural oscillation in the direction of a head displacement provided at the time of positioning the head can be prevented from being excited by the drive force. In addition, the oscillatory direction of a drive point in at least another one natural vibration mode is made perpendicular to said direction of the drive force, thereby preventing influence due to the oscillation being exerted on the reproduction signals.

Consequently, the servo bandwidth of the head positioner is not limited by this natural vibration mode and thus it is possible to realize a head positioner provided with high head positioning accuracy.

A 3rd. invention of the present invention is a head positioner according to the 1st. or 2nd. invention where in

said head supporting means comprises

a first arm for supporting said head,

a second arm disposed, at said rotate support portion, in a direction perpendicular to said first arm, and supplied with said drive force from said drive means, and

a third arm disposed, at said rotate support portion, to said first arm and having different rigidities each depending on a direction to the center of said rotate support portion.

The head positioner configured as such allows a third arm with different rigidity to specify the oscillatory directions of a plurality of natural vibration modes that the head positioner has in two as the directions parallel to and perpendicular to a straight line that connects the center of the support portion to the head or a direction of a tangent of a provided recording track when said head is at least positioned the provided recording track on the said recording medium. Consequently, the natural oscillation in the direction of head displacement can be prevented from being excited by the drive force as well as the head from

being affected by the natural oscillation in the direction of excitation by the drive force.

A 6th. invention of the present invention is a head positioner according to the 1st. or 2nd. invention where in fourth arm

said head supporting means comprises

a fourth arm for supporting said head,

a fifth arm disposed, at said rotate support portion, and disposed at a position displaced by a predetermined angle from a direction perpendicular to said fourth arm, and supplied with said drive force from said drive means,

a sixth arm disposed, at said rotate support portion, at said rotate support portion, on a line substantially dividing a central angle between said fourth arm and said fifth arm into two angles, in an opposite side to said first and second arms with respect to said rotate support portion, and

a natural frequency of said fourth arm and a natural frequency of said fifth arm are apart from each other by two times or more.

The head positioner configured as such provides a difference two times or more between the first and second natural frequencies, thereby making it possible in the oscillatory directions of a plurality of natural vibration modes that the head positioner has in two as the directions parallel to and

perpendicular to a straight line that connects the center of the support portion to the head or a direction of a tangent of a provided recording track when said head is at least positioned the provided recording track on the said recording medium. Consequently, the natural oscillation in the direction of head displacement can be prevented from being excited by the drive force as well as the head from being affected by the natural oscillation in the direction of excitation by the drive force.

A 10th. invention of the present invention is a The head positioner according to any one of the 1st. to 9th. inventions wherein

said head supporting means is configured so that a center of mass thereof coincides substantially with a center of rotation thereof

According to the head positioner configured as such, the center member is provided with anisotropy rigidity, and the oscillatory directions of a plurality of natural vibration modes that the head positioner has can be thereby specified in two as the direction parallel to and the direction perpendicular to the straight line that connects the center of the support portion to the head or a direction of a tangent of a provided recording track when said head is at least positioned the provided recording track on the said recording medium. Consequently, this allows

for preventing the natural oscillation in the direction of displacement of the head from being excited as well as preventing the natural oscillation in the direction of excitation due to the drive force from exerting an influence on the head.

A 13th invention of the present invention is an information recording or reproducing apparatus at least comprising:

the head positioner according to any one of the 1st to 12th inventions and a recording medium.

According to the information recording or reproducing apparatus configured as such, positioning of the head is performed by the said head positioner of the present invention, thus high head-positioning accuracy is obtained.

A 14th invention of the present invention is an information recording or reproducing apparatus comprising:

a recording medium having recording tracks formed thereon,
a head for recording or reproducing information on said recording medium, and

a head positioner for positioning said heads at predetermined recording tracks on said recording medium, wherein
said head positioner has at least two head arms,
said at least two head arms support zero, or one or more heads, respectively, and

a head arm for supporting a larger number of heads has greater support rigidity than a head arm for supporting a smaller number of heads.

A 15th invention of the present invention is the information recording or reproducing apparatus according to the 14th invention wherein

a second moment of area of said head arm for supporting a larger number of heads is greater than that of said head arm for supporting a smaller number of heads, said second moment of area being derived from a bending in a plane parallel to said recording medium.

A 19th invention of the present invention is the information recording or reproducing apparatus according to the 18th invention, wherein

an area of a cross section, parallel to said recording medium, of said penetrating hole is greater than that of said head arm for supporting a larger number of heads.

A 21st invention of the present invention is an information recording or reproducing apparatus comprising:

a recording medium having recording tracks formed thereon, heads for recording or reproducing information on said recording medium,

a head positioner, provided on a base, for positioning said heads at predetermined recording tracks on said record media, wherein

said head positioner comprises

a carriage for supporting said heads,

a rotation support mechanism for supporting rotatably said carriage at a center on a predetermined rotational shaft provided on said base,

a translation support mechanism for supporting said

carriage in a radial direction of said predetermined rotational shaft with predetermined translation rigidity, disposed between said carriage and said rotation support mechanism, between said rotation support mechanism and said base, or inside said rotation support mechanism, and

a drive mechanism for providing rotational drive forces for said carriage.

A 27th invention of the present invention is an information recording or reproducing apparatus comprising:

recording medium having recording tracks formed thereon,
heads for recording or reproducing information on said recording medium,

a head positioner, provided on a base, for positioning said heads at predetermined recording tracks on said record media, wherein

said head positioner comprises

a carriage for supporting said heads,

a rotation support mechanism for supporting rotatably said carriage at a center on a predetermined rotational shaft provided on said base, and

a drive mechanism for providing rotational drive forces for said carriage,

said head positioner has nodes of mode shape of natural vibration modes of said head positioner coinciding with points of application of a resultant force of said rotational drive forces.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.A1 is a plan view showing a major portion of a magnetic disk unit according to embodiment 1 of the present invention.

Fig.A2 (a) is a plan view showing the oscillation of a quasi rigid body mode in the direction parallel to straight line A of a head positioner in a magnetic disk unit according to embodiment 1 of the present invention.

Fig.A2 (b) is a plan view showing the oscillation of a quasi rigid body mode in the direction perpendicular to straight line A of a head positioner in a magnetic disk unit according to embodiment 1 of the present invention.

Fig.A3 is a plot showing the frequency response characteristics of a head positioner according to embodiment 1 of the present invention.

Fig.A4 is a plan view showing a major portion of a magnetic disk unit according to embodiment 2 of the present invention.

Fig.A5 is a plot showing the frequency response characteristics of a head positioner according to embodiment 2 of the present invention.

Fig.A6 is a plan view showing a major portion of a magnetic disk unit according to embodiment 3 of the present invention.

Fig.A7 is a plan view showing a major portion of a magnetic disk unit according to embodiment 4 of the present invention.

Fig.A8 is a plan view showing a major portion of a head positioner of a magnetic disk unit according to embodiment 4 of the present invention.

Fig. A9 is a plan view showing a major portion of a magnetic disk unit according to a prior art.

Fig. A10 is a plot showing the frequency response characteristics of a head positioner of a magnetic disk unit according to a prior art.

Fig. B1 is a plan view showing a major portion of a magnetic disk unit according to embodiment 1 of the present invention.

Fig. B2 is a cross-sectional view showing the vicinity of a head positioner in a magnetic disk unit according to embodiment 1 of the present invention.

Fig. B3 is a perspective view showing a carriage of a head positioner in a magnetic disk unit according to embodiment 1 of the present invention.

Fig. B4 is a graph showing the frequency response characteristics of a head positioner according to each embodiment of the present invention.

Fig. B5 is a plan view showing a arm sway mode of a head positioner in a magnetic disk unit according to embodiment 1 of the present invention.

Fig. B6 is a graph showing the relationship between the resonance peak of a arm sway mode and the ratio of arm widths in embodiment 1 of the present invention.

Fig. B7 is a perspective view showing a carriage of a head positioner in a magnetic disk unit according to embodiment 2 of the present invention.

Fig. B8 is a perspective view showing a carriage of a head positioner in a magnetic disk unit according to embodiment 3 of the present invention.

Fig. B9 is a plan view showing a major portion of a magnetic disk unit according to embodiment 4 of the present invention.

Fig. B10 is a plan view showing a carriage of a head positioner in a magnetic disk unit according to embodiment 4 of the present invention.

Fig. B11 is a side view showing a carriage of a head positioner in a magnetic disk unit according to embodiment 4 of the present invention.

Fig. B12 is a graph showing the frequency response characteristics of a head positioner according to embodiment 4 of the present invention.

Fig. B13 is a plan view showing a coupled arm-bearing mode of a head positioner in a magnetic disk unit according to embodiment 4 of the present invention.

Fig. B14 is a view showing a driving force of a head positioner in a magnetic disk unit according to embodiment 4 of the present invention.

Fig. B15 is a graph showing the relationship between the resonance peak of the coupled arm-bearing mode and the position of a drive point in embodiment 4 of the present invention.

Fig. B16 is a plan view showing a major portion of a magnetic disk unit according to a prior art.

Fig. B17 is a cross-sectional view showing the vicinity of a head positioner in a magnetic disk unit according to a prior art.

Fig. B18 is a perspective view showing a carriage of a head positioner in a magnetic disk unit according to a prior art.

Fig. B19 is a plan view showing a arm sway mode of a head

positioner in a magnetic disk unit according to a prior art.

Fig. B20 is a graph showing the frequency response characteristics of a head positioner according to a prior art.

[Description of Symbols]

- 1 Magnetic disk
- 2 Magnetic head
- 3 Spindle motor
- 4 Base
- 6 Shaft
- 7 Ball bearing
- 8 Suspension
- 10, 10a, 10b Carriage
- 11 Head arm
- 12, 12a, 12b Coil arm
- 13a High rigidity portion
- 13b Low rigidity portion
- 13c Balance member
- 14, 14a Center member
- 14b Hinge portion
- 14c Slot
- 15 Coupling member
- 16, 17, 18, 19 Head positioner
- 20 Drive mechanism
- 21 Coil

23 Permanent magnet
5 Head positioner
10', 110, 210, 310, 410 Carriage
11a, 11b, 11c, 111a, 111b, 111c, 211a, 211b, 211c, 311a, 311b,
311c, 411a, 411b, 411c Head arm
105, 405 Head positioner
112, 412 Sleeve
113 Elastic member
114, 414 Rotor
413a Parallel plate spring
415a, 415c Notch
421a Main coil
421b Sub coil

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A magnetic disk units according to the preferred embodiments of a head positioner and an information recording or reproducing apparatus of the present invention will be explained below with reference to Fig.A 1 through Fig.A8. Furthermore, component elements that are the same as those of the prior-art magnetic disk unit are given the same reference numbers for purposes of explanation.

(Embodiment 1)

Fig.A1 is a plan view showing a major portion of a magnetic disk unit according to embodiment 1 of the present invention. Referring to Fig.A1, a magnetic disk 1 on which concentric record

tracks are formed rotates by means of a spindle motor 3 with constant angular speed in the direction shown by the arrow. A head 2 that records and reproduces information on the magnetic disk 1 is positioned at a desired recording track of the magnetic disk 1 by means of a head positioner 16.

A carriage 10 provided on the head positioner 16 is rotatably supported by means of a ball bearing 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. The carriage 10 is provided with a cylindrical center member 14, and three arms consisting of a head arm 11, a coil arm 12, and a balance arm 13, each having the shape of a cantilever extending outwardly from the center member 14. The head arm 11 supports, at the distal end portion thereof, the head 2 via the suspension 8 in the proximity of the recording surface of the magnetic disk 1.

The coil arm 12 is provided with a coil 21 of the shape of a flat plate. A magnet 23 is opposed to the coil 21 via a slight space therebetween. The magnet 23 is attached to a yoke (not shown) secured to a base 4. On the side opposite to the magnet 23 of the coil 21 is provided a yoke (not shown) via a likewise slight space, thus a closed magnetic circuit is formed. The aforementioned coil 21 and the said closed magnetic circuit constitute a known drive mechanism 20, which is called a voice coil motor. The direction of drive force D given to the carriage 10, a movable body, by means of the drive mechanism 20 is parallel

to a straight line "A" that connects the axial center of the shaft 6 to the head 2.

The balance arm 13 comprises a high rigidity portion 13a extending opposite to the head arm 11 from the axis of the shaft 6 that is the center of rotation, a low rigidity portion 13b extending in the direction perpendicular to the straight line "A" from the distal end of the high rigidity portion 13a, and a balance member 13c that serves as a weight fixed to the distal end of the low rigidity portion 13b. The flexural rigidity of the low rigidity portion 13b is set so as to be half or less than that of the high rigidity portion 13a.

This configuration allows the balance member 13c to be supported to provide low rigidity in the direction parallel to the straight line "A" and high rigidity in the direction perpendicular to the straight line "A". That is, the rigidity of the balance arm 13 has anisotropy. The balance member 13c is made of a metal with a large specific gravity such as tungsten. The center of mass of the carriage 10 (the center of gravity) lies on the center axis of the shaft 6.

The operation of the magnetic disk unit, according to embodiment 1 of the present invention, is to be explained.

The head 2 reproduces servo position information written beforehand on the magnetic disk 1 and the current flowing in the

coil 21 is controlled based on the servo bandwidth to transport and position the head 2 so as to oppose a desired record track. The head positioner 16 allows the carriage 10 to be rotatably supported by means of the shaft 6 via the ball bearing 7. The carriage 10 is driven by means of the drive mechanism 20 in a mode in that the carriage 10 is rotated with at the center on the shaft 6 as a rigid body, that is, in a so-called "rigid body mode" and transports the head 2 to carry out positioning.

in the above configuration, carriage 10 and each member connecting thereof and coil 21 is correspond to a head supporting means of the present invention, shaft 6 and bearing 7 are correspond to a rotate support portion of the present invention, drive mechanism without coil 21 is correspond to a drive means of the present invention, the head arm 11 is correspond to the first arm of the present invention, the coil arm 12 is correspond to the second arm of the present invention, and the balance arm 13 is correspond to the third arm of present invention.

The bearing used in the rotation support mechanism of the carriage 10 is the typical ball bearing 7 like the one used in the conventional example. In principle, the ball bearing 7 restricts degrees of freedom other than the degree of freedom of rotation, however, from a microscopic point of view, the ball bearing 7 has a degree of freedom of moving in the direction perpendicular to the center axis (hereinafter referred to as the

direction of translation) due to elastic deformation of the balls or the race rings. That is, the head positioner 16 has three degrees of freedom of a degree of freedom of rotation within a rotational plane and two degrees of freedom (degrees of freedom of translation) of moving in the two-dimensional direction of translation. Therefore, there exist three natural vibration modes derived from the degrees of freedom of the ball bearing 7. One of them is the aforementioned rigid body mode, while the other two are the quasi rigid body modes in which mainly the bearing is displaced in the direction of translation. Therefore, it is necessary to consider the two quasi rigid body modes in order to extend the servo bandwidth of the positioning control of the head positioner 16.

The head positioner 16 of the embodiment 1 assigns (hereinafter referred to as "to specify") the directions of the oscillations of these two quasi rigid body modes to predetermined directions, thereby making one "undetectable" and another "unexcitable". Here being "unexcitable" means that no occurrence of the oscillation is caused by the drive force D. This allows for eliminating the influence of the quasi rigid body mode in the head positioning control. Here, being "undetectable" means that the occurrence of oscillation in the head positioner 16 would not be detected by means of the magnetic head to result in exerting no effect on positioning. In addition, being "unexcitable" means

that the potential existence of an oscillatory mode in the head positioner 16 would not cause the head positioner 16 to be excited in this oscillatory mode.

First, the action for specifying the oscillatory direction of the quasi rigid body mode will be explained with reference to Fig.A2. Fig.A2 (a) and (b) are plan views showing the oscillations of the two quasi rigid body modes of the head positioner 16, respectively. Furthermore, in the drawings, the displacements caused by the oscillations are exaggerated for purposes of explanation as shown by dashed lines. The head positioner 16 of embodiment 1 provides anisotropy for rigidity of the balance arm 13 as described in the foregoing. That is, the balance member 13c is supported to provide low rigidity in the direction parallel to the straight line "A" and high rigidity in the direction perpendicular to the straight line "A". Accordingly, the balance arm 13 acts as an oscillatory system with one degree of freedom in the direction parallel to the straight line "A". Moreover, the balance arm 13 acts substantially as a rigid body in the direction perpendicular to the straight line "A". Therefore, as shown in Fig.A2 (a), the head positioner 16 constitutes an oscillatory system with two degrees of freedom of a degree of freedom of translation of the ball bearing 7 and the degree of freedom of the balance arm 13 in the direction parallel to the straight line "A".

By contrast, as shown in Fig.A2 (b), the head positioner 16 constitutes an oscillatory system with one degree of freedom in which the balance arm 13 displaces integrally with the carriage 10 in the direction perpendicular to the straight line "A". Therefore, the dynamic balances of forces are different from each other in the directions perpendicular to and parallel to the straight line "A". Even with the rigidity of the ball bearing 7 itself being isotropic, this causes the oscillation of the quasi rigid body mode to be divided into two oscillations as an oscillation in a first quasi rigid body mode in the direction parallel to the straight line "A" and an oscillation in a second quasi rigid body mode in the direction perpendicular to the straight line "A". In addition, the frequencies of oscillation of both modes are different from each other. Thus, the head positioner 16 of embodiment 1 allows the balance arm 13 to specify one of the potential quasi rigid body modes in the direction parallel to the straight line "A" and the other in the direction perpendicular to the straight line "A".

Next, the reason why the oscillations of the two quasi rigid body modes exert no effect on head positioning will be explained. The oscillation of the first quasi rigid body mode in the direction parallel to the straight line "A" shown in Fig.A 2 (a) is excited by means of drive force D. However, the direction

P of the oscillation of the head 2 on the recording track on which the head 2 is positioned on the magnetic disk shown in Fig.A1 is parallel to the tangent of a recording track and has no component in the direction (the direction of head positioning) of the displacement of the head 2. Therefore, the positioning of the head 2 will never be affected by this oscillation.

On the other hand, for the second quasi rigid body mode in the direction perpendicular to the straight line "A" shown in Fig.A2 (b), the direction of oscillation at the point of application of the drive force D intersects orthogonally that of the drive force D, so that the head positioner 16 would not be excited by means of the drive force D even when an oscillatory mode would potentially exist. Therefore, none of these two oscillations of the quasi rigid body mode can exert an effect upon head positioning.

For simplicity, an explanation has been given on the precondition that there exists no elastic deformation of the head arm 11 and the coil arm 12 in Fig.A2. However, it is necessary in an actual design of the head positioner 16 to consider the elastic deformation of both arms to determine the rigidity of the balance arm 13 so that the oscillatory direction of the head position in the first quasi rigid body mode is parallel to the straight line "A" and the oscillatory direction of the drive point in the second quasi rigid body mode is perpendicular to the drive

force D. More specifically, this rigidity can be determined by selecting appropriately the cross-sectional shape and length of the balance arm 13. The degrees of freedom of design can be increased by making the angle between the longitudinal direction of the low rigidity portion 13b with the straight line "A" less than 90 degrees by 5 to 10 degrees.

Furthermore, the head positioner 16 of embodiment 1 is of a rotary type and thus the carriage 10 needs to rotate approximately 20 degrees between the innermost recording track and the outermost recording track. Therefore, the straight line "A" cannot be made parallel to the tangents to all recording tracks. However, the absolute values of the angles between tangents to the record tracks and the straight line "A" are designed to be substantially equal to each other between the innermost recording track and the outermost recording track. This is, for example, achieved by constructing carriage 10 as shown in Fig. 1, so that the straight line "A" is substantially equal to the tangent from the position of the head 2 on a certain recording track. And the recording track is located where each distance from the outermost recording track and from the innermost recording track is equal or substantially equal on the magnetic disk 1. This allows the effect of the quasi rigid body mode to be suppressed to a minimum and provides substantially the same effect, even if the head 2 is positioned on any recording track of the magnetic disk 1.,

as in the case where the straight line "A" is made parallel to a tangent to a recording track.

Fig.A3 is a graph showing the measurements of the frequency response characteristics of the head positioner 16 according to the embodiment 1. Referring to Fig.A3, the abscissa axis represents the frequency of a drive current, while the ordinate axis represents the displacement, per unit current, in the direction of head positioning. In Fig.A3, the peaks shown by arrows "a" and "b" are the resonance derived from two quasi rigid body modes. Compared with the frequency response characteristics of the conventional head positioner shown in Fig.A10, the resonance peak value shown by arrow "a" has been greatly suppressed, resulting in good frequency characteristics. The peak shown by arrow "c" is a peak derived from the arm sway mode.

As described above, the head positioner 16 of the embodiment 1 specifies two quasi rigid body modes to be parallel to and perpendicular to tangents to recording tracks, respectively, by the combination of the degree of freedom of bending of the balance arm 13 having anisotropy and the degree of freedom of translation of the ball bearing 7. This allows for making the first quasi rigid body mode "undetectable" and the second quasi rigid body mode "unexcitable". Consequently, this allows oscillations to be eliminated without exerting an effect on head positioning and

the servo bandwidth of the head positioning control to be extended without being limited by the quasi rigid body mode, thereby providing improved accuracy of positioning.

Furthermore, the head positioner 16 of the embodiment 1 is provided with the balance member 13c to allow the center of mass of the carriage 10 to substantially coincide with the center of rotation. This allows no rotational force to be produced even by the application of oscillations due to disturbance and thus allows for maintaining highly accurate positioning. Moreover, one balance member 13c is allowed to serve as means for specifying the oscillatory direction of the quasi rigid body mode and to serve also as means for making the center of mass of the carriage 10 coincide with the center of rotation, thereby simplifying the structure of the carriage 10.

In addition, since the balance member 13c is made of a material with a large specific gravity such as tungsten, the balance member 13c can be disposed within a small rotational radius. Therefore, the carriage 10 can be balanced without increasing the moment of inertia too much.

Furthermore, explanation has been given of the head positioner 16 of embodiment 1 in which the balance arm 13 is configured so that the rigidity in the direction parallel to a tangent to a recording track is lower than that in the direction perpendicular to the tangent to the recording track. On the

contrary, the balance arm 13 may be configured so that the rigidity in the direction perpendicular to a tangent to a recording track is lower than that in the direction parallel to the tangent to the recording track. The same effect can be obtained regardless of whether the direction of the anisotropy of the rigidity is parallel to or perpendicular to the tangent to the recording track.

Furthermore, explanation has been given of an example in which the balance arm 13 is provided as the means for specifying the oscillatory direction of the quasi rigid body mode. However, other components of the carriage 10 may be configured to have the anisotropy of the rigidity. For example, the carriage 10 and the ball bearing 7 may be configured to have an elastic member with anisotropic rigidity interposed therebetween. In addition, other components other than the carriage 10 may be configured to have anisotropy. For example, the same effect can be obtained from the configuration in which the ball bearing 7 itself, the shaft 6 journaled in the ball bearing 7, or the support member thereof may be provided with an elastic member having anisotropic rigidity.

(Embodiment 2)

A head positioner and information recording or reproducing apparatus, according to embodiment 2 of the present invention, will be explained below with reference to Fig. A4, a magnetic disk

being taken as an example. Fig.A4 is a plan view showing a major portion of the magnetic disk unit according to embodiment 2 of the present invention. The magnetic disk unit according to embodiment 2 has the same configuration as that of said embodiment 1 except for a head positioner 17 and thus the same reference numbers are given to the same components with their explanations being omitted. The difference between the magnetic disk unit of embodiment 2 and that of embodiment 1 lies in that the head positioner 17 has a coupling member 15 for connecting the head arm 11 to the coil arm 12. The coupling member 15 is made of the same material as the head arm 11 and the coil arm 12, integrally therewith. Moreover, Fig.A4 shows only one head arm 11, however, in cases where a plurality of head arms are provided (not shown), each of the head arms may be connected to the coil arm 12.

The magnetic disk unit, configured as such, according to embodiment 2 has a further effect of extending the servo bandwidth by means of the coupling member 15 provided as well as the effect obtained by substantially the same action as that of the head positioner 16 of said embodiment 1. When the influence of the quasi rigid body mode has been eliminated in the head positioner 16 of embodiment 1, another factor limiting the servo bandwidth is the resonance derived from the bending mode of the head arm 11. In the frequency characteristics of the head positioner 16 of embodiment 1 shown in Fig.A3, the peak shown by arrow "c" is

a resonance peak derived from the bending mode of the head arm 11. The oscillation in this bending mode of the head arm 11 causes the head arm 11 and the coil arm 12 to bend with inverse phase with each other in a plane. That is, such an oscillatory mode is present that the distal ends of the head arm 11 and coil arm 12 come close to each other and more away from each other.

The head positioner 17 of embodiment 2 is configured so as to increase the rigidity of the arm against this oscillatory mode to increase the resonance frequency of the natural oscillation by providing the coupling member 15 between the head arm 11 and the coil arm 12. Fig.A5 is a graph showing the frequency response characteristics of the head positioner of embodiment 2. In Fig.A5, the resonance peak shown by arrow "c", which is found in Fig.A3 of embodiment 1, has disappeared, resulting in good characteristics over a wide range of frequencies.

As described above, the magnetic disk unit, according to embodiment 2, enables extending further the servo bandwidth by providing the coupling member 15 between the head arm 11 and the coil arm 12 in addition to the effect provided by the magnetic disk unit of embodiment 1. Consequently, this allows for providing improved accuracy of positioning and realizing a magnetic disk unit with a higher track density.

(Embodiment 3)

A magnetic disk unit as a head positioner an information recording or reproducing apparatus, according to embodiment 3 of the present invention, will be explained below with reference to Fig.A6. Fig.A 6 is a plan view showing a major portion of the magnetic disk unit according to embodiment 3 of the present invention. The magnetic disk unit according to embodiment 3 has the same configuration as that of said embodiment 1 except for a head positioner 18 and thus the same reference numbers are given to the same components with their explanations being omitted.

Referring to Fig.A6, a carriage 10a provided on the head positioner 18 is rotatably supported by means of a ball bearing 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. The carriage 10a is provided with a cylindrical center member 14, and three arms consisting of a head arm 11, a coil arm 12a, and a balance arm 13d, each having the shape of a cantilever extending outwardly from the center member 14. The head arm 11 supports, at the distal end portion thereof, the head 2 via the suspension 8 in the proximity of the record surface of the magnetic disk 1.

The coil arm 12a is provided with a coil 21 of the shape of a flat plate. A magnet 23 is opposed to the coil 21 via a slight clearance therebetween. The magnet 23 is attached to a yoke (not shown) secured to the base 4. On the side opposite to the magnet 23 of the coil 21 is provided a yoke (not shown) via a likewise

slight space, thus a closed magnetic circuit is formed. The aforementioned coil 21 and the said closed magnetic circuit constitute a known drive mechanism 20, which is called a voice coil motor.

A straight line "B" connecting the point of application of drive force D of the coil arm 12a to the center axis of the shaft 6 forms an angle of 80 degrees with straight line "A" connecting the center axis of the shaft 6 to the head 2. The direction of the drive force D given to the carriage 10a, a movable body, by the drive mechanism 20 is perpendicular to the straight line "B". On both sides of the portion close to the coupling portion of the center member 14 of the coil arm 12a, provided is a semi-circular notched portion 12b.

This notched portion 12b causes the bending rigidity of the coil arm 12a to decrease. By this notched portion 12b, the natural frequency determined by the ratio of the bending rigidity of the coil arm 12a to the equivalent mass (hereinafter referred to as single natural frequency) is set so as to be half or less the single natural frequency of the head arm 11.

In the magnetic disk unit according to embodiment 3, the single natural frequency of the head arm 11 is set to 7.5kHz, while the single natural frequency of the coil arm 12a is set to 3.5kHz.

In the above configuration, the head arm 11 is correspond

to the fourth arm of the present invention, the coil arm 12a is correspond to the fifth arm of the present invention, and the balance arm 13d is correspond to the sixth arm of present invention.

The balance arm 13d is disposed opposite to the head arm 11 and the coil arm 12a with respect to the center member 14 on a line that substantially bisects the central angle between the head arm 11 and the coil arm 12a, provided with the balance member 13c fixed to the distal end thereof. The single natural frequency of the balance arm 13d is set to a sufficiently higher value than the single natural frequency of the coil arm 12a. In this magnetic disk unit of embodiment 3, the single natural frequency of the balance arm 13 is set to 20kHz. The balance arm 13d is made of a metal with a large specific gravity such as tungsten. The center of mass of the carriage 10a lies on the center axis of the shaft 6.

The head positioner 18 of the magnetic disk unit, according to embodiment 3, configured as such can obtain substantially the same effect as the head positioner 16 of embodiment 1. In said head positioner 16 of embodiment 1 shown in Fig. A1, the rigidity of the balance arm 13 has anisotropy in the directions parallel to and perpendicular to the straight line "A". This allows for forming an oscillatory system with one degree of freedom by elastic deformation in the direction parallel to the straight line "A"

and allows for acting as substantially a rigid body in the direction perpendicular to the straight line "A". This is combined with the degree of freedom of translation of the ball bearing 7, thereby specifying the two quasi rigid body modes to be parallel to and perpendicular to a tangent to a recording track, respectively.

In the head positioner 18 of the embodiment 3, the coil arm 12a acts substantially in the same way as the balance arm 13 of embodiment 1. That is, this allows for forming an oscillatory system with one degree of freedom by elastic deformation in the direction parallel to the straight line "B" and allows for acting as substantially a rigid body in the direction perpendicular to the straight line "B".

Furthermore, since the head arm 11 and the balance arm 13d are set to a sufficiently higher single natural frequency than the coil arm 12a, both can be considered a rigid body. Therefore, this allows for forming an oscillatory system of two degrees of freedom having the combination of the degree of freedom of elastic deformation of the coil arm 12a and the degree of freedom of translation of the ball bearing 7 in the direction perpendicular to the straight line "B". On the other hand, this allows also for forming an oscillatory system of one degree of freedom only of translation of the ball bearing 7 in the direction parallel to the straight line "B". Therefore, of the two quasi rigid body modes, the first quasi rigid body mode is specified in the direction

perpendicular to the straight line "B", whereas the second quasi rigid body mode is specified in the direction parallel to the straight line "B".

Since the direction of drive force D is perpendicular to the straight line "B", the second quasi rigid body mode will not be excited even if the mode potentially exists, and no oscillation is produced in practice. On the other hand, the first quasi rigid body mode is excited by the drive force to cause an oscillation to occur. However, since the oscillatory direction at the position of the head 2 is parallel to recording tracks, the head 2 will not detect the oscillation. Therefore, the first quasi rigid body mode will never exert an effect on the positioning control system.

Furthermore, strictly speaking, a rotational moment occurs on the carriage 10a as a reacting force against the elastic deformation of the coil arm 12a to cause the rotational motion at the center on the shaft 6 to be generated. However, in the head positioner 18 of the embodiment 3, the angle between the straight line "A" and straight line "B" is set to 80 degrees, that is, or less than 90 degrees. This makes the oscillatory direction of the carriage 10a substantially parallel to a tangent to a recording track at the position of the head 2 when the translation motion and the rotational motion are combined. Consequently, this rotational motion will never affect the positioning control.

The head positioner 18 in the magnetic disk unit, according to the embodiment 3, can extend the servo bandwidth of the head positioning control without being limited by the quasi rigid body mode and provide further improved positioning accuracy.

(Embodiment 4)

A head positioner and an information recording or reproducing apparatus, according to embodiment 4 of the present invention, will be explained below with reference to Fig.A7 and Fig.A8, with a magnetic disk unit as an example. Fig.A7 is a plan view showing a major portion of the magnetic disk unit according to embodiment 4 of the present invention. Fig.A8 is a plan view showing a carriage 10b of Fig.A7. The magnetic disk unit, according to embodiment 4, has the same configuration as that of said embodiment 1 except for a head positioner 19 and thus the same reference numbers are given to the same components with their explanations being omitted.

Referring to Fig.A7, a carriage 10b provided on the head positioner 19 is rotatably supported by means of a ball bearing 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. The carriage 10b is provided with a cylindrical center member 14a, and three arms consisting of a head arm 11, a coil arm 12b, and a balance arm 13d, each having the shape of a cantilever

extending outwardly from the center member 14a.

The head arm 11 supports, at the distal end portion thereof, the head 2 via the suspension 8 in proximity of the record surface of the magnetic disk 1. The coil arm 12b is provided with a coil 21 in the shape of a flat plate. A magnet 23 is opposed to the coil 21 via a slight clearance therebetween. The magnet 23 is attached to a yoke (not shown) secured to the base 4. On the side opposite to the magnet 23 of the coil 21 is provided a yoke (not shown) via a likewise slight space, thus a closed magnetic circuit is formed. The aforementioned coil 21 and the said closed magnetic circuit constitute the known drive mechanism 20, which is called a voice coil motor. The direction of the drive force D given to the carriage 10b, a movable body, by the drive mechanism 20 is parallel to the straight line "A" that connects the axial center of the shaft 6 to the head 2.

The balance arm 13d is disposed opposite to the head arm 11 and the coil arm 12b with respect to the center member 14a on a line that substantially bisects the central angle between the head arm 11 and the coil arm 12b, provided with the balance member 13c fixed to the distal end thereof. The balance arm 13c is made of a metal with a large specific gravity such as tungsten. The center of mass of the carriage 10 lies on the center axis of the shaft 6.

As shown in Fig.A8, there are provided two slots 14c (penetrating holes) in the shape of a circular arc, symmetrically with respect to a line perpendicular to the straight line "A", and the carriage 10b is coupled to the ball bearing 7 only at two hinged portions 14b. The two hinged portions 14b are disposed on a line perpendicular to the straight line "A", respectively, and can be elastically deformed only in the direction parallel to the straight line "A". The carriage 10b is supported by means of the center member 14a to provide low rigidity in the direction parallel to the straight line "A" and high rigidity in the direction perpendicular to the straight line "A". Each single natural frequency of the head arm 11, coil arm 12b, and the balance arm 13d is set to a sufficiently higher value than the single natural frequency of the center member 14a.

In the above configuration, the head arm 11 is correspond to the seventh arm of the present invention, the coil arm 12b is correspond to the eighth arm of the present invention, and the balance arm 13d is correspond to the ninth arm of present invention.

The magnetic disk unit, according to embodiment 4, configured as such can obtain substantially the same effect as the head positioner 16 of embodiment 1. In said head positioner 16 of embodiment 1 shown in Fig.A1, the rigidity of the balance arm 13 has anisotropy in the directions parallel to and

perpendicular to the straight line "A". This allows the balance arm 13 to act as substantially a rigid body in the direction perpendicular to the straight line "A". This is combined with the degree of freedom of translation of the ball bearing 7, thereby making the two quasi rigid body modes parallel to and perpendicular to a tangent to a recording track, respectively.

In the head positioner 19 of the embodiment 4, the center member 14a acts substantially in the same way as the balance arm 13 of embodiment 1. That is, the carriage 10b is supported by means of the hinged portions 14b to provide low rigidity in the direction parallel to the straight line "A" and high rigidity in the direction perpendicular to the straight line "A". Moreover, the head arm 11, coil arm 12b, and the balance arm 13d are provided with a single natural frequency sufficiently higher than that of the center member 14a and thus can be regarded as rigid bodies. Therefore, this allows the carriage 10b to form an oscillatory system of two degrees of freedom having the combination of the degree of freedom of elastic deformation of the center member 14a and the degree of freedom of translation of the ball bearing 7 in the direction parallel to the straight line "A". On the other hand, this allows also for forming an oscillatory system of one degree of freedom only in translation of the ball bearing 7 in the direction perpendicular to the straight line "A". Consequently, of the two quasi rigid body modes, the first quasi rigid body

mode is specified in the direction parallel to the straight line "A", whereas the second quasi rigid body mode is specified in the direction perpendicular to the straight line "A".

Since the direction of drive force D is parallel to the straight line "A", the second quasi rigid body mode will not be excited even if the mode potentially exists, and no oscillation is produced in practice. On the other hand, the first quasi rigid body mode is excited by the drive force to cause an oscillation to occur. However, since the oscillatory direction at the position of the head 2 is parallel to recording tracks, the head 2 will not detect the oscillation. Therefore, the first quasi rigid body mode will never exert an effect on the positioning control system.

The head positioner 19 in the magnetic disk unit, according to the embodiment 4, can extend the servo bandwidth of the head positioning control without being limited by the quasi rigid body mode and provide further improved positioning accuracy.

Moreover, the explanations have been given to a magnetic disk unit as an example in embodiments 1 through 4, however, the present invention is not limited thereto but can also be applied, for example, to an optical disk unit. That is, positioning a head so as to oppose a recording track of a recording medium by using the head positioner allows the present invention to be applied to any apparatus for recording or reproducing information.

Likewise, the apparatus, not limited to a disk-shaped recording medium, may be such that employs a tape-shaped recording medium.

Moreover, in the explanation of the head positioning mechanism of each embodiment of the present invention, there a following condition: (A) the straight line "A" connecting the center of the shaft 6 of carriage 10 and the head 2,

(B) (one of) the direction(s) of the bearing transition mode which is not orthogonal to the direction of the driving force D and

(C) the tangent of the recording track when the head 2 is positioned on the recording track including the position of the head 2

are all equal or parallel.

However, the effect of the present invention is given by being satisfied that at least (B) and (C) are all equal or parallel. Thus, as the present invention, the explanation has been given to an embodiment with a rotary head positioner, however, the present invention can also be applied to an information recording or reproducing apparatus having a reciprocally movable head positioner. Moreover, in a swingable head positioning mechanism, even if the configuration (A) is not provided to the carriage 10, the present invention is realized only with the configuration (B) and (C).

Furthermore, explanation has been given to an embodiment

with a voice coil motor as means for generating drive force, however, the drive means may be any other type such as an electromagnetic type, an electrostatic type, or piezoelectric type other than the voice coil motor.

As described above the head positioner and the information recording or reproducing apparatus, according to the present invention, is provided with the means that make the oscillatory direction at the position of the head in at least one natural vibration mode among the natural vibration modes in that the head positioner is substantially parallel to a tangent to a recording track, and makes as well the oscillatory direction of the drive point in at least one natural vibration mode substantially perpendicular to the resultant force of the aforementioned drive forces. Therefore, the present invention can eliminate the effect of mechanical resonance that has been a limiting factor in servo bandwidth of the head positioning control to extend the servo bandwidth. This allows for providing improved head positioning accuracy. The present invention makes it possible to ensure a servo bandwidth of 1.1kHz on a magnetic disk unit with a 3.5-inch disk. Consequently, this allows an information recording or reproducing apparatus with a high track density to be realized.

Next, magnetic disk units, according to the preferred embodiments of an information recording or reproducing apparatus of the present invention, will be explained below with reference to Fig. B1 through Fig. B15. Moreover, component elements that are the same as those of the prior-art magnetic disk unit

(hereinafter referred to as prior art embodiment 1) shown in Fig. B16 through Fig. B20 are given the same reference numbers for purposes of explanation.

(Embodiment B1)

Fig. B1 is a plan view showing a major portion of a magnetic disk unit according to embodiment B1 of the present invention. Fig. B2 is a cross-sectional view showing the vicinity of a head positioner in a magnetic disk unit according to embodiment B1 of the present invention. Fig. B3 is a perspective view showing a carriage of a head positioner in a magnetic disk unit according to embodiment B1 of the present invention.

Referring to Fig. B1 through Fig. B3, two magnetic disks 1a and 1b, on which concentric recording tracks are formed, rotate by means of a spindle motor 3 with constant angular speed. Four magnetic heads 2a, 2b, 2c, and 2d, which record and reproduce information on each of the four recording surfaces of the magnetic disks 1, are supported close to the recording surfaces by means of suspensions 8, respectively. The magnetic heads 2a, 2b, 2c, and 2d are transported by means of a head positioner 105 to position in order to oppose desired recording tracks of the magnetic disks 1.

A carriage 110 of the head positioner 105 is rotatably disposed, at the shaft 6 center, by means of two ball bearings 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. However, the carriage 110 is provided with a sleeve 112 for holding the ball bearings, and a rotor 114. The rotor

114 is attached to the sleeve 112 via an elastic member 113. The elastic member 113 is filled with effervescent resin having a viscoelasticity, with the rigidity thereof set so as to have a natural frequency, which is determined by the spring constant thereof and the mass of the rotor 114, approximately equal to 110Hz.

The rotor 114 comprises three head arms 111a, 111b, and 111c, which have a predetermined length from the center of rotation in the radial direction. The head arm 111a is provided, on the distal end portion thereof, with a head 2a via the suspensions 8. The head arm 111b is provided, on the distal end portion thereof, with heads 2b and 2c via the suspensions 8. The head arm 111c is provided, on the distal end portion thereof, with a head 2d via the suspensions 8. That is, the head arm 111a disposed above the magnetic disk 1a (when viewed toward the surface of the page of Fig. B2) and the head arm 111c disposed below the magnetic disk 1b (when viewed in the same direction) support one head. On the other hand, the head arm 111b disposed between the two magnetic disks 1a and 1b supports two heads. Each of the head arms 111a, 111b, and 111c has the same thickness. In addition, the head arm 111a and 111c has the same planar shape, whereas the head arm 111b is larger in the spread angle compared therewith, with the head arms 111a and 111c being 75% the width of the proximal end of the head arm 111b. That is, the head arm 111b is approximately two times larger than the head arms 111a and 111c in the second moment of area produced by the deflection of the magnetic disks 1 toward the surfaces thereof. Furthermore, the magnetic heads

2a, 2b, 2c, and 2d have the same shape.

There is provided a planar coil 21 opposite to the head arms 111 across the center of rotation of the rotor 114. There is disposed a permanent magnet 23 opposite to the coil 21 with a predetermined space maintained therebetween, the permanent magnet 23 and the coil 21 forming a drive mechanism 20 that is typically called a voice coil motor. The interaction between the magnetic flux generated by the permanent magnet 23 and the current flowing in the portion of the coil 21 (a side extending in the radial direction) that cuts the magnetic flux causes an electromagnetic force to be generated to provide torque that allows the carriage 110 to rotate with the rotational axis on the shaft 6. Since the distribution of the magnetic flux is substantially uniform on the surface of the permanent magnet 23, the distribution of the electromagnetic force generated is also substantially uniform. Therefore, as shown in Fig. B1, when the electromagnetic force is expressed as a concentrated force (resultant force) f , the point of application of the force can be considered to lie on an arc equally distant from the perimeter (inner perimeter) near the shaft 6 and from the perimeter distant therefrom (outer perimeter). Here, moreover, the rotation support mechanism of the present invention corresponds to the shaft 6 and the ball bearings 7 of the embodiments, while the translation support mechanism of the present invention corresponds to the elastic member 113 according to the embodiments.

The operation of the magnetic disk unit, according to

embodiment B 1 of the present invention, with such a configuration as described above is to be explained.

The basic operation is the same as that of conventional example 1. That is, the magnetic heads 2 reproduce known servo position information written beforehand on the magnetic disks 1 and the current flowing in the coil 21 is controlled based on the servo position information to transport and position the head 2 so as to oppose desired recording tracks. The head positioning operation performs positional control in a mode (hereinafter referred to as a rigid body mode) which allows the carriage 110 to rotate as a rigid body around the center axis of the shaft 6. The servo bandwidth (gain crossover frequency) is set to 1kHz.

As described above, the servo bandwidth of the magnetic disk unit of the conventional example 1 was limited by a resonance peak caused by high-order oscillation modes other than the rigid body mode of the head positioner 5, that is, the quasi rigid body mode, the arm sway mode, and the coupled arm-bearing mode. However, in these embodiments, the quasi rigid body mode is stabilized by means of placing the resonance frequency sufficiently apart from the servo bandwidth (gain crossover frequency). On the other hand, concerning the arm sway mode and coupled arm-bearing mode, the servo bandwidth has been drastically improved by reducing the resonance peak tremendously.

First, the operation concerning the quasi rigid body mode is described. In the head positioner 105, the shaft 6, a fixing

portion, is provided with the sleeve 112 (first mass) via the ball bearings 7 (a first spring) having translation rigidity. In addition, the sleeve 112 is provided with the rotor 114 (second mass) via the elastic member 113 (a second spring). Such a configuration can be considered to form a "mass-spring system" with two degrees of freedom in series in the direction of translation.

In general, a translation oscillatory system with two degrees of freedom in series has two oscillatory modes in the direction of translation. In the embodiments, the first translation oscillatory mode allows the sleeve 112 and the rotor 114 to oscillate in phase with each other, while the second translation oscillatory mode allows the sleeve 112 and the rotor 114 to oscillate 180° out of phase with each other.

For the first translation oscillatory mode, the translation rigidity of the elastic member 113 is set sufficiently smaller than that of the ball bearings 7, thereby making the natural frequency thereof equal to 110Hz and thus making it sufficiently small relative to the crossover frequency. In addition, for the second translation oscillatory mode, the mass of the sleeve 112 is set sufficiently smaller than that of the rotor 114, thereby making the natural frequency thereof equal to 18kHz and thus making it sufficiently large relative to the crossover frequency.

Both of these two oscillatory modes can be excited by means of the drive force generated in the coil 21, and as shown in Fig.

B3, resonance can occur in the direction shown by arrow u in the drawing.

However, in this embodiment, the resonance frequencies caused by the two oscillatory modes are both placed apart sufficiently from the servo bandwidth, being adapted not to cause instability in the control. Moreover, the elastic member 113 employs resin with viscoelasticity, thereby making the modal damping ration large to provide more improved stability than ever.

Fig. B4 is a graph showing the frequency response characteristics of the head positioner 5 according to the embodiment B1 of the present invention. In Fig. B4, the abscissa axis indicates the frequency of a sinusoidal current for activating the head positioner 5, while the ordinate axis indicates in decibels the displacement of the magnetic heads 2 per unit current of the coil 21. A resonance peak, near 110Hz, shown by arrow "a" in Fig. B4 is derived from the first quasi rigid body mode. The resonance peak is sufficiently apart from 1kHz of servo bandwidth (a gain crossover frequency) with a sufficiently large attenuation ratio, not exerting effects on the stability of control. Furthermore, a resonance peak derived from the second quasi rigid body mode does exist near 18kHz, however, the peak does not appear in Fig. B4 because of a small gain thereof.

Next, the operation relating to the arm sway mode is explained. The arm sway mode provided for the head positioner 105 in the magnetic disk unit, according to the embodiment B1,

is a mode in which, as shown in Fig. B3, the upper and lower head arms 111a and 111c are deflected in the directions indicated by arrows p and r, respectively, when the middle head arm 111b is deflected in the direction shown by arrow "q". Here, Fig. B5 is a plan view showing the arm sway mode head positioner in a magnetic disk unit according to embodiment B1 of the present invention. Fig. B5 illustrates schematically the shape of the arm sway mode.

The arm sway mode of this embodiment is similar in shape to that of the aforementioned conventional example 1 shown in Fig. B14. However, they are different from each other in that the conventional example 1 allows the coil 21 to oscillate in the direction shown by arrow s in the drawing, whereas this embodiment does not allow the coil 21 to oscillate.

In general, the natural vibration modes of a mechanical structure with a multi-degree-of-freedom system are formed by a condition in which the inertial force and elastic force in each degree of freedom are dynamically in balance in the entire system. The arm sway mode is one of the multi-degree-of-freedom oscillatory modes, being formed by the coupling of the deflection of the respective head arms 111a, 111b, and 111c, the deflection of the coil 21, and the translation of the rotor 114.

From the point of view of dynamics, it is found that the necessary condition in that the oscillation at the position of the coil 21 (a component of the eigenvector) in the arm sway mode is equal to zero is given when all head arms have the same ratio

of equivalent rigidity to the equivalent mass of each head arm (hereinafter referred to as the arm balance condition). This state gives the inertial force and elastic force internally balanced in the respective head arms. Under this condition, such a configuration is made possible as makes portions other than the head arm of the rotor 114 including the coil 21 a node of oscillation. On the contrary, when the arm balance condition is not satisfied, any configuration employed allows a dynamic balance to be kept to form the arm sway mode with the coil 21 being oscillated as well as the respective head arms 111a, 111b, and 111c.

In the aforementioned conventional example 1, each the head arms 11a and 11c supports each of the magnetic heads 2a and 2d, whereas the head arm 11b supports two magnetic heads 2b and 2c. The middle head arm 11b supports two times as large the mass as each of the upper and lower head arms 11a and 11c does. However, since head arms 11a, 11b and 11c have the same support rigidity, the arm sway mode of the conventional head positioner does not satisfy the arm balance condition, so that the coil 21 is inevitably forced to oscillate.

By contrast, the head positioner of this embodiment is identical to conventional example 1 in that the middle head arm 111b supports two times as large the mass as each of the head arms 111a and 111c on both ends do. However, the middle head arm 111b is larger in width than the upper and lower head arms 111a and 111c, giving approximately two times the support rigidity. This configuration satisfies the aforementioned arm balance

condition. Under this condition, the shape of each portion of the carriage has been further determined such that the eigenvector of the coil position becomes substantially zero. Therefore, the arm sway mode of the head positioner according to this embodiment hardly allows the coil 21 to oscillate.

Furthermore, strictly speaking, a change in width of the head arms 111 results not only in a change in rigidity but also in mass. In addition, the magnetic heads 2 supported by means of the suspensions 8 serves not only as a mass but also as spring. Therefore, in consideration thereof, the width of each of the head arms 111 is selected so that the ratio of the equivalent rigidity and the equivalent mass of the entire movable portion including the heads 2 and the head arms 111 have the same value in all movable portions.

In general, in a certain natural vibration mode, the smaller the eigenvector at the point of application of oscillation (the smaller the amplitude), the smaller the peak value of the resonance excited becomes. When the eigenvector of the point of application of oscillation is zero (when no oscillation occurs), the natural oscillation is not excited to produce no resonance peak even if a natural mode does potentially exist. The head positioner 105, according to this embodiment, satisfies the aforementioned arm balance condition and is configured to make the eigenvector component at the coil position substantially equal to zero, thereby reducing the amplitude of the coil 21 and suppressing the resonance peak value. Furthermore, to make the eigenvector

component substantially equal to zero means to allow the component in the direction of the drive force in the oscillation at the coil position to be equal to zero, not necessarily meaning that the component orthogonal to the drive force is equal to zero.

Next, Fig. B6 is a graph showing the relationship between the resonance peak of the arm sway mode and the ratio of arm widths in embodiment B1 of the present invention. Referring to Fig. B6, the ordinate axis indicates the height of the resonance peak, while the abscissa axis indicates the ratio of the width of the upper and lower head arms 111a and 111c to the width of the middle head arm 111b. The larger the ratio of the head arms, the smaller the ratio of the support rigidities becomes. As shown in Fig. B6, a ratio of arm widths of 0.735 allows the oscillatory excitation of the arm sway mode to be completely ceased, thus eliminating the resonance peak. In addition, a ratio of arm widths within the range of 0.62 through 0.86 can make the resonance peak half the height of conventional example 1 that has the ratio of arm widths equal to 1. Moreover, a ratio of arm widths within the range of 0.71 through 0.76 can make the resonance peak one-tenth the height of conventional example 1 that has the ratio of arm widths equal to 1.

Here, referring back to the graph shown in Fig. B4, which shows the frequency response characteristics of the head positioner 5 according to this embodiment, the resonance peak indicated by arrow b in the drawing is derived from the arm sway mode. It can be found that the resonance peak is drastically

suppressed to be one-twentieth or less the height of the conventional example 1 of Fig. B15.

Next, the operation of the coupled arm-bearing mode is explained. Like the aforementioned conventional example 1, the head positioner 105 of the magnetic disk unit, according to this embodiment, also has the coupled arm-bearing mode. As described above, this oscillatory mode caused oscillatory nodes (points showing no displacement when oscillation occurs) to appear, one node on the side of the head arms 111 and one node on the side of the coil 21, respectively. The carriage 110, according to this embodiment, is configured so that the node appearing on the side of the coil 21 coincides with the position of the point of application c of the resultant force f of the aforementioned drive force. More specifically, the distribution of the mass of each portion of the carriage 110 and the rigidity have been determined in consideration that the elastic member 113 has rigidity. If the node of the coupled arm-bearing mode coincides with the point of application c of the drive force, the mode will not be excited by drive force f even when the coupled arm-bearing mode is potentially present. Referring to the graph shown in Fig. B4, which shows the frequency response characteristics of the head positioner 5 according to this embodiment, the resonance peak indicated in the drawing by arrow c is derived from the arm sway mode. It is found that the resonance peak is remarkably suppressed in height compared with the aforementioned conventional example 1 shown in Fig. B15. Moreover, as described above, the point of application c of drive force f lies on an arc equally distant

from the perimeter (inner perimeter) near the shaft 6 and from the perimeter distant therefrom (outer perimeter), on the permanent magnet 23 having the shape of a sector. Accordingly, a process for the fine adjustment of the position to which the permanent magnet 23 is attached may be added on a line orthogonal to the arc, thereby allowing the position of the point of application c to coincide with the node of the coupled arm-bearing mode with higher accuracy.

As described above, the head positioner 105, according to embodiment B1 of the present invention, is configured so as to attach the sleeve 112 to the shaft 6, a fixing portion, via the ball bearings 7 having translation rigidity. Moreover, the head positioner 105 is configured so as to attach the rotor 114 to the sleeve 112 via the elastic member 113. Thus, the resonance frequency caused by the quasi rigid body mode can be placed apart from the servo bandwidth in order not to become an unstable factor in the control. Moreover, use of resin having a viscoelasticity for the elastic member 113 enables making the attenuation ratio of resonance larger, thus providing more improved stability than ever. In addition, the configuration in which the middle head arm 111b is made larger in width than the upper and lower head arms 111a and 111c, and about two times larger in support rigidity can drastically reduce the resonance peak which is caused by the arm sway mode. In addition, the point of application c of drive force coincides with the node of the coupled arm-bearing mode can prevent the coupled arm-bearing mode from being excited, thereby drastically reducing the resonance peak. These allow the

servo bandwidth for the control of head positioning to be extended. The application of this embodiment to a magnetic disk unit of a form factor of 3.5 inches has made it possible to control a bandwidth of 1kHz which has been controlled with difficulty by means of the prior art. This allows providing improved positioning accuracy and realizing a magnetic disk unit with a high track density.

Furthermore, according to this embodiment, the geometrical position of the drive force providing mechanism is not limited, thereby allowing the head positioner to be readily accommodated in a housing with standard dimensions.

Still furthermore, according to this embodiment, excessive inertia needs not to be added to the head carriage, thereby providing a reduced moment of inertia of the carriage. This allows the implementation of a magnetic disk unit that can perform high-speed operation of head positioning.

Furthermore, this embodiment employs a trapezoidal shape as a planar shapes for the head arms 111a, 111b, and 111c, however, other shape may be employed as well. In addition, the upper and lower head arms 111a and 111c may be configured so as to have notches at the proximal ends thereof, thereby providing the predetermined support rigidity.

(Embodiment B2)

An information recording or reproducing apparatus, according to embodiment B2 of the present invention, will be

explained below with reference to Fig. B7, a magnetic disk being taken as an example. Fig. B7 is a perspective view showing a carriage of a head positioner in the magnetic disk unit according to embodiment B2 of the present invention. The magnetic disk unit according to this embodiment has the same components and operation as embodiment B1 and thus its explanation is omitted, except for a carriage 210 shown in Fig. B7.

What is different in the carriage 210 of Fig. B7 from the carriage 110 of embodiment B1 is only the configuration of the head arms 211a, 211b, and 211c. The configuration of the carriage 210 except for this is the same as the carriage 110 of embodiment B1, and its explanation is omitted with the same reference numbers given to the same components.

As shown in Fig. B7, the middle head arm 211b is two times the thickness of the upper and lower head arms 211a and 211c, respectively. In addition, the three head arms have all the same plane shapes. Therefore, the head arm 211b is approximately two times larger than the head arms 211a and 211c in the second moment of area produced by the deflection of the magnetic disks toward the surfaces thereof.

The head positioner, configured as such, of the magnetic disk unit, according to this embodiment, is adapted not to cause the resonance derived from the quasi rigid body mode and the coupled arm-bearing mode to provide an unstable factor to the control of head positioning based on the same action as that of the head

positioner according to embodiment B1.

Moreover, concerning the arm sway mode, the middle head arm 211b is two times the thickness of the upper and lower head arms 211a and 211c, and is thus approximately two times the support rigidity, thereby satisfying the arm balance condition described in the foregoing. Therefore, the same action as that of the head positioner of embodiment B1 allows the resonance peak derived from the arm sway mode to be reduced, thus providing the same property as the frequency characteristics shown in Fig. B4. Like the embodiment B1, this allows servo bandwidth for the dynamic control of head positioning to be extended, thereby providing improved positioning accuracy.

Furthermore, this embodiment allows each of the head arms 211 to have the same planar shape, and thus provides such an effect as thereby facilitates the design and fabrication, for example, the handling of the signal wires to the heads 2.

(Embodiment B3)

An information recording or reproducing apparatus, according to embodiment B3 of the present invention, will be explained below with reference to Fig. B8, a magnetic disk being taken as an example. Fig. B8 is a perspective view showing a carriage of a head positioner in the magnetic disk unit according to embodiment B3 of the present invention. The magnetic disk unit, according to this embodiment, has completely the same components and operation as embodiment B1 and thus its explanation is omitted, except for a carriage 310 shown in Fig. B8.

What is different in the carriage 310 of Fig. B8 from the carriage 110 of embodiment B1 is only the configuration of the head arms 311a, 311b, and 311c. The configuration of the carriage 310 except for this is the same as the carriage 110 of embodiment B1, and its explanation is omitted with the same reference numbers given to the same components.

As shown in Fig. B8, the head arms 311a, 311b, and 311c have completely the same thickness and planar shape. In addition, the upper and lower head arms 311a and 311c are provided with penetrating holes 315a and 315c, respectively, whereas the head arm 311b is not provided with a penetrating hole. Therefore, the head arm 311b is two times larger than the head arms 311a and 311c in the second moment of area produced by the deflection of the magnetic disks toward the surfaces thereof.

The head positioner, configured as such, of the magnetic disk unit according to this embodiment, is adapted not to cause the resonance derived from the quasi rigid body mode and the coupled arm-bearing mode to provide an unstable factor to the control of head positioning based on the same action as that of the head positioner according to embodiment B1.

Moreover, concerning the arm sway mode, only the upper and lower head arms 311a and 311c are provided with penetrating holes and are thus two times the support rigidity of the middle head arm 311b, thereby satisfying the arm balance condition. The

same action as that of the head positioner of embodiment B1 allows the resonance peak derived from the arm sway mode to be reduced, thus providing the same property as the frequency characteristics shown in Fig. B4. Like the embodiment B1, this allows servo bandwidth for the dynamic control of head positioning to be extended, thereby providing improved positioning accuracy.

Furthermore, like the embodiment B2, this embodiment allows each of the head arms 311 to have the same planar shape, and thus provides such an effect as thereby facilitates the design and fabrication, for example, the handling of the signal wires to the heads 2.

Still furthermore, the carriage 210 of the embodiment B2 is provided with a predetermined value of support rigidity toward the surfaces of the disks by changing the thickness of the head arms 211. This has the possibility of exerting an effect on the support rigidity toward the surfaces of the disks and in the direction of torsion. By contrast, the carriage 310 according to embodiment B3 allows the head arms 311 to have also the same thickness, thereby exerting no great influence on the support rigidity toward the surfaces of the disks and in the direction of torsion and thus providing such an effect as realizes good overall oscillation properties.

Furthermore, in the embodiment B3, only the upper and lower head arms 311a, 311b, and 311c are configured so as to have penetrating holes, however, the middle head arm 311b may be.

provided with a penetrating hole having a different shape from those of the head arms 311a and 311c. For example, the middle head arm 311b can be configured so as to have a penetrating hole smaller in the cross-sectional area than those of the head arms 311a and 311c, thereby providing a reduced moment of inertia for the entire carriage 310 while satisfying the arm balance condition. Moreover, the configuration may employ not only a penetrating hole but also a projection and depression.

Furthermore, explanations have been given on the precondition that resin with a viscoelasticity is used as the elastic member 113 in embodiments B1 through B3, however, the present invention is not limited thereto and any elastic member with predetermined rigidity may be employed. For example, a spring such as a plate spring or a coil spring may be employed. Alternatively, without attaching a separate spring member, such a configuration may be employed in which the carriage is deformed to be integrated with a hinge having resilience.

Furthermore, in the embodiments B1 through B3, explanations have been given on the precondition that the elastic member 113 is interposed between the sleeve 112 and the rotor 114 in order to configure an oscillatory system with two degrees of freedom in series in which the ball bearings 7 serve as the first spring and the elastic member 113 serves as the second spring, however, the position of the elastic member 113 is not limited thereto. For example, the same effect can be obtained by configuring an oscillatory system with two degrees of freedom

in series in which the elastic member 113 is interposed anywhere between the sleeve 112 and the ball bearings 7, between the ball bearings 7 and the shaft 6, or between the shaft 6 and the base 4. Moreover, the elastic member 113 may be disposed in a plurality of the aforementioned positions to configure an oscillatory system with three degrees of freedom in series.

(Embodiment B4)

An information recording or reproducing apparatus, according to embodiment B4 of the present invention will be explained below with reference to Fig. B9 through Fig. B15, a magnetic disk being taken as an example. Fig. B9 is a plan view showing a major portion of the magnetic disk unit according to embodiment B4 of the present invention. Fig. B10 is a plan view showing a carriage of a head positioner in the magnetic disk unit according to embodiment B4 of the present invention. Fig. B11 is a side view showing a carriage of a head positioner in the magnetic disk unit according to embodiment B4 of the present invention.

Referring to Fig. B9 through Fig. B11, two magnetic disks 1a and 1b, on which concentric recording tracks are formed, rotate by means of a spindle motor 3 with constant angular speed. Four magnetic heads 2a, 2b, 2c, and 2d, which record and reproduce information on each of four recording surfaces of the magnetic disks 1, are supported close to the recording surfaces by means of suspensions 8, respectively. The magnetic heads 2a, 2b, 2c, and 2d are transported by means of a head positioner 405 to position in order to oppose desired recording tracks of the magnetic disks

1.

A carriage 410 of the head positioner 405 is rotatably disposed, at the shaft 6 center, by means of two ball bearings 7 provided on the shaft 6 secured to a base 4 of the magnetic disk unit. However, the carriage 410 is provided with a sleeve 412 for holding the ball bearings, and a rotor 414. The rotor 414 is attached to the sleeve 412 movably in translation via a pair of parallel plate springs 413a which are connected to the sleeve 412 at one end and to the rotor 414 at the other end.

Moreover, dampers 413b with a viscoelasticity are inserted in between the sleeve 412 and the rotor 414. That is, the rotor 414 is attached to the sleeve 412 via a "spring-damper system in a parallel arrangement". The spring constant thereof is set so that the natural oscillation determined by the relationship thereof with the mass of the rotor 414 is approximately 210Hz.

The rotor 414 comprises three head arms 411a, 411b, and 411c, which have a predetermined length from the center of rotation in the radial direction. The head arm 411a is provided, on the distal end portion thereof, with a head 2a via the suspensions 8. The head arm 411b is provided, on the distal end portion thereof, with heads 2b and 2c via the suspensions 8. The head arm 411c is provided, on the distal end portion thereof, with a head 2d and a head 2c via the suspensions 8. That is, the head arm 411a is disposed above the magnetic disk 1a (when viewed toward the surface of the page of Fig. B11) and the head arm 411c is disposed below

the magnetic disk 1b (when viewed in the same direction) support one head. On the other hand, the head arm 411b disposed between the two magnetic disks 1a and 1b supports two heads.

Each of the head arms 411a, 411b, and 411c has the same dimensions. However, the head arms 411a and 411c are provided near the proximal end thereof with a pair of notches 415a and 415c, whereas the head arm 411b is not provided. The width W_1 of the cross section with the notches of the head arms 411a and 411c is set to 75% the width of the cross section of the head arm 411b (that is, the width of the initial cross section).

With the aforementioned setting, the head arm 411b is approximately two times larger than the head arms 411a and 411c in the second moment of area produced by the deflection of the magnetic disks 1 toward the surfaces thereof. Furthermore, the magnetic heads 2a, 2b, 2c, and 2d have the same shape.

There is provided a main planar coil 421a on the side opposite to the head arms 411 across the center of rotation of the rotor 414. Moreover, there is provided a sub coil 421b inside the main coil 421a. There is disposed a permanent magnet 423 opposed to the two coils 421a and 421b with a certain clearance therebetween, thus constituting a drive mechanism 420, which is typically called the voice coil motor.

The portion that cuts the magnetic flux of the permanent magnet 420 along the sides of the main coil 421a and the sub coil

421b, which are orthogonal to the direction of rotation, that is, extend in the "radial" direction, serves as the drive force generating portion. The drive force generating portion of the main coil 421a is located at the same position as that of the end of the inner perimeter of the drive force generating portion of the sub coil 421b. In addition, the end of the outer perimeter of the sub coil 421b coincides substantially with the midpoint of the drive force generating portion of the main coil 421a. In addition, an output current I_o of a driver (not shown) is divided in a predetermined proportion into a current I_a flowing in the main coil 421a and a current I_b flowing in the sub coil 421b, with the proportion being variable.

Energizing the main coil 421a and the sub coil 421b will cause an electromagnetic force to develop, giving a torque to the carriage 410 with the rotational axis on the shaft 6. Furthermore, the rotation support mechanism of the present invention corresponds to the shaft 6 and the ball bearings 7 of this embodiment, while the translation support mechanism of the present invention corresponds to the parallel plate springs 413a and the dampers 413b of this embodiment.

The head positioner, configured as such, of the magnetic disk unit, according to this embodiment, is adapted not to cause the resonance derived from the quasi rigid body mode to provide an unstable factor to the control of head positioning based on the same action as that of the head positioner 105 according to embodiment B1.

Fig. B12 is a graph showing the frequency response characteristics of the head positioner according to embodiment B4 of the present invention. Referring to Fig. B12, the abscissa axis shows the frequency of the sinusoidal current I_0 for driving the head positioner 405, while the ordinate axis shows the displacement of the magnetic heads 2 per unit current in decibels. The resonance peak shown by arrow "a" in Fig. B4 near 210Hz is derived from the quasi rigid body mode. This resonance peak is sufficiently apart from the servo bandwidth (a gain crossover frequency) of 1kHz with the attenuation ratio being sufficiently large, thereby never exerting an influence on the stability of the control. Particularly, according to this embodiment, the sleeve 412 and the rotor 414 are coupled directly by means of the metallic parallel plate springs 413a, thus leading to less deformation against a variation in temperature or humidity making the same stable. Moreover, the dampers 413b are provided in parallel to the parallel plate springs 413a, thereby allowing the attenuation ratio to be set independently of the spring constant and thus providing a sufficient attenuation effect. Incidentally, in this embodiment, explanation has been given on the configuration in which the dampers 413b are provided on both sides of the sleeve 412 to be symmetric with each other. However, the number and positions of the dampers are not limited thereto so long as a member with a viscoelasticity is disposed across the sleeve 412 and the rotor 414.

Next, concerning the arm sway mode, the upper and lower

head arms 411a and 411c are provided with notches 415a and 415c, and are thus half times the support rigidity of the middle head arm 411b, thereby satisfying the arm balance condition described above.

Therefore, the same action as that of the head positioner 105 of embodiment B1 allows the resonance peak derived from the arm sway mode to be reduced. In the graph indicating the frequency response characteristics of the head positioner 405 according to this embodiment shown in Fig. B12, the resonance peak shown by arrow b in the drawing is derived from the arm sway mode. It can be seen that the height of the resonance peak is drastically suppressed compared with the aforementioned conventional example 1 of Fig. B20. This allows servo bandwidth for the dynamic control of head positioning to be extended, thereby providing improved positioning accuracy.

Next, the operation of the coupled arm-bearing mode is explained. Like the aforementioned conventional example 1, the head positioner 405 in the magnetic disk unit according to the embodiment B4 also has the coupled arm-bearing mode. Fig. B13 is a plan view showing the coupled arm-bearing mode of the head positioner 405 in the magnetic disk unit according to the embodiment B4 of the present invention. Shape A indicated by dashed lines in Fig. B13 is the shape before the deformation, whereas shape B shown by solid lines is the one when deformed. This oscillatory mode takes place in a manner such that the middle portion deflects upward when both ends of the carriage 410 deflect

downward when viewed toward the surface of the page.

Therefore, this oscillatory mode causes necessarily two oscillatory nodes (points showing no displacement when oscillation occurs) to appear, one toward the side of the drive mechanism among them being a point shown by n in the drawing. In this embodiment, the carriage 410 is configured in a manner such that the point n appears slightly toward the inner perimeter (at the position 21mm apart from the center of the shaft 6) from the midpoint of the drive force generating portion of the aforementioned main coil 421a. More specifically, the distribution of the mass of each portion of the carriage 410 and the rigidity of each portion such as the mounting portion of the main coil 421a have been determined on the precondition that the parallel plate springs 413a are rigid.

Fig. B14 is a view showing a drive force of the head positioner in the magnetic disk unit according to the embodiment B4 of the present invention. In the graph shown in the graph, the abscissa axis indicates distance r from the center of the shaft 6, while the ordinate axis indicates the drive force. In the graph, a graph indicated by p is the distribution of the drive force produced by means of the main coil 421a and while a graph indicated by 1 by q is the distribution of the drive force produced by means of the sub coil 421b.

When these distributed forces are displaced by equivalent concentrated forces, the distributed force p changes to force

f_a acting on point a and the distributed force q to f_b acting on point b. Here, letting the resultant force (that is, the resultant force of all drive forces) of f_a and f_b be equal to f_c , and the point of application be c, the position of point c is to vary depending on the ratio of the current I_a of the main coil 421a to the current I_b of the sub coil 421b. For example, with I_a constant, point c will coincide with point a if I_b is equal to zero, point c being to approach toward point b with increasing I_b . Therefore, the point of application c of the drive force can be set to any point depending on the setting of the ratio of I_a through I_b .

Fig. B15 is a graph showing the relationship between the resonance peak of the coupled arm-bearing mode and the position of the drive point in the embodiment B4 of the present invention. In the drawing, the abscissa axis represents the position of the drive point c with the distance from the center of the shaft 6, while the ordinate axis represents the magnitude of the resonance peak derived from the coupled arm-bearing mode. The point shown by arrow d (the position at 21mm) is the position of node n of the coupled arm-bearing mode, which has been explained with reference to Fig. B13.

Referring to Fig. B15, the magnitude of the resonance peak decreases as the position of drive point c approaches the node n of the mode. The coupled arm-bearing mode will be completely subjected to no excitation when the position of drive point c coincides precisely with node n of the mode, causing the resonance

peak to disappear. Moreover, the height of the resonance peak can be made one-tenth or less when the position of drive point c is 1.2mm apart from node n of the mode. In the same way, the height of the resonance peak can be made one-hundredth or less when the position of drive point c is within the distance of 0.18mm.

As described above, in this embodiment, first, the carriage 410 is configured so that the node n of the mode is positioned slightly toward the inner perimeter from the midpoint of the drive force generating portion of the main coil 421a. Secondly, the ratio of the current I_a of the main coil 421a to the current I_b of the sub coil 421b is set appropriately, thereby allowing the position of drive point c to coincide with the node n of the mode. In the graph illustrating the frequency response characteristics of the head positioner 405 according to this embodiment shown in Fig. B12, the resonance peak shown by arrow c in the drawing is derived from the coupled arm-bearing mode. It can be seen that the height of the resonance peak is drastically suppressed compared with the aforementioned conventional example 1 of Fig. B20.

This allows servo bandwidth for the dynamic control of head positioning to be extended, thereby providing improved positioning accuracy. Incidentally, a method for adjusting the ratio of current I_a to current I_b is as follows. That is, a sinusoidal wave of a single frequency of the resonance frequency of the coupled arm-bearing mode (equal to 4.1kHz in this embodiment) is inputted to vary the ratio of current I_a to current I_b while the displacement

of the magnetic heads 2 are measured, and the ratio is set to the minimum value of the displacement.

As described above, the head positioner 405 of the embodiment B4 of the present invention is configured in a manner such that the shaft 6, a fixing portion, is provided with the sleeve 412 via the ball bearings 7 having translation rigidity. The head positioner 405 is also configured such that the sleeve 412 is provided with the rotor 114 via the parallel plate springs 413a and the dampers 413b. This configuration allows the resonance frequency derived from the quasi rigid body mode to be separated sufficiently from the servo bandwidth as well as the resonance peak to attenuate sufficiently to avoid giving an unstable factor to the control.

Furthermore, the head positioner 405 has such a configuration that the upper and lower head arms 111a and 111c are provided with the notches 415a and 415c, respectively, and thus made smaller in the cross section than the middle head arm 111b, with support rigidity being about half. This allows the resonance peak derived from the arm sway mode to decrease tremendously.

Furthermore, the head positioner 405 is configured so as to be provided with the main coil 421a and the sub coil 421b with different points of application of drive force, and as to allow the point of application of the resultant force of drive points to coincide with the node of the coupled arm-bearing mode. This

allows the resonance peak derived from the coupled arm-bearing mode to decrease tremendously. This enables the servo bandwidth of the head positioning control to extend.

The application of this embodiment to a magnetic disk unit of a form factor of 3.5 inches has made it possible to control a bandwidth of 1kHz which have been controlled with difficulty by means of the prior art. This allows providing improved positioning accuracy and realizing a magnetic disk unit with a high track density.

Incidentally, this embodiment allows only the head arms 411a and 411c to be provided with notches 415a and 415c. However, such a configuration may be employed in that the middle head arm 411b is also provided with the notch, so long as the aforementioned arm balance condition is satisfied. In addition, the shape and position of the notches are not limited to particular ones.

Furthermore, the carriage 410 according to this embodiment is configured so as to set the support rigidity of the head arms 411 based on the notches 415, and thus provides high general versatility to serve as parts. For example, in this embodiment, explanations have been given of a carriage, as an example, having two recording media 1a and 1b with each surface thereof being a recording surface, and three head arms 411a, 411b and 411c for supporting one, two, and one magnetic heads 2, respectively. However, for such a unit as has the recording medium 1a the upper surface of which is not used for recording, the number of magnetic

heads 2 to be supported will be of three types, that is, zero, two, and one.

Furthermore, for a unit that employs only one recording medium, the number of magnetic heads 2 will be zero, one, and one, respectively. According to the present invention, a first process for forming the shape of the rotor 414 without notches and a second process for forming notches 415 in accordance with the number of magnetic heads 2 to be supported are provided, thereby allowing units having different specifications to be shared with the same component. Incidentally, even in cases where the number of the magnetic heads 2 to be supported is of three types or more, such a configuration can be employed that allows for providing notches, in order to satisfy the aforementioned arm balance condition, for the arm head in a manner such that the larger the number of magnetic heads to be supported, the higher the support rigidity of the head arm becomes.

Furthermore, in any embodiment of the present invention, explanation has been given on the precondition that each head arm is made of the same material since the rotor is made of the same material in one unit. However, for example, such a configuration may be employed in that the middle arm is made of a material higher in rigidity than the upper and lower arms to be attached to the rotor. Moreover, such a configuration may be employed in that each arm is formed as a separate member and provides a difference in rigidity of the coupling portion when attached to the rotor.

Furthermore, in any embodiment of the present invention, explanations have been given on the precondition that the head positioner has three head arms. However, the present invention, not limited to these embodiments, can be applied to any head positioner that comprises at least one or more head arms for supporting one head and for supporting two heads, respectively.

Still furthermore, the head positioner of the present invention can also be applied to a mechanism that has a head arm for supporting three or more heads or a head arm for supporting no heads, so long as the arm balance condition is satisfied. Even in these cases, the same effect can be obtained which has been explained in the embodiments. However, the arm for supporting no heads is, for example, an arm that is resulted as an excessive arm when arms (three in typical cases) for use in two recording media (for example, magnetic disks) are used for recording or reproducing one recording medium for reasons of fabrication. (This is because two arms are typically used for one recording medium.) This arm corresponds to a head arm for supporting zero heads according to the claims.

As is obvious from the explanations given above, the information recording or reproducing apparatus of the present invention can eliminate the effect of mechanical resonance that has been a limiting factor in servo bandwidth of the head positioning control to extend the servo bandwidth. This allows for providing improved head positioning accuracy, and realizing

an information recording or reproducing apparatus with a high track density.

What is Claimed is:

1. A head positioner comprising:

a head supporting means for supporting a head for recording or reproducing information on a recording medium having recording tracks formed thereon,

a rotate support portion for supporting rotatably said head supporting means,

a drive means for providing said head supporting means with a drive force at a predetermined drive point of said head supporting means, wherein

said head supporting means transports said head substantially in a direction orthogonal to said recording tracks around a center of a rotational axis in said rotate support portion to position said head at a predetermined recording track of said recording medium, and

said head supporting means makes an oscillatory direction of said head in at least one natural vibration mode of a plurality of natural vibration modes which said head positioner has, substantially parallel to a direction of a tangent at such position of a predetermined recording track of said recording medium, at said position of which said head can be provided, and for making an oscillatory direction of a drive point at least another one natural vibration mode substantially perpendicular to a direction of said drive force.

2. The head positioner comprising:



a head supporting means for supporting a head for recording or reproducing information on a recording medium having recording tracks formed thereon,

a rotate support portion for supporting rotatably said head supporting means, and

a drive means for providing said head supporting means with a drive force at a predetermined drive point of said head supporting means,

said head supporting means transporting said head substantially in a direction orthogonal to said recording tracks around a center of a rotational axis in said rotate support portion to position said head at a predetermined recording track of said recording medium, wherein

said head supporting means has oscillatory direction restricting means for making an oscillatory direction of said head in at least one natural vibration mode of a plurality of natural vibration modes which said head positioner has substantially parallel to a direction of a line connecting a center of said rotate support portion to said head, and for making an oscillatory direction of a drive point at least another one natural vibration mode substantially perpendicular to a direction of said drive force.

3. The head positioner according to Claim 1 or 2, where in

said head supporting means comprises



a first arm for supporting said head,

a second arm disposed, at said rotate support portion, in a direction perpendicular to said first arm, and supplied with said drive force from said drive means, and

a third arm disposed, at said rotate support portion, to said first arm and having different rigidities each depending on a direction to the center of said rotate support portion.

4. The head positioner according to Claim 3, wherein said third arm has rigidities different in a direction parallel to said first arm and in a direction perpendicular to the direction.

5. The head positioner according to Claim 2, wherein said third arm comprises

a high rigidity portion extending from said rotate support portion in a direction of opposite to said first arm, and

a low rigidity portion extending in a direction perpendicular to an extending direction of said high rigidity portion from a tip end of said high rigidity portion and having lower bending rigidity than said high rigidity portion.

6. The head positioner according to Claim 1 or 2, where in fourth arm

said head supporting means comprises

a fourth arm for supporting said head,

a fifth arm disposed, at said rotate support portion, and disposed at a position displaced by a predetermined angle from



a direction perpendicular to said fourth arm, and supplied with said drive force from said drive means,

a sixth arm disposed, at said rotate support portion, at said rotate support portion, on a line substantially dividing a central angle between said fourth arm and said fifth arm into two angles, in an opposite side to said first and second arms with respect to said rotate support portion, and

a natural frequency of said fourth arm and a natural frequency of said fifth arm are apart from each other by two times or more.

7. The head positioner according to Claim 6, wherein said fifth arm comprises

a notched portion is formed in a coupling portion of said fifth arm to said rotate support portion, and

said notched portion is to reduce the natural frequency of said fifth arm.

8. The head positioner according to claim 1 or 2, wherein said head supporting means comprises

a seventh arm for supporting said head,

a eighth arm disposed, at said rotate support portion, in a direction perpendicular to said first arm and supplied with said drive force from said drive means, and

a ninth arm disposed to said rotate support portion, at said rotate support portion, on a line substantially dividing a central angle between said seventh arm and said eighth arm into



two angles, in a direction opposite to said seventh and eighth arms with respect to said rotate support portion,

a center member for coupling said respective arms to support said respective arms, and

said center member has different rigidities in a direction parallel to said seventh arm and in a direction perpendicular to the direction.

9. The head positioner according to Claim 8, wherein said center member is provided with a plurality of curved slots disposed symmetrical with respect to a line orthogonal, at a center of rotation of said rotate support portion, to a line connecting said the center of said rotate support portion and said head.

10. The head positioner according to any one of Claims 1 to 9, wherein

said head supporting means is configured so that a center of mass thereof coincides substantially with a center of rotation thereof.

11. The head positioner according to any one of Claims 3 to 11, wherein

said third, sixth or ninth arm is provided, on a distal end thereof, with a balance member, and

said balance member is made of a material with a larger specific gravity than materials of said first and second arms, those of said forth and fifth arms or those of said seventh and



eight arms, respectively.

12. The head positioner according to any one of Claims 3 to 11, wherein

a coupling member provided between the first arm and the second arm, said fourth and fifth arms or said seventh and eighth arms.

13. An information recording or reproducing apparatus at least comprising:

the head positioner according to any one of Claims 1 to 12, and a recording medium.

14. An information recording or reproducing apparatus comprising:

a recording medium having recording tracks formed thereon,
a head for recording or reproducing information on said recording medium, and

a head positioner for positioning said heads at predetermined recording tracks on said recording medium, wherein said head positioner has at least two head arms, said at least two head arms support zero, or one or more heads, respectively, and

a head arm for supporting a larger number of heads has greater support rigidity than a head arm for supporting a smaller number of heads.

15. The information recording or reproducing apparatus according to Claim 14, wherein

a second moment of area of said head arm for supporting a larger number of heads is greater than that of said head arm



for supporting a smaller number of heads, said second moment of area being derived from a bending in a plane parallel to said recording medium.

16. The information recording or reproducing apparatus according to Claim 15, wherein

a surface, opposed to said recording medium, of said head arm for supporting a larger number of heads is greater in width than that of said head arm for supporting a smaller number of heads.

17. The information recording or reproducing apparatus according to Claim 15, wherein

a length of a shorter side of a plane, orthogonal to said recording medium, of said head arm for supporting a larger number of heads is greater than that of said head arm for supporting a smaller number of heads.

18. The information recording or reproducing apparatus according to Claim 15, wherein

said head arm for supporting a smaller number of heads has a penetrating hole on a plane opposed to said recording medium.

19. The information recording or reproducing apparatus according to Claim 18, wherein

an area of a cross section, parallel to said recording medium, of said penetrating hole is greater than that of said head arm for supporting a larger number of heads.

20. The information recording or reproducing apparatus according to Claim any one of Claims 14 through 18, wherein

said head arm for supporting a smaller number of heads supports one head, and



said head arm for supporting a larger number of heads supports two heads.

21. An information recording or reproducing apparatus comprising:

a recording medium having recording tracks formed thereon, heads for recording or reproducing information on said recording medium,

a head positioner, provided on a base, for positioning said heads at predetermined recording tracks on said record media, wherein

said head positioner comprises

a carriage for supporting said heads,

a rotation support mechanism for supporting rotatably said carriage at a center on a predetermined rotational shaft provided on said base,

a translation support mechanism for supporting said carriage in a radial direction of said predetermined rotational shaft with predetermined translation rigidity, disposed between said carriage and said rotation support mechanism, between said rotation support mechanism and said base, or inside said rotation support mechanism, and

a drive mechanism for providing rotational drive forces for said carriage.

22. The information recording or reproducing apparatus according to Claim 21, wherein said translation support mechanism is an elastic body.

23. The information recording or reproducing apparatus according to Claim 22, wherein said elastic body is made of a



material with a viscoelasticity.

24. The information recording or reproducing apparatus according to Claim 21, wherein said translation support mechanism has a pair of parallel plate springs with one end thereof fixed to said carriage and the other end thereof fixed to said rotation support mechanism.

25. The information recording or reproducing apparatus according to Claim 24, wherein said translation support mechanism has a further viscous elastic member with one end thereof fixed to said carriage and the other end thereof fixed to said rotation support mechanism.

26. The information recording or reproducing apparatus according to Claim 15, wherein

said head arm for supporting a smaller number of heads is formed so as to be substantially less than said head arm for supporting a larger number of heads in a cross-sectional area of a predetermined cross section orthogonal to said recording medium.

27. An information recording or reproducing apparatus comprising:

recording medium having recording tracks formed thereon,
heads for recording or reproducing information on said recording medium,

a head positioner, provided on a base, for positioning said heads at predetermined recording tracks on said recording media,
wherein

said head positioner comprises

a carriage for supporting said heads,



a rotation support mechanism for supporting rotatably said carriage at a center on a predetermined rotational shaft provided on said base, and

a drive mechanism for providing rotational drive forces for said carriage,

said head positioner has nodes of mode shape of natural vibration modes of said head positioner coinciding with points of application of a resultant force of said rotational drive forces.

28. The information recording or reproducing apparatus according to Claim 27, wherein

said drive mechanism has a drive point adjustment mechanism for allowing said nodes of natural vibration modes to coincide with said points of application of a resultant force of said rotational drive forces.

29. The information recording or reproducing apparatus according to Claim 28, wherein

said drive point adjustment mechanism has a first drive force generating portion and a second drive force generating portion, wherein

a distance between a point of application of a resultant force of drive forces generated by said first drive force generating portion and said rotational shaft is different from a distance between a point of application of a resultant force of drive forces generated by said second drive force generating portion and said rotational shaft, and

a ratio of a magnitude of a drive force generated by said first drive force generating portion to a magnitude of a drive



force generated by said second drive force generating portion
is adjustable.

