

INTERNAL DISC DRIVE GAS RESERVOIR

Related Applications

This application claims priority of United States provisional application Serial
5 Number 60/338,210, filed November 2, 2001.

Field of the Invention

This application relates generally to disc drives and more particularly to a
system for boosting the concentration of a gas other than air within a disc drive.

10 Background of the Invention

A disc drive typically includes a base to which various components of the disc
drive are mounted. A top cover cooperates with the base to form a housing that
defines an internal clean environment for the disc drive. Sealing and filling the clean
environment of disc drives with gases other than air can enhance their performance.
15 For example, low-density inert gases such as helium can reduce the aerodynamic drag
between the discs and their associated read/write heads by a factor of approximately
five-to-one compared to operating in air. This reduced drag results in reduced power
requirements for the spindle motor. A helium filled drive thus uses substantially less
power than a comparable disc drive that operates in an air environment

20 Despite the advantages of helium filled drives, such drives have not been
commercially successful. This is mainly due to problems associated with the helium
leaking from the disc drives over time. As the helium leaks out, air leaks in causing
undesirable effects in the operation of the disc drives and possibly causing the disc
drives to fail. For example, the increased concentration of air may increase the forces
25 on the read/write head due to turbulent airflow within a drive and it may cause noise
and/or the heads to fly at too great a distance above the discs.

Accordingly, there is a need for an improved system that can effectively boost
the concentration of a gas other than air, such as helium, in a disc drive during use.
The present invention provides a solution to this and other problems, and offers other
30 advantages over the prior art.

Summary of the Invention

Against this backdrop the present invention has been developed. An embodiment of the present invention is a system for boosting a concentration of a gas other than air, such as helium, within an enclosed disc drive environment. The system
5 includes a pressurized reservoir of the gas other than air within the disc drive environment. The gas other than air flows from the reservoir through an outlet and into the disc drive environment. Additionally, a particle trap within the disc drive environment traps air particles.

In one embodiment, the outlet is a diaphragm through which the gas other than
10 air diffuses into the disc drive environment. In another embodiment, a pressure sensor connected to the disc drive environment is able to produce a pressure signal representative of the disc drive environment pressure. A control module receives the pressure signal and supplies the gas other than air from the reservoir to the disc drive environment if the pressure within the disc drive environment is within a
15 predetermined pressure range. The control module ceases supplying the gas other than air from the reservoir to the disc drive environment if the pressure within the disc drive environment is above the predetermined pressure range.

Another embodiment of the present invention is a disc drive defining an enclosed disc drive environment. The disc drive includes a system for boosting a
20 concentration of a gas other than air, such as helium, within an enclosed disc drive environment. The system includes a pressurized reservoir of the gas other than air within the disc drive environment. The gas other than air flows from the reservoir through an outlet and into the disc drive environment. Additionally, a particle trap within the disc drive environment traps air particles.

25 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 incorporating a preferred embodiment of the present invention showing the primary internal components.

FIG. 2 is a schematic diagram of a preferred disc drive concentration boosting system in accordance with a preferred embodiment of the present invention.

FIG. 3 is a schematic diagram of an alternative disc drive concentration boosting system in accordance with a preferred embodiment of the present invention.

FIG. 4 is a graph comparing the percentage fill of helium over time for various disc drive configurations, some of which include helium concentration boosting systems in accordance with embodiments of the present invention.

FIG. 5 is a schematic diagram of a disc drive shipping or storage package according to an embodiment of the present invention.

Detailed Description

A disc drive **100** constructed in accordance with a preferred embodiment of the present invention is shown in FIG. 1. The disc drive **100** includes a base **102** to which various components of the disc drive **100** are mounted. A top cover **104**, shown partially cut away, cooperates with the base **102** to form a housing that defines an enclosed sealed environment or disc drive environment **105** for the disc drive in a conventional manner. The disc drive environment **105** is filled with helium to enhance the performance of the disc drive **100**.

The components of the disc drive **100** include a spindle motor **106**, which rotates one or more discs **108** at a constant high speed. Information is written to and read from tracks on the discs **108** through the use of an actuator assembly **110**, which rotates during a seek operation about a bearing shaft assembly **112** positioned adjacent the discs **108**. The actuator assembly **110** includes a plurality of actuator arms **114**, which extend towards the discs **108**, with one or more flexures **116** extending from each of the actuator arms **114**. Mounted at the distal end of each of the flexures **116** is a head **118**, which includes an air bearing slider enabling the head **118** to fly in close proximity above the corresponding surface of the associated disc **108**.

During a seek operation, the track position of the heads **118** is controlled through the use of a voice coil motor **124**, which typically includes a coil **126** attached to the actuator assembly **110**, as well as one or more permanent magnets **128**, which

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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**.

The spindle motor **106** is typically de-energized when the disc drive **100** is not in use for extended periods of time. The heads **118** are moved over park zones **120** near the inner diameter of the discs **108** when the drive motor is de-energized. The heads **118** are secured over the park zones **120** through the use of an actuator latch arrangement, which prevents inadvertent rotation of the actuator assembly **110** when the heads are parked.

A flex assembly **130** provides the requisite electrical connection paths for the actuator assembly **110** while allowing pivotal movement of the actuator assembly **110** during operation. The flex assembly includes a printed circuit board **132** to which head wires (not shown) are connected; the head wires being routed along the actuator arms **114** and the flexures **116** to the heads **118**. The printed circuit board **132** typically includes circuitry for controlling the write currents applied to the heads **118** during a write operation and a preamplifier for amplifying read signals generated by the heads **118** during a read operation. The flex assembly terminates at a flex bracket **134** for communication through the base deck **102** to a disc drive printed circuit board (not shown) mounted to the bottom side of the disc drive **100**.

A concentration boosting system **140** boosts the concentration of a gas other than air within the disc drive environment **105**. The concentration boosting system **140** includes a supply system **142** within the disc drive environment **105**. The concentration boosting system **140** also includes a trapping system **144** that traps air particles within a predetermined area of the disc drive **100**. Thus, over the life of the disc drive **100** the supply system **142** replaces gas other than air that has leaked out, and the trapping system **144** effectively removes air from the disc drive environment as the air leaks in by trapping it in a predetermined area. The concentration boosting system **140** thus boosts the concentration in the disc drive environment **105** by increasing the amount of the gas other than air and decreasing the amount of air. The

concentration boosting system **140** thereby extends the useful life of the disc drive **100**.

Referring now to FIG. 2, a concentration boosting system **200** in accordance with an embodiment of the present invention includes a supply system **202** and a trapping system **204**. The supply system **202** includes a container **206** that defines a reservoir **208** containing the gas other than air. The reservoir **208** is preferably pressurized to an initial pressure of from about 60 atmospheres to about 100 atmospheres absolute pressure. The container **206** is preferably a sealed metal container, such as an aluminum or steel container. It may be similar in construction to other sealed pressurized containers, such as carbon dioxide cartridges. In an embodiment of the present invention, the reservoir **208** has a volume that is about 10% of the volume of the disc drive environment **105**.

An exit line **210** extends from the reservoir **208**. The exit line **210** is preferably a small hole extending through a wall of the container **206**. A valve **212** is normally closed to prevent gas from leaking from the reservoir **208** through the exit line **210**. An actuator **214** is connected to the valve **212** and is operable to open and close the valve **212**. In an embodiment of the present invention, the valve **212** may include a bimetallic strip located within the container **206** that normally plugs the hole **210**, and the actuator **214** includes a coil mounted on the bimetallic strip. When a current runs through the coil, the coil heats the bimetallic strip, causing the bimetallic strip to deform and allowing the pressurized gas to enter the hole **210**. However, many other valve-actuator combinations are possible. For example, the valve could be a micro-machined valve.

A pressure sensor **218** emits a pressure signal **220** that represents the pressure within the disc drive environment **105**. A control module **222** receives the pressure signal **220**. The control module **222** produces a valve actuator signal **224** that prompts the actuator **214** to open the valve **212** when the pressure signal **220** indicates that the pressure within the disc drive environment **105** is within a predetermined pressure range. The gas other than air then flows from the reservoir **208**, through the exit line **210**, and into the disc drive environment **105**. After the pressure within the disc drive environment **105** rises above the predetermined pressure range, the control module **222** prompts the actuator **214** to close the valve **212**. The predetermined

pressure range is preferably at or slightly above ambient atmospheric pressure for drive operation, although other ranges may be used depending on the vacuum and/or pressure handling capability of the drive enclosure.

5 The valve **212**, the valve actuator **214**, the pressure sensor **218** and the control module **222** may all be included in a pressure regulator arrangement designed to maintain a constant pressure or pressure range within the disc drive environment **105**. In that case, the pressure signal could be an electrical, pneumatic, or mechanical signal within the pressure regulator.

10 The trapping system **204** preferably includes a particle trap **226** that traps air particles, which may include gaseous and solid air particles. In an embodiment of the present invention the particle trap **226** is a getter (a device that chemically reacts with air particles that have entered the disc drive environment **105**). When the gas other than air is helium, the getter preferably reacts with nitrogen and oxygen molecules to confine them to a predetermined area of the getter. In an embodiment of the present
15 invention, the getter is a 5M1045 Combo Getter available from SAES Getters S.p.A. of Lainate Italy. Alternatively, the particle trap **226** may be a filter system that traps oxygen and nitrogen molecules or a gas flow separation system that separates heavier molecules, such as oxygen and nitrogen molecules, from lighter molecules, such as helium molecules.

20 Referring now to FIG. 3, an alternative concentration boosting system **300** is shown that uses gas diffusion to regulate release of the gas other than air into the disc drive environment **105**. This system **300** also includes a supply system **302** and a trapping system **304**. The supply system **302** includes a container **306** that defines a reservoir **308**. The container **306** can be similar in construction to the container **206**
25 described above except that here the initial pressure should be within a range of about 5 atmospheres to about 10 atmospheres absolute pressure. The supply system **302** includes a diaphragm **310** that separates the reservoir **308** from the disc drive environment **105**. The diaphragm **310** preferably is constructed so that the gas other than air will continuously diffuse from the reservoir **308**, through the diaphragm **310**,
30 and into the disc drive environment **105**. The diffusion rate will vary with the pressure difference between the reservoir **308** and the disc drive environment **105**. Thus, as the reservoir pressure decreases, the diffusion rate will also decrease. In an

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embodiment of the present invention the diaphragm **310** is a glass plug seated within a wall of the container **306**. The trapping system **304** includes a particle trap **326** that is similar to the particle trap **226** described above.

The concentration boosting system **300** works in a manner similar to the
5 concentration boosting system **200**. However, rather than maintaining a predetermined pressure or pressure range within the disc drive environment **105** by intermittently supplying gas other than air through a valve, the supply system **302** continuously diffuses the gas other than air through the diaphragm **310**.

Referring now to FIG. 4, a graph **400** compares the percent fill of helium over
10 time (months) for various configurations in a diffusion concentration boosting system **300** in accordance with the present invention. The horizontal axis **402** represents time and the vertical axis **404** represents percent fill of helium. The percent fill of helium here represents the quantity of helium in the disc drive environment **105** compared to an initial quantity. In each example, the initial pressure of the disc drive environment **105** was at 1 atmosphere absolute. A critical value line **406** represents
15 the quantity of helium necessary for the disc drive **100** to operate properly. In the present examples, the critical value line **406** is at 95% of the initial value, but it will vary depending on the initial concentration of helium and on the features of the specific disc drive **100**. In all the exemplary configurations of FIG. 4, the volume of
20 the disc drive environment **105** is 100 cc's.

A first line **408** represents the percent fill of helium over time for a disc drive environment **105** with a leak rate of 3.5×10^{-7} cc's per second, which is a typical upper limit of the leak rate for a rubber gasket used to seal a disc drive **100**. A second line
25 **410** represents the percent fill of helium over time for a disc drive environment **105** with a leak rate of 3.5×10^{-8} cc's per second, which is a typical lower limit of the leak rate for a rubber gasket used to seal a disc drive **100**. As can be seen by these two lines **408**, **410**, a typical disc drive **100** using a typical rubber gasket would be operational for somewhere between about 6 months and about 55 months. For most disc drive applications, this is insufficient.

30 A third line **412** represents the percent fill of helium over time for a disc drive environment **105** that encloses a diffusion-type concentration boosting system **300** with a 10 cc reservoir at an initial reservoir pressure of 7.5 atmospheres absolute.

Even if the disc drive environment **105** leaks at a rate of 3.5×10^{-7} cc's per second (typical upper limit for a normal rubber gasket), the disc drive is operational for about 60 months, rather than 6 months.

5 A fourth line **414** represents the percent fill of helium over time for a disc drive environment **105** that encloses a diffusion-type concentration boosting system **300** with a 10 cc reservoir, this time at an initial reservoir pressure of 10 atmospheres absolute for a diffusion type boosting system. Even if the disc drive environment **105** leaks at a rate of 3.5×10^{-7} cc's per second (typical upper limit for a normal rubber gasket), the disc drive is operational for about 85 months, rather than about 6 months.

10 A fifth line **416** represents the percent fill of helium over time for a disc drive environment **105** that encloses a diffusion-type concentration boosting system **300** with a 10 cc reservoir at an initial reservoir pressure of 10 atmospheres absolute. Even if the disc drive environment **105** leaks at a rate of 5×10^{-7} cc's per second, which is above the typical upper limit for a normal rubber gasket, the disc drive **100** is
15 operational for about 60 months.

As can be seen from FIG. 4 and the preceding discussion, a concentration boosting system **200** or **300** according to the present invention significantly increases the useful life of a disc drive **100** filled with helium or some other non-air gas.

Referring to FIG. 5, in an embodiment of the present invention the disc drive
20 **100** is shipped and/or stored within a shipping package **500** to prevent significant leakage of helium from the disc drive environment **105** of the disc drive **100** before the disc drive **100** is used. The shipping package **500** includes a container **502** that contains a disc drive **100**. The container **502** includes a body **504** and a door or lid **506** that spans an aperture in the body **504** to seal the container **502**. The container
25 **502** thus defines an external enclosed environment **508**. The external enclosed environment **508** is also filled with the gas other than air. The external enclosed environment **508** will prevent significant leakage or diffusion of air into the internal disc drive environment **105** of the disc drive **100**. The body **504** and the lid **506** are preferably composed of a metal such as aluminum. They are preferably sealed
30 together by welding, brazing or soldering. If the body **504** and the lid **506** are welded together, the lid **506** or the body **504** can include a thinned portion that will readily allow a user to create an opening to remove the disc drive **100** from the container **502**.

Alternatively described, an embodiment of the present invention is a boosting system (such as **200** or **300**) for boosting a concentration of a gas other than air within an enclosed disc drive environment (such as **105**) containing a disc (such as **108**).

The boosting system includes a reservoir (such as **208** or **308**) within the disc drive environment, which contains the gas other than air at a reservoir pressure that is higher than a disc drive environment pressure of the disc drive environment. The gas other than air flows through an outlet (such as **210** or **310**) from the reservoir to the disc drive environment. The boosting system also includes a particle trap (such as **226** or **326**) within the disc drive environment for trapping air particles.

In one embodiment of the present invention, the outlet is a diaphragm (such as **310**) through which the gas other than air diffuses into the disc drive environment.

In another embodiment of the present invention, the boosting system further includes a pressure sensor (such as **218**) connected to the disc drive environment. The sensor is able to produce a pressure signal representative of the disc drive environment pressure. In this embodiment, the boosting system also includes a control module (such as **222**) that receives the pressure signal and supplies the gas other than air from the reservoir to the disc drive environment if the disc drive environment pressure is within a predetermined pressure range. The control module ceases from supplying the gas other than air from the reservoir to the disc drive environment if the pressure within the disc drive environment is above the predetermined pressure range. The predetermined pressure range may be at about ambient atmospheric pressure. In one embodiment of the present invention the predetermined pressure range is above ambient atmospheric pressure. The control module may supply the gas other than air from the reservoir to the disc drive environment by opening a valve (such as **212**) that is connected to the reservoir, and it may cease from supplying the gas other than air from the reservoir to the disc drive environment by closing the valve.

Alternatively, in a diffusion type embodiment of the boosting system, the reservoir pressure may drop from an initial pressure as the gas other than air flows from the reservoir by diffusion to the disc drive environment. That initial pressure is preferably from about 5 atmospheres to about 10 atmospheres in the diffusion embodiment.

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The particle trap preferably confines trapped particles to a predetermined area within the disc drive environment. In one embodiment of the present invention, the particle trap is a getter that chemically reacts with the trapped air particles. The trapped air particles are preferably nitrogen and oxygen molecules. The gas other
5 than air is preferably helium.

Another an embodiment of the present invention may be summarized as a disc drive (such as **100**) defining an enclosed disc drive environment (such as **105**). The disc drive includes a boosting system (such as **200** or **300**) for boosting a concentration of a gas other than air within the disc drive environment. The boosting
10 system includes a reservoir (such as **208** or **308**) within the disc drive environment, and the reservoir contains the gas other than air at a reservoir pressure that is higher than a disc drive environment pressure of the disc drive environment. The gas other than air flows from the reservoir to the disc drive environment through an outlet (such as **210** or **310**). The boosting system also includes a particle trap (such as **226** or **326**)
15 within the disc drive environment for trapping air particles.

An embodiment of the present invention may also be summarized as a disc drive (such as **100**) including an enclosed disc drive environment (such as **105**) and means within the disc drive environment for boosting a concentration of a gas other than air within the disc drive environment. The means for boosting may include
20 means for supplying helium to the disc drive environment and means for trapping air particles within the disc drive environment.

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 embodiments have been described for purposes of this disclosure, various changes and modifications may
25 be made which are well within the scope of the present invention. For example, the helium reservoir can be placed in any of various positions within the drive and can be any of various shapes depending on the type of drive and the desired size of the helium reservoir. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the scope of the
30 invention disclosed and as defined in the appended claims.

Claims

What is claimed is:

- 5 1. A boosting system for boosting a concentration of a gas other than air within an enclosed disc drive environment containing a disc, the boosting system comprising:
- a reservoir within the disc drive environment, the reservoir containing the gas other than air at a reservoir pressure that is higher than a disc drive environment
- 10 pressure of the disc drive environment;
- an outlet through which the gas other than air flows from the reservoir to the disc drive environment; and
- a particle trap within the disc drive environment, the particle trap trapping air particles.
- 15 2. The system of claim 1, wherein the outlet is a diaphragm through which the gas other than air diffuses into the disc drive environment.
3. The system of claim 1, further comprising:
- 20 a pressure sensor connected to the disc drive environment, the sensor being operable to produce a pressure signal representative of the disc drive environment pressure; and
- a control module receiving the pressure signal and operably supplying the gas other than air from the reservoir to the disc drive environment if the disc drive
- 25 environment pressure is within a predetermined pressure range and ceasing from supplying the gas other than air from the reservoir to the disc drive environment if the pressure within the disc drive environment is above the predetermined pressure range.
4. The system of claim 1, wherein the particle trap confines trapped air
- 30 particles to a predetermined area within the disc drive environment.
5. The system of claim 4, wherein the particle trap is a getter that chemically reacts with the trapped air particles.

6. The system of claim 5, wherein the trapped air particles are nitrogen and oxygen molecules.

5 7. A disc drive defining an enclosed disc drive environment containing a disc, the disc drive comprising a boosting system for boosting a concentration of a gas other than air within the disc drive environment, the boosting system comprising:

 a reservoir within the disc drive environment, the reservoir containing the gas other than air at a reservoir pressure that is higher than a disc drive environment

10 pressure of the disc drive environment;

 a reservoir outlet through which the gas other than air flows from the reservoir to the disc drive environment; and

 a particle trap within the disc drive environment, the particle trap trapping air particles.

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8. The disc drive of claim 7, further comprising:

 a pressure sensor connected to the disc drive environment, the sensor being operable to produce a pressure signal representative of the disc drive environment pressure; and

20 a control module receiving the pressure signal and operably supplying the gas other than air from the reservoir to the disc drive environment if the disc drive environment pressure is within a predetermined pressure range and ceasing from supplying the gas other than air from the reservoir to the disc drive environment if the pressure within the disc drive environment is above the predetermined pressure range.

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9. The disc drive of claim 8, wherein the control module supplies the gas other than air from the reservoir to the disc drive environment by opening a valve that is connected to the reservoir and wherein the control module ceasing from supplying the gas other than air from the reservoir to the disc drive environment by closing the

30 valve.

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10. The system of claim 7, wherein:
the gas other than air is helium; and
the particle trap confines oxygen and nitrogen particles to a predetermined area within
the disc drive environment.