An improved lead suspension assembly employing a wider and stiffer load beam (12) and a flexure (32) having universal lateral stiffness and a higher natural frequency.
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HEAD SUSPENSION ASSEMBLY

Background of Invention

1. Field of the Invention

The present invention relates generally to an improved magnetic head suspension assembly (HSA). The HSA is a component within a disk drive which positions a magnetic read/write head over the desired position on the storage media where information is to be retrieved or transferred. More specifically, the invention relates to a load beam and flexure assembly having increased lateral stiffness and a higher natural frequency than prior art assemblies.

2. Description of the Prior Art

With the advent of more powerful computers and the rapid growth in the personal computer market it has become increasingly more important to enable a user to access data from storage devices with increased speed and accuracy.

Because there is a need to reduce access times to enable rapid retrieval of data, it has become increasingly more important to reduce undesirable levels of vibration of components within the rigid disk drive. Vibration of drive components can cause instability of the drive's servo system.
It also may delay the transfer of data because the data can not be confidently transferred until the amplitude of the vibration has substantially decayed. The current invention solves this problem by substantially increasing the natural frequency of vibration of the HSA and by increasing its lateral stiffness.

In terms of the dynamic characteristics of head suspension assemblies, higher vibration amplitudes or gains are more acceptable at higher frequencies. Lower spring rates yield better gram stability through stack up tolerances of drive actuator assemblies. A lower assembly and flexure pitch and roll stiffness help maintain assembly compliance. Increases in flexure lateral stiffness decrease unwanted assembly compliance.

**Summary of the Invention**

It is therefore the major object of this invention to provide a head suspension assembly with enhanced performance in lateral stiffness.

More specifically, the suspension assembly of the present invention includes a spring load beam element portion joined to the arm at a proximal end thereof for supporting a magnetic head at a fixed distance from a rigid arm, where the flexure comprises a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element and where the flexure portion has a width W_f, wherein the flexure is divided into a central head mounting support means for receiving a disk drive head to be bonded thereto, a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the head
support means from the distal end thereof for gimbaled movement relative to the load beam element, and wherein the flexible arm portions at the end thereof distal to the load beam have a width $W_a$, the ratio of $W_a/W_f$ falling within the range of about 0.2 to 0.4, thereby increasing the lateral stiffness and the natural frequency of the flexure.

The invention may also include a magnetic head suspension for attachment to a rigid arm, where the head suspension includes a spring load beam element portion joined to the arm at a proximal end thereof, a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element and wherein the flexure portion has a width $W_f$ and wherein the flexure includes a central head mounting support means for receiving a disk drive head to be bonded thereto and a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimbaled movement relative to the load beam element; the flexible arm portions at the end thereof distal to the load beam having a width $W_a$, the ratio of $W_a/W_f$ falling within the range of about 0.2 to 0.4, thereby increasing the lateral stiffness and the natural frequency of the flexure.

These and other objects of the present invention will be apparent with reference to the drawings, the description of the preferred embodiment, and the claims.

_Brief Description of the Drawings_

Fig. 1 is a perspective view of a flexure in accordance with the present invention;
Fig. 2 is a perspective view of a head support assembly utilizing the flexure of Fig. 1 in accordance with the present invention;

Fig. 3 is a perspective view of another embodiment of the present invention;

Fig. 4 is a perspective view showing a perspective view of a further embodiment of the flexure mounted at the distal end of a load beam;

Fig. 5 is a perspective view of the flexure shown in Fig. 4;

Fig. 6 is a perspective view of a further embodiment showing a flexure mounted at the distal end of a load beam;

Fig. 7 is yet another embodiment of the invention with the flexure mounted at the distal end of a load beam; and

Fig. 8 is a perspective view of the flexure shown in Fig. 7.

**Detailed Description of the Drawings**

Fig. 1 and 2 show an embodiment of the flexure means of the present invention. In Fig. 2, a spring load beam element 12 is shown. At the proximal end of load beam element 12 are means for joining the load beam to the rigid arm in the disk drive. For example, in Fig. 2 a base plate 14 is welded by a series of conventional welds 16 to the proximal end of load beam 12. Base plate 14 includes a swaging boss 18 which projects through the surface of load beam element 12 and is used to attach the load beam element to a rigid arm in the disk drive.

Reference line 22 illustrates the width of load beam element 12 at the proximal end of the load beam element and reference character 24 is used to designate the length measurement from the center line...
of the point of attachment to the rigid arm to the
distal extremity of the load beam element. In the
embodiment shown in Fig. 2 the length is taken from
the distal tip of the load beam element to the center
of swaging boss 18.

Although load beam elements constructed in
accordance with the prior art may have the same
general appearance as the load beam element shown in
Fig. 2, load beam element 12 is substantially wider
than comparable prior art units. Comparable prior
art units have width to length ratios generally in
the range of .2 and below. In the embodiment shown
in Fig. 2, the width to length ratio exceeds 0.4.

In order to tune or adjust the spring
characteristics of load beam element 12, an aperture
26 can be cut from a portion of the face of load beam
element 12. Removal of the material in aperture 26
changes the spring rate stiffness of the suspension
in the region between base plate 14 and the stiffened
portion of the load beam element between side rails
28 and 30. In this manner, the spring rate of the
suspension can be made, if desired, to be comparable
with that of the prior art devices despite the
stiffness otherwise contributed by the increased
relative width of the suspension.

In the embodiment shown, flexure 32 is
welded to load beam element portion 12 by a series of
welds 34. A tooling hole 38 in the surface of
flexure 32 is aligned with a similar tooling hole 40
in spring load beam element 12 to assist in assembly
of the flexure and load beam element and in the later
assembly of the disk drive.

In accordance with the present invention,
flexure portion 32 includes a central head mounting
support means 42 to which a disk drive head is to be bonded. The width \( W_f \) of flexure 32 measured at its widest point is selected to be substantially wider than the prior art flexures in order to increase the lateral stiffness and the natural frequency of the flexure. As shown in Fig. 1, central head mounting support 42 is depressed from the remainder of the body of the flexure by form lines 46 and 48.

A pair of arms 44 connects, at the extreme distal end of flexure 32, central head mounting support means 42 to the distal ends of arms 44. The proximal width \( W_a \) of the arms 44 is substantially wider than the distal end of the arms and the ratio of the distal arm width to the width of the proximal end of the arms can be between 0.2 and 0.8.

In the prior art, similar flexure arms do not have a proximal increase in the width of the arms and the arms are relatively narrower, having a ratio of width \( W_a/W_f \) of about 0.19. In the preferred embodiment shown, the width \( W_f \) of the flexure is substantially greater, and the width of the arm \( W_a \) is increased so that the ratio \( W_a/W_f \) is in the range of 0.2 through 0.4.

As can also be seen in Fig. 1, the inside and outside facing edges of the arms 44 are notched with a notch 45 to reduce the width of the arm 44 from a fixed maximum width to a minimum width between the midpoint and the proximal end of arm 44 to lower the pitch and roll flexure stiffness. The ratio of the thinnest portion of the arm to the widest is at least about 0.2 to 0.8.

Fig. 3 shows a different embodiment of the present invention. The portion of the load beam at the proximal end has a substantially reduced width so
that the load beam element flares outwardly from the
distal end and mounting plate 50 to a maximum width
at the proximal end of side rails 52 and 54.

Fig. 4 shows an alternative embodiment of a
load beam where the distal end of load beam 12 has
its distal apex portion 60 relieved by a further
embossing step to form rail means receiving
indentations 61 thereby permitting the the surface of
the flexure means 32 to be flushly aligned with the
surface of the load beam element 12 with the rail
means 64 projecting into the rail means receiving
indentations 61. Flexure 62 has stiffening side
rails 64 positioned along its side edges to prevent
the ramp used in a head lifter of the disk drive from
contacting the etched edge of the flexure.

Fig. 6 shows a slightly different form of
modified load beam 12 where rail means receiving
apertures 66 are cut in the distal apex portion of
the load beam to accomodate side rails 64 of flexure
62 and to permit rails 64 to project through the rail
means receiving apertures.

Fig. 7 shows a flexure 70 welded to load
beam 12 having a distal apex portion which is not
modified by forming or cutting as was the load beam
shown in Fig. 4 and 6. Side rails 74 prevent the
ramp used in the head lifter of the disk drive from
contacting the etched edge of the flexure.

The flexure shown in Fig. 8 can be utilized
without the necessity of modifying the load beam as
was the case in Fig. 4 or 6.

Further, the embodiments described above are
by no means limited, and various changes and
modifications are possible without departing from the
scope and spirit of the invention.
What Is Claimed Is:

1. A magnetic head suspension for attachment to a rigid arm, said head suspension comprising, in combination:

   (a) a spring load beam element portion joined to the arm at a proximal end thereof, said load beam element having a width to length ratio of at least 0.4 where the width is measured at the proximal end thereof and the length is measured from the centerline of the point of attachment to the rigid arm to the distal extremity of the load beam element;

   (b) a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion having a width \( W_f \), being divided into

      a central head mounting support means for receiving a disk drive head to be bonded thereto;

      a plurality of slots in the surface of the flexure portion to define at least two extended...
flexible arms for suspending the support means from the distal end thereof for gimballed movement relative to the load beam element, the flexible arm portions at the proximal end thereof having a width \( W_a \), the ratio of \( W_a/W_f \) falling within the range of about 0.2 to 0.4, thereby increasing the lateral stiffness and the natural frequency of the flexure.

2. In a magnetic head suspension including a spring load beam element portion joined to the arm at a proximal end thereof for supporting a magnetic head at a fixed distance from a rigid arm, said flexure comprising:

   a flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion being divided into

   a central head mounting support means for receiving a disk drive head to be bonded thereto;

   a plurality of slots in the surface of the flexure portion to define at least two extended
flexible arms for suspending the support means for gimbaled movement relative to the load beam element, the flexure arm portions cooperating to provide gimbal support for the head support means, each of the arms having a reduced width portion which extends over at least a portion of its length, thereby reducing the pitch and roll stiffness of the flexure.

3. In a magnetic head suspension including a spring load beam element portion joined to the arm at a proximal end thereof for supporting a magnetic head at a fixed distance from a rigid arm, said flexure comprising:

a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion having a width \( W_f \), being divided into a central head mounting support means for receiving a disk drive head to be bonded thereto,
a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimbaled movement relative to the load beam element, the flexible arm portions at the proximal end thereof having a width \( W_a \), the ratio of \( W_a / W_f \) falling within the range of about 0.2 to 0.4, thereby increasing the lateral stiffness and the natural frequency of the flexure.

4. The invention of claim 3 wherein the outer perimeter of the arms is notched from a maximum width at the proximal end of the arm to a fixed minimum width at the approximate midpoint of the arm thereby lowering the pitch and roll stiffness and wherein the inside facing edge of the arm is notched from a fixed maximum width between the base and the midpoint to a fixed minimum width between the midpoint and the proximal end thereof thereby lowering the pitch and roll stiffness.

5. The invention of claim 4 wherein the ratio of the width of the arms at the distal end thereof to the width of the arms at the proximal end thereof is between 0.2 and 0.8, thereby increasing the lateral stiffness of the flexure.
6. A magnetic head suspension for attachment to a rigid arm, said head suspension comprising, in combination:

(a) a spring load beam element portion joined to the arm at a proximal end thereof;

(b) a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion having a width $W_F$, and being divided into

a central head mounting support means for receiving a disk drive head to be bonded thereto;

a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimbaled movement relative to the load beam element, the flexible arm portions at the proximal end thereof having a width $W_A$, the ratio of $W_A/W_F$ falling within the range of about
0.2 to 0.4, thereby increasing the lateral stiffness and the natural frequency of the flexure.

7. In a magnetic head suspension including a spring load beam element portion joined to the arm at a proximal end thereof for supporting a magnetic head at a fixed distance from a rigid arm, said flexure comprising:

a unitary flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion being divided into

a central head mounting support means for receiving a disk drive head to be bonded thereto;

a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimballed movement relative to the load beam element, rail means comprising at least a pair of unitary rails positioned along opposite sides of the
flexure portion, each of said rails produced by manufacturing a portion of the flexure material to form a projecting surface constructed and arranged for interfacing with a ramp structure in a disk drive to move a read head away from the surface of a disk when the ramp engages the rail means.

8. A magnetic head suspension for attachment to a rigid arm, said head suspension comprising, in combination:

(a) a unitary flexure portion divided into a central head mounting support means for receiving a disk drive head to be bonded thereto;

a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimballed movement relative to the load beam element, rail means comprising at least a pair of unitary rails positioned along opposite sides of the
flexure portion, each of said rails produced by manufacturing a portion of the flexure material to form a projecting surface constructed and arranged for interfacing with a ramp structure in a disk drive to move a read head away from the surface of a disk when the ramp engages the rail means.

(b) a spring load beam element portion joined to the arm at a proximal end thereof, the load beam element portion having a portion of its distal surface removed to form rail means receiving apertures thereby permitting the the surface of the flexure means to be flushly aligned with the surface of the load beam element with the rail means projecting through the rail means receiving apertures, said flexure means mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the load beam element.
9. A magnetic head suspension for attachment to a rigid arm, said head suspension comprising, in combination:

(a) a unitary flexure portion divided into a central head mounting support means for receiving a disk drive head to be bonded thereto, ;

a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms for suspending the support means from the distal end thereof for gimbaled movement relative to the load beam element, rail means comprising at least a pair of unitary rails positioned along opposite sides of the flexure portion, each of said rails produced by manufacturing a portion of the flexure material to form a projecting surface constructed and arranged for interfacing with a ramp structure in a disk drive to move a read head away from the surface of a disk when the ramp engages the rail means.
(b) a spring load beam element portion joined to the arm at a proximal end thereof, the load beam element portion having a portion of its distal surface embossed to form rail means receiving indentations thereby permitting the surface of the flexure means to be flushly aligned with the surface of the load beam element with the rail means projecting into the rail means receiving indentations, said flexure means mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the load beam element.

10. In a magnetic head suspension including a spring load beam element portion joined to the arm at a proximal end thereof for supporting a magnetic head at a fixed distance from a rigid arm, said flexure comprising:

a flexure portion mounted on the load beam element at the distal end thereof and projecting beyond the distal apex of the element, the flexure portion being divided into

a central head mounting support means for receiving a disk drive head to be bonded thereto;
a plurality of slots in the surface of the flexure portion to define at least two extended flexible arms, each of which has a length \( L \), for suspending the support means for gimballed movement relative to the load beam element, the flexure arm portions cooperating to provide gimbals support for the head support means, each of the arms having a width \( W_a \) at the proximal end thereof and wherein the ratio of \( \frac{W_a}{L} \) is between 0.1 and 0.5 thereby increasing the lateral stiffness of the flexure.

11. The invention of claim 10 wherein the outer perimeter of the arms is notched from a maximum width at the proximal end of the arm to a fixed minimum width at the approximate midpoint of the arm thereby lowering the pitch and roll stiffness and wherein the inside facing edge of the arm is notched from a fixed maximum width between the base and the midpoint to a fixed minimum width between the midpoint and the proximal end thereof thereby lowering the pitch and roll stiffness.
12. The invention of claim 11 wherein the ratio of the width of the arms at the distal end thereof to the width of the arms at the proximal end thereof is between 0.2 and 0.8, thereby increasing the lateral stiffness of the flexure.
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

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According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

- U.S. : 360/103

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US, A, 4,663,682 (McNEIL) 05 May 1987, See figures 1-3.</td>
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<td>US, A, 4,167,765 (WATROUS) 11 September 1979, See figures 1-4.</td>
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* Further documents are listed in the continuation of Box C.  
See patent family annex.

- Special categories of cited documents:
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  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search: 12 AUGUST 1992

Date of mailing of the international search report: 24 SEP 1992

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