

Gimbal Suspension for the Slider of a Magnetic Disk Drive

Field of the Invention

The present invention relates to a magnetic disk drive of the type in which an electromagnetic transducer for reading magnetic disks is provided in a slider which is mounted on a resilient gimbal assembly. In particular it provides a
5 head suspension assembly for such a drive, an arm containing such an assembly, and a disk drive containing such an arm

Background of the Invention

Magnetic disk drives conventionally include an electromagnetic transducer
10 head for reading from/writing to magnetic disks, such as floppy disks or hard disks, located within the drive. The head is part of a slider which is attached to an arm which can be moved over the disk. The attachment of the slider to the arm is via a "gimbal assembly", which resiliently supports the slider. The gimbal assembly conventionally includes a gimbal having a flexible portion
15 ("flexure") to which the slider is attached. The gimbal is attached to a loadbeam, which is mounted on an arm of the disk drive. It is known to provide a dimple between the flexure of the gimbal and the loadbeam, such that the dimple provides a contact between the flexure and the loadbeam, and the flexure moves relative to the loadbeam rolling or pitching about this point
20 of contact. The dimple may be provided on a surface of the flexure or of the loadbeam.

During the operation of the disk drive, when the disk is being revolved in its plane at high speed, the surface of the slider which faces the disk is spaced by a small distance (e.g. 30nm) from the disk. The shape and configuration of
25 the slider are selected to include recesses to improve aerodynamics and such that movements of air within the disk drive, caused by the motion of the disk, create an air film bearing between the disk and the surface of the slider which

faces the disk. This air film bearing maintains the slider at a desired distance from the disk. This is illustrated in Fig 1, where a slider 1 is shown attached to a loadbeam 3 by a gimbal 5 having a support portion 7 attached to the loadbeam 3 and a flexure 9. A disk (not shown) is spaced from the slider 1 in the downward direction on the figure. The slider 1 is subject to a downward force F_o from the dimple 11, and an upward force F_{air} due to positive (more than one atmosphere) pressure developed from the air bearing. In other arrangements, the slider can be designed to develop a negative (less than one atmosphere) pressure on a portion of the slider surface and a positive pressure on another portion of the slider surface. This is referred to as a "negative pressure slider", although the air bearing in fact generates more positive force than negative force in most operating conditions and thus enables the slider to fly with an effective upward lift force. However, such a bearing is able to generate more negative force than positive force in some conditions.

When the disk is revolving more slowly, e.g. at the beginning or end of the read/write operation, its motion is not fast enough to cause the air movements required for the air film to be generated. Some known disk drives employ "contact-start-stop" technology, in which the slider comes into contact with the disk when the disk rotation speed is low. However, this technology involves the risk that frictional contact between the slider and disk will cause damage to the disk during this time.

Consequently, this technology is increasingly being replaced by "dynamic load/unload" ("L/UL") technology, in which the disk drive includes a ramped surface facing away from the disk and typically proximate the radially outmost portion of the disk. The ramping surface is inclined to the plane of the disk, such that its radially outward portion is furthest from the disk. When the disk is revolving and the slider is flying on it, and it is desired to slow the disk down, the slider is moved radially outwards across the surface of the disk, where the

suspension encounters the ramping surface. Further radially outward motion of the slider draws the suspension along the ramping surface, and the slider moves away from the surface of the disk ("unload"). The disk can now be slowed without danger of it contacting the slider. Similarly, when it is desired to restart the rotation of the disk, the disk can be accelerated and the slider only subsequently moved onto its surface by a radially inward motion when the disk is spinning quickly enough for the air film to be generated ("load").

This known system suffers however from the problem that if the slider approaches the disk surface, the disk surface may rotate it relative. This dramatically changes the properties of the air film bearing. In the unload process, the air bearing positive force releases faster than the air bearing negative suction force, and therefore the total air bearing forces develop to be a negative pressure force at some time during the unloading process, as shown in Fig. 2. Thus, there is a net force urging the slider against the disk.

Furthermore, the net force from the air may be before or after the mass centre of the slider in the rotation direction, as shown in Fig. 3(a) and 3(b). The positive pressure F_{air} in Fig. 1 is replaced by a suction force F_{air} , which is ahead of the slider centre (in the direction along the flexure 9 from towards the slider) in Fig. 3(a) and behind the slider centre in Fig. 3(b). The pressure from the dimple is replaced with a force F_u applied by the flexure to urge the slider 1 into the desired position.

To keep the slider in position the flexure must thus resist powerful vertical and/or rotational forces. If it fails to do so, gimbal separation (i.e. excessive motion of the flexure, and thus the slider, from the loadbeam) will cause physical contact between the slider and the rapidly spinning disk, and may further cause frictional damage to the disk, and possibly even a head crash.

Twisting of the slider and time of loading and unloading are not the only problems to which such arrangements are subject. Additionally, if the disk

drive is subject to a shock (e.g. if it is the disk drive of a portable computer) while the disk is being read, the sudden force may cause gimbal separation, and even force the slider into physical contact with the disk, once again giving rise to a risk of damage to the disk and/or slider.

- 5 To address this problem in particular, US 5333085 (to Prentice et al), the disclosure of which is incorporated herein in its entirety, proposes that the flexure has a tab (limiter) at a free end which projects through a window in the loadbeam. If the flexure moves excessively, the tab comes into contact with the loadbeam, and thus limits the degree to which the flexure may move
10 relative to the loadbeam.

Many similar limiter arrangements are known, also directed to the problem of alleviating the risk of shocks. Generally, these arrangements provide limiters which can only engage the loadbeam at a single location along the length of the suspension, and all of the existing arrangements have to employ a gap
15 between the limiter and the suspension to avoid constraining the slider flying altitude. In other words, constant contact is not allowed. For such reasons, known limiters cannot offset suction force.

Summary of the Invention

In general terms the invention proposes that the movements of the flexure
20 away from the loadbeam should be limited by tab(s) which project towards the loadbeam (for example, in certain embodiments, they project through windows in the loadbeam) and which contact or approach the loadbeam on its side facing away from the gimbal in the case that the flexure and slider move excessively away from the loadbeam. The tabs are provided at locations
25 which are selected in view of the forces typically encountered by the slider during load/unload.

In a first case, the invention proposes a disk drive head suspension assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the assembly comprising:

a loadbeam;

5 a gimbal including a support portion attached to the loadbeam and a tongue-shaped flexible flexure connected to the support portion, the flexure having a body portion which contacts the loadbeam at a dimple formed therebetween; and

a slider mounted on the body portion of the flexure, the slider
10 comprising an electromagnetic transducer and being shaped to create an air bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;

the flexure having a tab extending from a location on the flexure between the dimple and the connection of the flexure to the support portion,
15 the tab projecting toward the loadbeam and having a limiter portion for contacting the loadbeam when the flexure flexes away from the loadbeam, whereby the tab limits the flexing of the flexure away from the loadbeam.

In a second case, the invention proposes a disk drive head suspension
20 assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the assembly comprising:

a loadbeam;

a gimbal attached to the loadbeam and including a flexible flexure having a body portion which contacts the loadbeam at a dimple formed
25 therebetween; and

a slider mounted on the body portion of the flexure, the slider comprising an electromagnetic transducer and being adapted to create an air bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;

the flexure having a tab projecting towards the loadbeam, the tab having a limiter portion for contacting the loadbeam opposite the dimple, whereby the tab limits the flexing of the flexure away from the loadbeam.

- 5 This case makes it possible to limit the gimbal separation to effectively zero, which is the safest design. This is in contrast to the known limiters described above which must permit a certain degree of gimbal separation so as to enable the free pitch/roll motion of flying slider, e.g. typically 50,000nm even though the preferred slider flying height is typically 30nm, and thus still permit
10 head-disk crash in exceptional circumstances.

In a third case, the invention proposes a disk drive head suspension assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the assembly comprising:

- 15 a loadbeam;
a gimbal attached to the loadbeam and including a flexible flexure having a body portion which contacts the loadbeam at a dimple; and
a slider mounted on the body portion of the flexure, the slider comprising an electromagnetic transducer and being adapted to create an air
20 bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;

- the flexure having at least two tabs projecting towards the loadbeam, the tabs having respective limiter portions located to respective sides of the dimple for contacting the loadbeam when the flexure flexes away from the
25 loadbeam, whereby the tabs limit the flexing of the flexure away from the loadbeam.

All of the above cases are combinable in any combination. Which of these cases is suitable for a particular head suspension assembly will depend in

general on the design of the slider, and thus the forces to which the slider is subject during load/unload.

5 In many embodiments, and especially in the case of a tab provided in a location on the flexure on the opposite side of the dimple from the connection of the flexure to the support portion of the gimbal, the tab(s) project through a window provided in the loadbeam, so as to reach the face of the loadbeam which faces away from the gimbal.

10 Note that the present invention is applicable both to cases in which the slider develops a positive pressure between it and the disk, and also, and more particularly, to the case in which the slider develops a negative pressure between it and the disk.

15 The dimple is provided either on the loadbeam or on the flexure itself.

All tab(s) on the flexure preferably project, measured in the direction along the length direction of the flexure, towards the dimple. For example, in embodiments in which the tab(s) project through window(s) in the loadbeam,
20 they preferably contact the loadbeam at locations on the loadbeam between the dimple and the window(s). Thus (unlike the arrangement of US 5333085) they are able to apply force opposite the suction centre, and fully offset the suction force.

25 As well as limiting the movements of the slider relative to the loadbeam in load/unload, the limiter tabs of the present invention provide a degree of resistance to mechanical shocks experienced by the head suspension assembly.

The invention further relates to an arm incorporating such a disk drive head suspension assembly, and to a disk drive comprising such an arm.

Brief description of the drawings

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Embodiments of the invention will now be described in detail for the sake of example only, with reference to the following figures in which:

Figure 1 shows diagrammatically a side view of a known disk drive
10 head suspension assembly;

Figure 2 shows the force history of a typical negative pressure slider during the unloading process;

Figure 3, which is composed of figure 3(a) and 3(b), shows the
configuration of the assembly of figure 1 in the case that the slider is subject
15 to excessive downward suction forces;

Figure 4 shows a first embodiment of an assembly according to the present invention;

Figure 5 shows a second embodiment of an assembly according to the present invention;

20 Figure 6 shows the construction of a third embodiment according to the present invention; and

Figure 7 shows the construction of a fourth embodiment of the present invention.

25 Detailed Description of Embodiments

Referring firstly to figure 4, the first embodiment of the assembly comprises a loadbeam 13, a gimbal 15 having a support portion 17 and a tongue-shaped flexure. Features of the gimbal which would not otherwise be visible through
30 the loadbeam 13 are shown in dashed lines. The flexure 19 moves within a

region defined by a window 21 in the support portion 17. A dimple 33 is provided on the flexure 19 for contacting the underside (as shown in figure 4) of the loadbeam 13. The loadbeam 13 is formed with a window 35, and the flexure 19 is formed with a tab 37 which projects through the window 35, and
 5 is rearwardly deformed such that its tip contacts the upper surface of the loadbeam 13 which faces away from the gimbal 15, at a point on the loadbeam 13 which is directly opposite the dimple 33. The tab 37 limits the downward motion of the slider, by limiting the downward motion of the flexure 19 relative to the loadbeam 13. Note that in this embodiment, the tab 37 is in
 10 contact with the upper surface of the loadbeam 13 at all times, but in other embodiments the tip of the tab 37 must be above and spaced from the upper surface of the loadbeam 13 when the dimple 33 is in contact with the underside of the loadbeam 13, and only comes into contact with the loadbeam when flexure 19 moves downward relative to the loadbeam 13 so that the
 15 loadbeam 13 and dimple 33 part.

For the sake of clarity, the slider 1 is shown downwardly spaced from the gimbal 15, but in reality its upper face is attached to the underside of the flexure 19 with its centre preferably directly below the dimple 33.

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Turning now to fig. 5, a second embodiment of the invention is shown. In figure 5 the slider is not shown, but it should be understood as being attached to the underside of the flexure 19 as described above in relation to figure 4. As in figure 4, in figure 5 the gimbal 115 is composed of a support portion 117 and a tongue-shaped flexure 119 extending through a window 121 defined by
 25 the support portion 117. A dimple 133 is provided on the upper surface of the flexure 119, for contacting the lower surface of the loadbeam 113. In this embodiment, the flexure 119 comprises a tab 137 which extends diagonally upwardly towards the loadbeam 113 and through an arcuate recess 125
 30 provided on the tip of the loadbeam 113. The tip of the tab 137 is bent

downward so that its point is directed towards the upper surface of the loadbeam 113. When the dimple 133 is in contact with the lower surface of the loadbeam 113, the tip of the tab 137 is spaced from and vertically above the upper surface of the loadbeam 113, but if the gimbal is flexed so that the
5 dimple 133 becomes separated from the loadbeam 113, the tip of the tab 137 comes into contact with the upper surface of the loadbeam 113, and limits the motion. Thus, the tab 137 limits the separation of the slider 1 from the loadbeam 113.

10 Turning to figure 6, the loadbeam 213 of the assembly is provided with a tongue 214 extending from its end. The tongue 214 is provided as a headlift which helps to guide the loadbeam 213 onto/off the ramping surface during the load/unload process. As in figure 4 and figure 5, the gimbal 215 consists of two portions: a support portion 217 defining a window 221 in which a
15 tongue-shaped flexure 219 can move. The flexure 219 is attached on its underside to a slider (not shown). The flexure 219 is provided with a dimple 233 on its upper surface to contact a lower surface of the loadbeam 213. The flexure 219 is further provided with two tabs 237a, 237b which project upwardly from the flexure 219, and through respective windows 235a, 235b,
20 provided in the loadbeam 213. The tabs 237a, 237b are to either side of the dimple 233, on the longitudinal axis of both the flexure 219 and the loadbeam 213. The tip portions of the tabs 237a, 237b project inwardly towards the dimple 233. When the dimple 233 is in contact with the loadbeam 213, the tips of the tabs 237a, 237b are spaced from and above the upper surface of
25 the loadbeam 213, but when the flexure 219 is downwardly displaced, the tips of the tabs 237a, 237b come into contact with the upper surface of the loadbeam 213, and limit the extent to which the slider 1 attached to the flexure 219 can be moved from the loadbeam 213.

Turning now to figure 7, a fourth embodiment of the invention resembles that of figure 6, but in this case the loadbeam 313 is not provided with a tongue corresponding to tongue 214 of figure 6. In this case the gimbal 315 extends to the left of the figure further than the end of the loadbeam 313. The gimbal
5 consists of a support portion 317 and a flexure 319, which moves within a window 321 defined by the support portion 317. The flexure 319 is provided with a dimple 333, and with tabs 337a and 337b. The tab 337a projects upwardly towards the loadbeam 313 and through a window 335a defined therein. The tab 337b projects upwardly towards the loadbeam 313, and its
10 tip is bent downwardly towards the loadbeam 313. When the dimple 333 is in contact with the undersurface of the loadbeam 313, the tabs 337a, 337b are above and spaced from the upper surface of the loadbeam 313. However, when the flexure 319 is flexed away from the loadbeam 313, one or both of the tabs 337a, 337b come into contact with the upper surface of the loadbeam
15 313, and limit the extent to which the flexure 319 can be moved away from the loadbeam 313.

Although the invention has been described above in relation to particular embodiments, many variations within the scope of the invention will be clear
20 to a skilled person.

Claims

1. A disk drive head suspension assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the
5 assembly comprising:
a loadbeam;
a gimbal including a support portion attached to the loadbeam and a flexible flexure connected to the support portion, the flexure having a body portion which contacts the loadbeam at a dimple formed therebetween; and
10 a slider mounted on the body portion of the flexure, the slider comprising an electromagnetic transducer and being shaped to create an air bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;
the flexure having a tab extending from a location on the flexure
15 between the dimple and the connection of the flexure to the support portion of the gimbal, the tab projecting toward the loadbeam and having a limiter portion for contacting the loadbeam when the flexure flexes away from the loadbeam, whereby the tab limits the flexing of the flexure away from the
20 loadbeam.
2. A disk drive head suspension assembly according to claim 1 in which the flexure includes a further tab extending from a location on the flexure on the other side of the dimple from the connection of the flexure to the support portion, the further tab having a limiter portion for contacting the loadbeam
25 when the flexure flexes away from the loadbeam.
3. A disk drive head suspension assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the assembly comprising:
30 a loadbeam;



a gimbal attached to the loadbeam and including a flexible flexure having a body portion which contacts the loadbeam at a dimple formed therebetween; and

5 a slider mounted on the body portion of the flexure, the slider comprising an electromagnetic transducer and being adapted to create an air bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;

10 the flexure having a tab projecting towards the loadbeam, the tab having a limiter portion for contacting the loadbeam directly opposite the dimple, whereby the tab limits the flexing of the flexure away from the loadbeam.

4. A disk drive head according to claim 3 in which the tab is shaped such that when the loadbeam and the flexure are in contact via the dimple, the tab
15 is in contact with the loadbeam.

5. A disk drive head suspension assembly for a magnetic disk drive having a rotator mechanism for rotating a magnetic data storage disk, the assembly comprising:
20 a loadbeam;
a gimbal attached to the loadbeam and including a flexible flexure having a body portion which contacts the loadbeam at a dimple; and
a slider mounted on the body portion of the flexure, the slider comprising an electromagnetic transducer and being adapted to create an air
25 bearing between a surface of the slider and a magnetic disk rotated by the rotator mechanism;

the flexure having at least two tabs projecting towards the loadbeam, the tabs having respective limiter portions located to respective sides of the dimple for contacting the loadbeam when the flexure flexes away from the



loadbeam, whereby the tabs limit the flexing of the flexure away from the loadbeam.

6. A disk drive head suspension assembly according to any preceding
5 claim in which at least one said tab projects through a window provided in the loadbeam.

7. A disk drive head suspension assembly according to claim 6 in which
10 both of the tabs project through respective windows provided in the loadbeam.

8. A disk drive head suspension assembly according to claim 6 or claim 7
15 in which the tab or tabs which project through the window or windows in the loadbeam are for contacting the loadbeam between that window and the dimple.

9. A disk drive head suspension assembly according to any preceding
20 claim in which contact between the or each tab and the loadbeam is on a longitudinal axis of the loadbeam.

10. A disk drive head suspension assembly according to any preceding
25 claim in which the or each tab is located on a longitudinal axis of the flexure.

11. A disk drive head suspension assembly according to any preceding
30 claim in which the slider is shaped to develop in use a negative pressure between it and a disk.

12. A disk drive head suspension assembly according to any of claims 1 to
10 in which the slider is shaped to develop in use a positive pressure between it and a disk.



13. An arm for a disk drive for a magnetic disk, the arm comprising a head suspension assembly according to any preceding claim.
14. A disk drive for a magnetic disk, the disk drive comprising:
- 5 a rotator mechanism for rotating the disk;
an arm carrying a disk drive head suspension assembly according to any of claims 1 to 12; and
an actuator for moving the arm, to carry the disk drive head suspension assembly over the surface of the disk.

