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ACTUATOR SHOCK SNUBBER

Field of the Invention

This application relates generally to the field of disc drive storage devices, and more particularly, to an apparatus and method for mitigating shock and reduce damage to the actuator assembly and other components in the disc drive.

Background of the Invention

Disc drives are data storage devices that store digital data in magnetic form on a rotating storage medium, such as a disc. Modern disc drives comprise one or more rigid discs that are coated with a magnetizable medium and mounted on the hub of a drive motor for rotation at a constant high speed. Information is stored on the discs in a plurality of concentric circular tracks typically by an array of transducers ("heads") each mounted on a slider. Each slider is supported on a flexure attached to an actuator arm which is part of an actuator assembly that moves the head relative to the discs. Each transducer, e.g., a magnetoresistive read or write head, is used to transfer data between a desired track and an external environment. During a write operation, the write head writes the data onto the disc track, and during a read operation, the read head senses the data previously written on the disc track and transfers the information to a disc drive circuit board in the external environment.

The slider with the heads are mounted via flexures at the end of an actuator arm that projects radially outward from an actuator body in the actuator assembly. The actuator body pivots about a bearing assembly mounted on a base plate at a position closely adjacent to the outer extreme of the discs. The head(s) read data and transfer it through conductors on the actuator arm to a preamplifier which amplifies the signals coming from the heads.

Typically, the actuator assembly includes a voice coil motor to position the heads with respect to recording tracks on the disc surfaces. The actuator voice coil motor includes a coil mounted to the actuator body opposite the actuator arm and is immersed in the magnetic field of a magnetic circuit comprising one or more permanent magnets and magnetically permeable pole pieces. When controlled direct current (DC) is passed through the coil, an electromagnetic field is set up which interacts with the magnetic field of the magnetic circuit to cause the coil to move in

accordance with the well-known Lorentz relationship. As the coil moves, the actuator body and arm pivot about the bearing assembly and the heads move across the disc surfaces. When the disc drive is stationary, the voice coil motor pivots the actuator arm, flexure, and slider away from the disc and parks the slider on a load ramp attached to the base plate adjacent to the outer diameter of the disc. Alternatively, the slider may be parked in a loading zone on the outer perimeter of the disc.

The flexure includes a load beam and a gimbal insert. One end of the load beam is attached to an end of the actuator arm opposite of the actuator body. The other end of the load beam is connected to the gimbal insert. The gimbal insert in turn is attached to and supports the slider. The physical connection between the gimbal insert and the load beam is essential for maintaining a slider flying height which will allow the heads to read and write data to and from the disc.

Mechanical shock events caused by an impact to a computer may cause permanent damage to a hard disc drive. Shock events often cause damage to the flexure and associated slider. Specifically a shock event which occurs while the disc is stationary causes deflection of the actuator arm and attached flexure which in turn may cause elements of the actuator assembly to be permanently damaged such that the recording heads loose their ability to function.

Summary of the Invention

Against this backdrop the present invention has been developed to solve the above and other problems by using a snubber in a disc drive to reduce deflective movement of the actuator assembly.

A head disc assembly in a disc drive has a base plate and a top cover which encloses a drive motor, a disc supported thereon, and an actuator assembly. The actuator assembly has an actuator arm attached to one end of a flexure, and a slider or read/write head attached proximate to an opposite end of the flexure. A snubber is fastened to a stationary portion of the head disc assembly and has a snubber body and two or more snubber arms connected to the snubber body. The adjacent snubber arms form slots therebetween. As the actuator assembly pivots towards an outer diameter of the disc, a portion of the actuator assembly is inserted into each of the slots. While the actuator assembly is located within the slots, the snubber arms reduce the deflective movement of the actuator assembly during a mechanical shock

event. By reducing the deflective movement, the chances of permanently damaging the actuator assembly and other disc drive components are likewise reduced.

These and various other features as well as advantages which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

Brief Description of the Drawings

FIG. **1** is a plan view of a disc drive head disc assembly with the cover partially broken away which incorporates a snubber in accordance with one preferred embodiment of the invention with the head disc assembly.

FIG. **2** is top partial perspective view of the snubber shown in FIG. 1.

FIG. **3** shows a top partial perspective view of another preferred embodiment of the present invention.

FIG. **4** is a top partial perspective view of yet another preferred embodiment of the present invention.

Detailed Description

FIG. **1** shows a disc drive **100** with a snubber **200** constructed in accordance with one preferred embodiment of the present invention. The snubber **200** is fastened to a stationary portion of a head disc assembly. Preferably, the snubber **200** is formed from a rigid material with damping properties, such as plastic, but a non–damping material like aluminum or other metal may be used. The snubber **200** includes a snubber body **202** and one or more snubber arms **216**. A slot **230** may be formed between every two adjacent snubber arms **216**, between a base plate **102** and an adjacent snubber arm **216**, and between a metal top cover **104** and an adjacent snubber arm **216**. The slots **230** are adapted to receive an actuator arm **114** or a flexure **116** when an actuator assembly **110** is parked and/or when the disc drive **100** is not in operation. The number snubber arms **216** may depend upon the number of discs **108** or the number of actuator arms **114** and flexures **116** in the disc drive **100**. During a mechanical shock event, the vibrating actuator assembly **110** makes contact with the snubber arms **216** which reduce the deflection or vibration to thereby minimize the risk of permanent damage to the disc drive **100**.

Various other components of the disc drive **100** are mounted to the base plate **102**. The top cover **104** cooperates with the base plate **102** to form an internal, sealed environment for the disc drive components in a conventional manner. The

components include a drive motor **106** which rotates the discs **108** at a constant high speed. Information is written to and read from tracks on each of the discs **108** through the use of an actuator assembly **110**, which rotates about a bearing shaft assembly **112** positioned adjacent the discs **108**. The actuator assembly **110** includes an actuator body **113**, or E-Block, having one or more actuator arms **114**, which extend towards the discs **108**, with one or more flexures **116** extending from each actuator arm **114**. Mounted at an end of each of the flexures **116** opposite the actuator arm **114** is a head slider or "read/write head" **120** including one or more read and/or write heads **118**. The head slider **120** enables the heads **118** to fly in close proximity (or at a "flying height") above the corresponding surface of the associated disc **108**. The flying height is a height at which the heads can read from and write data onto a disc while not touching the disc surface.

The radial position of the slider **120** and its heads **118** are controlled through the use of a voice coil motor (VCM) **124**. The VCM **124** typically includes a coil **126** attached to the actuator assembly **110**, as well as one or more permanent magnets **128** which establish a magnetic field in which the coil **126** is immersed. The controlled application of current to the coil **126** causes magnetic interaction between the permanent magnets **128** and the coil **126** so that the coil **126** moves in accordance with the well known Lorentz relationship. As the coil **126** moves, the actuator assembly **110** pivots about the bearing shaft assembly **112** and the heads **118** are caused to move across the surfaces of the discs **108**.

Each of the flexures **116** includes a load beam **134** and a gimbal insert **142**. The load beam **134** has a distal end **136** positioned near the slider **120** and an opposite end (not shown) which is attached to the actuator arm **114**. The gimbal insert **142** is connected to the distal end **136** of the load beam **134**. The gimbal insert **142** is also attached to the load beam **134** at a point between the slider **120** and the actuator arm **114**. The slider **120** is mounted to the gimbal insert **142** in close proximity to the distal end **136** of the load beam **134**.

A load ramp **150** is attached to the base plate **102** at a point adjacent to the outer diameter of the disc **108**. One end **152** of the load ramp partially overlaps the outer diameter **109** of the disc **108**. When the disc **108** is stationary, the actuator assembly **110** pivots such that the slider **120** moves towards the outer diameter **109** of the disc **108** until a ramp arm **139** located at the distal end **136** of the load beam **134** makes contact with the load ramp **150**. The ramp arm **139** slides into the load ramp **150** until it reaches a parked position as shown in FIGS. **1** and **2**. The ramp

arm **139**, and thus the actuator assembly **110**, stay in the parked position while the disc drive **100** is not in operation.

The snubber **200** is attached to the base plate **102** adjacent to an opposite end **154** of the load ramp **150** from end **152**. Alternatively, the snubber **200** may be formed integrally with the load ramp **150** which would save manufacturing costs by reducing the number of separate parts in the disc drive **100**. However, the snubber **200** does not need to be attached to base plate **102**, but may be attached to any other stationary disc drive component, such as, the load ramp **150**.

The snubber body has an inner wall **204** facing disc **108**, and outer wall **206** opposite to the inner wall **204**, an inner end **208** facing the actuator body **113**, and an outer end **210** opposite of the inner end **208**. The snubber arms **216** are formed integrally with the inner wall **204** at a point adjacent to the inner end **208**.

As shown in FIGS. **1** and **2**, each snubber arm **216** is flat piece of rigid material having a generally square shape. However, the snubber arms **216** may be formed in any shape, such as a half circle, a triangle, or a combination of shapes. Each snubber arm **216** has an end **222**, two opposite sides **218** and **220** that connect the end **222** to the inner wall **204**, and opposite surfaces **224**. Preferably, the distance between the inner wall **204** of the snubber body **202** and the end **222** of the snubber arm **216** is greater than or equal to the width of the actuator arm **114** at the point where it attaches to the flexure **116**.

As best seen in FIG. **2**, the snubber arms **216** are stacked in linear alignment with a plane which is perpendicular to the plane of the disc **108** and every two adjacent snubber arms **216** form a slot **230** therebetween. The slots **230** are adapted to receive one or more actuator arms **114** and/or flexures **116** when the actuator assembly **110** is parked on the load ramp **150**. Another slot **230** is formed between one snubber arm **216** and the base plate **102** and is adapted to receive the actuator arm **114** that reads from and writes to a surface of disc **108** adjacent to the base plate **102**. Alternatively, the snubber **200** may have an additional snubber arm **216** which fits flush against the base plate **102**.

FIG. **2** shows snubber **200** installed in a disc drive with two discs **108**. Snubber **200** has three snubber arms **217**, **219**, and **221** that form slots **231** and **233**. Snubber arm **221** and the base plate **102** form a slot **235** (not shown). Slot **233** is larger than slots **231** and **235** because it is adapted to receive two actuator arms **114**. However, snubber **200** is not limited to three snubber arms **216** and may have more or less snubber arms **216** depending upon the number of actuator arms **114** in the

disc drive **100**. So for example, in a disc drive with four discs **108**, snubber **200** would have either five or six snubber arms **216** depending on whether or not there is a snubber arm **216** flush with the base plate **102**.

The snubber **200** is mounted to the base plate **102** via screw **214** through the snubber body **202**. The length of the snubber body, defined by the distance between the outer end **208** and the inner end **210**, will depend upon the following factors: the location where the snubber **200** is mounted to the base plate **102**, the size of the snubber arms **216**, and the part of the actuator assembly **110** that needs to be snubbed.

When a mechanical shock event occurs and causes deflection or vibration of the actuator assembly **110**, the actuator assembly **110** will make contact with the surfaces **224** of the snubber arms **216** which, in turn, will limit the deflective movement of the actuator assembly **110**. Preferably, the snubber arms **216** are positioned to cover at least a portion of the actuator arms **114** and a portion of the flexures **116** when the actuator assembly **110** is parked. In this way, the snubber arms **216** will limit the deflective movement of the actuator arms **114** and the flexures **116** during a mechanical shock event. By limiting the deflective movement of the actuator assembly **110**, the chances that the gimbal insert **142** will become permanently separated from the load beam **134** are greatly reduced. Additionally, limiting deflective movement of the actuator assembly **110** will cause the following benefits: preventing the ramp arm **139** from pulling out the load ramp **150** while the actuator assembly **110** is parked, reducing the strain on the flexures **116** and thereby protecting a spring force on the flexure **116** which helps maintain the flying height during disc drive **100** operation, and reducing the strain on many of the drive components, such as, electrical traces along the actuator assembly **110**.

FIG. **3** shows another preferred embodiment of the present invention having a modified snubber **300** used in connection with a disc drive **101** having two discs **107** and **109** and an actuator assembly **111** with four actuator arms **115**, **117**, **119**, and **121** and four flexures **125**, **127**, **129**, and **131**.

Similar to first preferred embodiment of the present invention, snubber **300** is formed from a rigid material preferably with damping properties, such a plastic or rubber, but may also include non–damping materials such as metal. Snubber **300** includes a snubber body **302** and four snubber arms **317**, **319**, **321**, and **323**. Likewise, the number of snubber arms **316** will depend upon the number of actuator arms **114** in the disc drive **100**, and may have any number of snubber arms **316**. The

snubber body **302** has an inner wall **304** facing the disc **108**, and outer wall **306** opposite to the inner wall **304**, an inner end **308** facing the actuator body **113**, and an outer end **310** opposite of the inner end **308**. The snubber arms **317**, **319**, **321**, and **323** are flat, square–shaped pieces of rigid material. The snubber arms **317**, **319**, **321**, and **323** are formed integrally with the inner wall **304** and extend the entire length of inner wall **304**. Snubber arms **317** and **319** from slot **331**. Snubber arms **319** and **321** form slot **333**. Snubber arm **321** and the **323** form slot **335**.

Slot **331** is adapted for insertion of the actuator arm **115** and the flexure **125**. Slot **333** is adapted for insertion of the actuator arms **117** and **119** and the flexures **127** and **129**. Slot **335** is adapted for insertion of the actuator arm **121** and the flexure **131**. Snubber arms **317**, **319**, **321**, and **323** partially cover the actuator arms **115**, **117**, **119**, and **121** and the flexures **125**, **127**, **129**, and **131**.

Snubber **300** additionally has secondary snubber arms **337**, **339**, **341**, and **343** formed within snubber arms **319** and **321**. The secondary snubber arms **337** and **339** form a secondary slot **345** and the secondary snubber arms **341** and **343** form another secondary slot **347**. A portion of an outer diameter of the disc **107** is inserted into the secondary slot **345** and a portion of the outer diameter of disc **109** is inserted into the secondary slot **347** irregardless of the position of the actuator assembly **111**. In this way, the snubber **300** additionally reduces deflective movement of the discs **107** and **109** during a mechanical shock event via the secondary snubber arms **337**, **339**, **341**, and **343**.

As the actuator assembly **111** pivots towards the outer diameter of the discs **107** and **109**, the actuator arms **115**, **117**, **119**, and **121** and the flexures **125**, **127**, **129**, and **131** will be inserted into the slots **331**, **333**, and **335** as described above. In this way, the snubber arms **317**, **319**, **321**, **323** will limit the deflection of actuator arms **115**, **117**, **119**, and **121** and the flexures **125**, **127**, **129**, and **131** by providing a barrier against deflective movement of the actuator assembly **111**.

FIG. **4** shows another preferred embodiment of the present invention having a modified snubber **400**. Instead of having flat snubber arms, the snubber **400** has one or more pins **416** attached to an inner wall **404** of a snubber body **402**. The pins **416** can be made of metal or plastic or some other type of rigid material. Similar to the other preferred embodiments, the number of pins **416** will depend upon the number of discs **108** in the disc drive **100**. Likewise snubber **400** is mounted onto the base plate **102**. The snubber pins **416** may be positioned at any point along either the actuator arm **114** or the flexure **116**. Alternatively, the snubber **400** could

have pins **416** positioned along the actuator arm **114** and an additional set of pins **416** positioned along the flexure **116**.

In summary, one exemplary embodiment of the present invention as an apparatus reduces deflection of an actuator assembly (such as **110** or **111**) within a head disc assembly in a disc drive (such as **100** or **101**) during a mechanical shock event. The head disc assembly has the base plate (such as **102**) and the top cover (such as **104**) which encloses the drive motor (such as **106**) and the actuator assembly (such as **110** or **111**). The drive motor (such as **106**) supports the disc (such as **107**, **108**, or **109**) which spins at a given velocity during disc drive operation.

The actuator assembly (such as **110** or **111**) has the actuator arm (such as **114**, **115**, **117**, **119**, or **121**) attached to one end of the flexure (such as **116**, **125**, **127**, **129**, or **131**), and the slider or read/write head (such as **120**) attached proximate to the opposite end of the flexure (such as **116**, **125**, **127**, **129**, or **131**).

The snubber (such as **200**, **300**, or **400**), located within the head disc assembly, has the snubber body (such as **202**, **302**, or **402**) and two or more snubber arms (such as **216**, **217**, **219**, **221**, **316**, **317**, **319**, **321**, **323**, or **416**) connected to the snubber body (such as **202**, **302**, or **402**) wherein the adjacent snubber arms (such as **216**, **217**, **219**, **221**, **316**, **317**, **319**, **321**, **323**, or **416**) form a plurality of slots (such as **230**, **231**, **233**, **235**, **330**, **331**, **333**, **335**, or **430**) therebetween. The snubber arms (such as **216**, **217**, **219**, **221**, **316**, **317**, **319**, **321**, **323**, or **416**) are stacked in linear alignment with the plane perpendicular to the plane of the disc (such as **107**, **108**, or **109**). An additional slot (such as **235**) may be formed between the base plate (such as **102**) and the snubber arm (such as **221**) adjacent to the base plate (such as **102**).

A portion of the actuator assembly (such as **110**, **111**, **114**, **115**, **117**, **119**, **121**, **116**, **125**, **127**, **129**, or **131**) is located within the slots (such as **230**, **231**, **233**, **235**, **330**, **331**, **333**, **335**, or **430**) when the actuator assembly (such as **110** or **111**) is parked whereby deflection of the actuator assembly (such as **110** or **111**) is reduced during a mechanical shock event. The actuator assembly (such as **110** or **111**) may have a plurality of actuator arms (such as **114**, **115**, **117**, **119**, or **121**) and a portion of each actuator arm (such as **114**, **115**, **117**, **119**, or **121**) may be located within one of the slots (such as **230**, **231**, **233**, **235**, **330**, **331**, **333**, **335**, or **430**).

The snubber arms (such as **216**, **217**, **219**, **221**, **316**, **317**, **319**, **321**, **323**, or **416**) may be formed integrally with the snubber body (such as **202**, **302**, or **402**) or may be attached to the snubber body (such as **202**, **302**, or **402**). The snubber arms

(such as **216, 217, 219, 221, 316, 317, 319, 321, 323,** or **416**) may be a flat piece of rigid material (such as **216, 217, 219, 221, 316, 317, 319, 321,** and **323**) or a pin (such as **416**).

The snubber (such as **200, 300,** or **400**) may additionally have secondary snubber arms (such as **337, 339, 341,** and **343**) formed within snubber arms (such as **216, 217, 219, 221, 316, 317, 319, 321, 323,** or **416**). The adjacent secondary snubber arms (such as **337, 339, 341,** and **343**) form the secondary slot (such as **345** or **347**) therebetween within one or more of the snubber arms (such as **216, 217, 219, 221, 316, 317, 319, 321, 323,** or **416**). A portion of the outer diameter of the disc (such as **107, 108,** or **109**) is inserted into the secondary slot (such as **345** or **347**). In this way, the secondary snubber arms (such as **337, 339, 341,** and **343**) allow the snubber (such as **300**) to additionally reduce deflective movement of the discs (such as **107, 108,** or **109**) during a mechanical shock event.

Another exemplary embodiment of the invention is a method for reducing deflection of an actuator assembly (such as **110** or **111**) within a head disc assembly in a disc drive (such as **100** or **101**) during a mechanical shock event is as follows. The snubber (such as **200, 300,** or **400**) is provided to the disc drive (such as **100** or **101**) proximate to an outer diameter of a disc (such as **107, 108,** or **109**). The actuator assembly (such as **110** or **111**) is pivoted towards the outer diameter of the disc (such as **107, 108,** or **109**). And a portion of the actuator assembly (such as **110** or **111**) is inserted into each of the slots (such as **230, 231, 233, 235, 330, 331, 333, 335,** or **430**) between the snubber arms (such as **216, 217, 219, 221, 316, 317, 319, 321,** or **416**) wherein deflection of the actuator assembly (such as **110** or **111**) is reduced during a mechanical shock event.

In the method, a portion of the actuator arm (such as **114, 115, 117, 119,** or **121**) may be inserted into each of the slots (such as **230, 231, 233, 235, 330, 331, 333, 335,** or **430**). Or a portion of a flexure (such as **116, 125, 127, 129,** or **131**) may be inserted into each of the slots (such as **230, 231, 233, 235, 330, 331, 333, 335,** or **430**). Or a portion of the actuator assembly (such as **110** or **111**) where the flexure (such as **116, 125, 127, 129,** or **131**) attaches to the actuator arm (such as **114, 115, 117, 119,** or **121**) may be inserted into each of the slots (such as **230, 231, 233, 235, 330, 331, 333, 335,** or **430**). The snubber (such as **200, 300,** or **400**) may be affixed to a load ramp (such as **150**) within the disc drive (such as **100** or **101**) or may be formed integrally with the load ramp (such as **150**) within the disc drive (such as **100**

or **101**). Or the snubber (such as **200**, **300**, or **400**) may be fastened to any other stationary portion of the head disc assembly.

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes may be made which will readily suggest themselves to those skilled in the art. For example, the snubber body and the snubber arms may be of any shape that will sufficiently cover any portion of the actuator assembly to reduce deflection during a mechanical shock event. Also, the snubber may be located at any position within the disc drive so as to make contact with any portion of the actuator assembly. Accordingly, all such modifications, changes and alternatives are encompassed in the spirit of the invention disclosed and as defined in the appended claims.

WHAT IS CLAIMED IS:

1. An apparatus for reducing deflection of an actuator assembly within a head disc assembly in a disc drive during a mechanical shock event, the actuator assembly having an actuator arm attached to one end of a flexure, and a slider attached proximate to an opposite end of the flexure, the apparatus comprising:

a snubber fastened to a stationary portion of the head disc assembly having a snubber body and two snubber arms connected to the snubber body wherein each of the snubber arms is a pin and the snubber arms form a slot therebetween; and

a portion of the actuator assembly is located within the slot when the actuator assembly is parked whereby deflection of the actuator assembly is reduced during a mechanical shock event.

2. The apparatus of claim 1 wherein the snubber has more than two snubber arms and a slot is formed between adjacent snubber arms so that there are a plurality of slots.

3. The apparatus of claim 1 wherein the actuator assembly has a plurality of actuator arms wherein one or more portions of each actuator arm is located within one of the slots.

4. The apparatus of claim 1 wherein a portion of the snubber arm covers a portion of a disc within the disc drive.

5. The apparatus of claim 1 wherein each of the snubber arms is formed integrally with the snubber body.

6. The apparatus of claim 3 further comprising two secondary snubber arms forming a secondary slot therebetween and a portion of the disc is located within the secondary slot.

7. A method for reducing deflection of an actuator assembly within a head disc assembly in a disc drive during a mechanical shock event, the actuator assembly having an actuator arm attached to one end of a flexure, and a head slider attached proximate to an opposite end of the flexure; the method comprising steps of:

a) providing a snubber in the disc drive adjacent to an outer diameter of a disc, the snubber having a snubber body and two snubber arms connected to the snubber body wherein each of the snubber arms is a pin and a slot is formed between every two adjacent snubber arms;

b) pivoting the actuator assembly towards the outer diameter of the disc; and

c) inserting a portion of the actuator assembly into each of the slots between the snubber arms wherein deflection of the actuator assembly is reduced during a mechanical shock event.

8. A disc drive comprising:

a head disc assembly having a base plate and a top cover enclosing a drive motor supporting a disc thereon and an actuator assembly;

the actuator assembly having an actuator arm, a flexure having one end connected to the actuator arm and a read/write head connected proximate to an opposite end of the flexure; and

a snubber having a snubber body and two snubber arms connected to the snubber body wherein the snubber body is mounted to the base plate and wherein each of the snubber arms is a pin and the snubber arms form a slot therebetween for receiving insertion of a portion of the actuator assembly to reduce deflection of the actuator assembly during a mechanical shock event.

9. The disc drive according to claim 8 wherein an additional slot is formed between the base plate and a snubber arm adjacent to the base plate.

10. The apparatus of claim 8 further including one or more additional snubber arms forming one or more additional slots wherein one or more portions of each actuator arm is located within one of the slots.