

SERVO TRACK WRITERS

The present invention relates to servo track writers.

5 In manufacturing a storage medium such as a hard disk drive, a head disk assembly consisting of the read/write head(s), the magnetic disk or disks, the motor and arm electronics, is mounted in a mastering station known as a servo track writer. The servo track writer writes a
10 pattern of magnetic information (the "servo track pattern") onto the disk. The servo track pattern becomes the master reference which is used by the disk drive during normal operation in order to locate the tracks and sectors on the disk for data storage and retrieval.

15 Conventionally, several servo track writers have been mounted on top of a rack or a bench-like support with the servo track writers being arranged in a single horizontal plane. This is illustrated in Figures 1 to 3 which
20 respectively show a view from the front, a view from the side, and a view from above of a conventional mounting of three servo track writers 1 in a horizontal plane on top of a bench 2. Each servo track writer 1 is isolated from mechanical vibrations transmitted through the bench 2 by
25 vibration-isolation mounts. The electronic systems 3 which control the servo track writers 1 are mounted below the servo track writers 1 in the lower portion of the bench 2. The electronic systems 3 are connected to the servo track writers 1 by cables (not shown). Because the head disk
30 assemblies are usually not sealed during the servo track writing process, servo track writing has to take place in a clean room. A flow of clean air 4 passes in a vertical direction over the servo track writers 1 and head disk assemblies supported by the servo track writers 1. Ionised
35 air is used if the head disk assemblies are sensitive to static electricity.

It is the applicant's understanding that every single manufacturer of head disk assemblies presently mounts their servo track writers in the manner shown in Figures 1 to 3, i.e. with the servo track writers arranged in a single horizontal plane on top of some kind of bench or rack. The reasons for this are numerous. First, servo track writers have traditionally been extremely heavy, weighing as much as 1500 kg in the past. Such servo track writers were therefore difficult to install and installation was more easily achieved by placing the servo track writer on top of a bench. The servo track writers were effectively fixed in place and immovable once installed (unless special lifting equipment was available). Second, as access to the servo track writer 1 is required for maintenance purposes, the servo track writers 1 were mounted on top of a bench 2 to allow easy access for maintenance in situ. Furthermore, the head disk assemblies were loaded into the servo track writers 1 from above. This was originally the most convenient manner for loading the head disk assemblies as, in the past, head disk assemblies themselves were relatively heavy. Third, clean rooms themselves have usually had a vertical flow of clean air, again encouraging the horizontal top-mounting of the servo track writers 1 in the past. Moreover, historically, servo track writers were developed from laboratory-style equipment, which would have been mounted on the top of a laboratory bench, and this philosophy has carried through to the present day. The benches presently used for supporting servo track writers are very substantial welded steel structures using large and expensive isolation systems to isolate the servo track writers from vibration.

As mentioned above, it is believed that every disk manufacturer mounts their servo track writers in the manner shown in Figures 1 to 3. There is enormous prejudice in the industry against mounting the servo track writers 1 in any other manner.

The time taken to write the servo tracks is increasing greatly each year. There are several reasons for this. Improved manufacturing techniques and improved control of the read/write heads leads to an increase in the number of tracks per inch on the disk at a rate of 50% more tracks per inch each year. For example, in 1996, on average there were 8,000 tracks per inch. In 1997, on average there were 12,000 tracks per inch. Projected figures for 1998, 1999 and 2000 are 18,000, 24,000 and up to 60,000 tracks per inch respectively. The number of servo tracks per data track has also increased so that whilst previously two revolutions of the disk were required to write a servo track for each data track, now three or even four revolutions of the disk are required to write a servo track for each data track, leading to an increase in the servo write time of 50% or 100%. The servo track writing process is therefore taking longer and longer and thus there is a greatly increased demand for clean room space. Furthermore, head disk assemblies are being manufactured and assembled more and more quickly each year so that the rate at which assembled head disk assemblies come off the production line ready for servo track writing is increasing each year, again placing extra demands on clean room space. As a result of these factors, the demand for clean room space is at least doubling each year. It will be appreciated that construction, operation and maintenance of a clean room is extremely expensive and forms a significant part of the total cost of manufacturing a head disk assembly.

According to a first aspect of the present invention, there is provided apparatus for writing servo tracks to a storage medium, the apparatus comprising a plurality of servo track writers arranged in a vertical column.

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The apparatus preferably comprises a support supporting the servo track writers in vertically separated layers.

5 According to a second aspect of the present invention, there is provided apparatus for writing servo tracks to a storage medium, the apparatus comprising a plurality of servo track writers and a support supporting the servo track writers in vertically separated layers.

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Each layer may contain plural servo track writers.

The layers are preferably arranged in a vertical column.

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Where a support is provided, the support may have plural shelves, at least some of the shelves supporting at least one servo track writer.

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At least some of the shelves on which servo track writers are mounted are preferably arranged to be slidable in the support to allow access to the servo track writers from the front of the support.

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Where a support is provided, the support is preferably arranged such that the servo track writers can be removed from the support from the front of the support.

Each servo track writer is preferably mechanically
30 substantially isolated from the support by at least one vibration-isolation mount. As the servo track writers are isolated from the support, they are effectively isolated from each other. That means for example that access can be had to one of the servo track writers without affecting the
35 operation of any of the other servo track writers in the support.

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There may be at least one fan for providing a horizontal flow of air across the servo track writers.

The apparatus may comprise an air duct to provide an
5 air flow path for air which has passed horizontally over
the servo track writers to direct said air downwards.
Where the apparatus includes a support, the air duct may be
provided by secondary wall which is spaced from the rear
wall of the support, air flowing from the servo track
10 writers through apertures in the secondary wall and into
the space between the secondary wall and the rear of the
support.

The servo track writers may be arranged to be front-
15 maintainable. In other words, maintenance of the servo
track writers may be carried out from the front (in
contrast to prior art servo track writers which were
maintained from above in accordance with their bench top
mounting shown in Figures 1 to 3). In particular, a clock
20 head assembly of each servo track writer may be replaced
from the front of the servo track writer. (The clock head
is used to write a usually temporary clock track onto the
disk which serves as a timing reference during writing of
the servo track. The clock head wears out rapidly in
25 practice, and needs to be replaced typically every 500 to
1000 operations.) It is preferred that the clock head in a
servo track writer can be replaced whilst other servo track
writers in the support are in use without affecting the
operation of the other servo track writers.

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The servo track writers may be arranged so that a head
disk assembly can be loaded onto and unloaded from the
servo track writer from the front of the apparatus.

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It will be appreciated that reference to "front-
loading" and servicing and maintenance from the front,
etc., should be taken to include such from any vertical

side of the support and the term "front" is used herein for convenience and by convention.

Alternatively, the servo track writers may be arranged
5 to be maintainable from above.

The servo track writers, or the bases on which they are mounted, may be mounted on sliders. This allows the servo track writers to slide out, which facilitates access
10 to the servo writers generally and particularly provides easy access to the top of the servo track writers.

Control electronics may be provided for controlling the servo track writers. The control electronics may be
15 supported on shelves below the servo track writers. Preferably, however, the control electronics for each servo track writer is placed close to the servo track writer, most preferably in the same horizontal plane as the servo track writer. This means that there is as short a path as
20 possible for the very high frequency signals between the servo track writer and the control electronics. This arrangement also facilitates removal of the servo track writer and its associated control electronics as a unit for major maintenance.

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According to a third aspect of the present invention, there is provided a clean room having apparatus as described above, and means for providing a flow of clean air in a horizontal direction over the servo track writers.

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The invention makes much more efficient use of clean room space and overcomes the prejudice of the prior art. Many more servo track writers can be fitted into a clean room than was possible in the prior art arrangements. In
35 the preferred embodiment, the servo writers are stacked vertically, making the best use of the volume available in a clean room whilst minimising the floor space required.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

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Fig. 1 is a front view of a prior art apparatus;

Fig. 2 is a side view of the prior art apparatus of Figure 1;

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Fig. 3 is a plan view from above of the prior art apparatus of Figures 1 and 2;

Fig. 4 is a front view of a first example of apparatus according to the present invention;

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Fig. 5 is a side view of the apparatus of Figure 4;

Fig. 6 is a perspective view of a second example of apparatus according to the present invention; and,

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Fig. 7 is a perspective view of an example of a servo track writer and its control electronics for the apparatus of Fig. 6.

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Referring now to Figures 4 and 5, there is shown a first example of apparatus 10 for writing servo tracks to a storage medium. The apparatus 10 includes a support 11 which supports plural servo track writers 12 in a vertical column.

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The support 11 in the example shown is in the form of a rack having four vertical corner posts 13 between which are plural horizontal shelves 14. The support rack 11 has a top plate 15 and a bottom plate 16 each of which is horizontal and parallel to the respective shelves 14. The

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bottom plate 16 has castor wheels 17 which allow the support rack 11 to be moved.

In the example shown, there are three shelves 14
5 separated from one another in a vertical direction and lying vertically over each other. Each shelf 14 has a width w which is sufficient to allow two servo track writers 12 to be placed side by side on each shelf 14. Thus, in the example shown, the support rack 11 can support
10 six servo track writers 12 in three vertically separated layers arranged in a vertical column. Each servo track writer 12 is isolated by vibration-isolation mounts 18 from transmission of mechanical vibrations through the support rack 11, the vibration-isolation mounts 18 being interposed
15 between the servo track writers 12 and the respective shelves 14.

Control electronics 19 for the servo track writers 12 are supported in the lower portion of the support rack 11.
20 In the example shown, there are six sets of control electronics 19, one for each servo track writer 12, and each set of control electronics 19 is connected via a cable (not shown) to a respective servo track writer 12.

25 In the example shown in Figures 4 and 5, because the servo track writers 12 are stacked in a vertical direction, the flow of clean ionised air 20 over the servo track writers 12 is in a horizontal direction in order for the air to be able to flow over all of the servo track writers
30 12.

The servo track writers 12 may be arranged so that they can be maintained from the front of the support rack 11. (As mentioned above, reference to "front" shall be
35 taken to include any vertical side of the support rack 11. For example, maintenance could be carried out from the side shown in Figure 5.) The servo track writers 12 may be

arranged so that a head disk assembly can be loaded onto the servo track writer 12 from the front to allow quick and easy loading and unloading of the head disk assemblies.

5 Alternatively, the servo track writers may be arranged to be maintainable from above. The servo track writers may be mounted on sliders, such as sliding rails, allowing the servo track writers to slide out to provide access to the top of the servo track writers.

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 The support rack 11 is preferably arranged so that the servo track writers 12 can be removed from the front of the support rack 11. Retaining blocks 21 can be provided at the front of each shelf 14 to retain each servo track
15 writer 12 on its shelf 14, the retaining blocks 21 being movable or removable to allow the servo track writers 12 to be removed from and replaced onto a shelf 14.

 A second example of apparatus 10 for writing servo
20 tracks to a storage medium is shown in Figures 6 and 7. Those features of the second example which correspond to those features of the first example described above have the same reference numerals and will not be described further in detail.

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 In the second example, the support 11 is in the form of a cabinet which is open on its front face. The support 11 has eight bays 30 in its upper portion each for receiving a respective servo track writer 12. The bays 30
30 are arranged in two vertical columns of four bays 30 each. Each bay 30 has runners or rails (not shown). A shelf 14 sits on the rails in each bay 30 so that the shelf 14 can be slid into and out of the bay 30 from the front of the support 11. Each shelf 14 has latches 31 which can be
35 released to enable the shelf 14 to be slid out of the bay 30 and locked to retain the shelf 14 in the bay 30. Each

shelf 14 can be removed completely from the support 11 by lifting the shelf 14 off the rails.

Each shelf 14 carries on its uppermost surface a servo track writer 12 which is mounted towards the front of the shelf 14. Each servo track writer 12 is isolated from its shelf 14 by vibration-isolation mounts (not shown) to isolate the servo track writer 12 from transmission of mechanical vibrations through the support rack 11, the vibration-isolation mounts being interposed between the servo track writers 12 and the respective shelves 14.

Each servo track writer 12 has its own control electronics 19 which is supported on the same shelf 14. It is not normally necessary for the control electronics 19 to be isolated from the shelf 14 though this may be done if desired. As shown in the drawings, each control electronics 19 is positioned behind its respective servo track writer 12 and is positioned as close as possible to its servo track writer 12. This means that the path for the very high frequency signals between the control electronics 19 and its servo track writer 12 is as short as possible, thereby minimising any attenuation or interference of the signals. This mounting of the control electronics 19 behind the servo track writers 12 also means that the control electronics 19 and the servo track writer 12 can be removed as a unit from the support 11, for example for replacement or maintenance.

AC/DC power distribution units 32 for the control electronics 19 and the servo track writers 12 are positioned in horizontal bays 33 at the bottom of the support 11.

The servo track writers 12 are arranged so that they can be maintained from the front of the support rack 11. (As mentioned above, reference to "front" shall be taken

to include any vertical side of the support rack 11. For example, maintenance could be carried out from the side shown in Figure 6.) This is facilitated by the shelves 14 being slidable in the bays 30.

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The servo track writers 12 are arranged so that a head disk assembly 34 can be loaded onto the servo track writer 12 from the front of the support 11 to allow quick and easy loading and unloading of the head disk assemblies 34. To
10 achieve this in the example shown, each servo track writer 12 has a transport mechanism 35 in the form of a drivable caddy or tray which carries the head disk assembly 34 and which can be driven towards and away from the front of the servo track writer 12 as necessary. A vertical clamp 36,
15 which may be under automatic control, clamps the head disk assembly 34 to the servo track writer 12 when the head disk assembly 34 is in the correct position.

It will be understood that in conventional clean
20 rooms, the clean air flows into the room through apertures in the ceiling and then down from the ceiling in a vertical direction to exhaust through apertures in the clean room floor. In the arrangement of the present invention, it is desirable for the clean ionised air flow to be directed
25 horizontally across the servo track writers 12 in order for the air to be able to flow over all of the servo track writers 12. This is indicated in Figure 7 where it is also shown that the clean air 20 flows from the front to the back of the support 11 in this example.

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To achieve the horizontal air flow 20 across the servo track writers 12 in a conventional clean room, as indicated in Figure 7, the rear of the control electronics 19 in the second example may fit directly into apertures 40 provided
35 in a secondary rear wall 41 which is spaced from the actual rear of the support 11. A centrifugal fan 42 is mounted at the rear of each of the control electronics 19. The fan 42

draws air 20 in from the front of the support 11 horizontally across the servo track writer 12 and the control electronics 19, thereby keeping the servo track writer 12 clean and the control electronics 19 cool. Air
5 passing through the apertures 40 in the spaced wall 41 is thrown downwards by the centrifugal fan 42 towards the floor of the clean room from where the air can be exhausted from the clean room. It will be appreciated that the arrangement of the spaced wall 41 at the rear of the
10 support 11 may be replaced by other ducting to direct air which has passed over the servo track writers 12 downwards to the clean room floor.

In the first example shown in Figures 4 and 5, fans 42
15 may be mounted at the front of the servo track writers 12.

The present invention provides a system which allows much improved utilisation of expensive clean room space during the manufacture of a storage medium such as a disk
20 drive. Several servo track writers can be supported in a floor area which previously only supported one servo track writer. This avoids the need to build further or larger clean rooms and allows a higher throughput of storage media such as disk drives through the servo track writing
25 process. In the preferred embodiment, the usual vertical air flow in a conventional clean room is directed horizontally across the servo track writers.

An embodiment of the present invention has been
30 described with particular reference to the examples illustrated. However, it will be appreciated that variations and modifications may be made to the examples described within the scope of the present invention.

CLAIMS

1. Apparatus for writing servo tracks to a storage medium, the apparatus comprising a plurality of servo track writers arranged in a vertical column.
2. Apparatus according to claim 2, comprising a support supporting the servo track writers in vertically separated layers.
3. Apparatus for writing servo tracks to a storage medium, the apparatus comprising a plurality of servo track writers and a support supporting the servo track writers in vertically separated layers.
4. Apparatus according to claim 3, wherein each layer contains plural servo track writers.
5. Apparatus according to claim 3 or claim 4, wherein the layers are arranged in a vertical column.
6. Apparatus according to any of claims 2 to 5, wherein the support has plural shelves, each shelf supporting at least one servo track writer.
7. Apparatus according to any of claims 2 to 6, wherein at least some of the shelves on which servo track writers are mounted are arranged to be slidable in the support to allow access to the servo track writers from the front of the support.
8. Apparatus according to any of claims 2 to 7, wherein the support is arranged such that the servo track writers can be removed from the support from the front of the support.

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9. Apparatus according to any of claims 2 to 8, wherein each servo track writer is mechanically substantially isolated from the support by at least one vibration-isolation mount.

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10. Apparatus according to any of claims 1 to 9, comprising at least one fan for providing a horizontal flow of air across the servo track writers.

10 11. Apparatus according to any of claims 1 to 10, comprising an air duct to provide an air flow path for air which has passed horizontally over the servo track writers to direct said air downwards.

15 12. Apparatus according to any of claims 1 to 11, wherein the servo track writers are arranged to be front-maintainable.

13. Apparatus according to any of claims 1 to 11, wherein
20 the servo track writers are arranged to be maintainable from above.

14. Apparatus according to any of claims 1 to 13, wherein the servo track writers are mounted on sliders.

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15. Apparatus according to any of claims 1 to 14, wherein the servo track writers are arranged so that a head disk assembly can be loaded onto and unloaded from the servo track writer from the front of the apparatus.

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16. Apparatus according to any of claims 1 to 15, comprising control electronics for controlling the servo track writers.

35 17. Apparatus according to claim 16, wherein the control electronics are supported on shelves below the servo track writers.



18. Apparatus according to claim 16, wherein the control electronics for a servo track writer is positioned close to and in the same horizontal plane as said servo track
5 writer.

19. A clean room having apparatus according to any of claims 1 to 18, and comprising means for providing a flow of clean air in a horizontal direction over the servo track
10 writers.



PRIOR ART

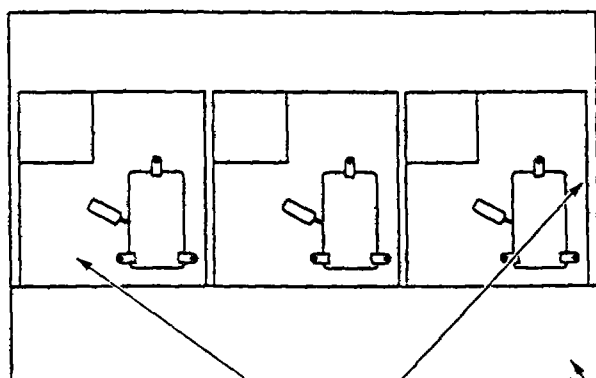


Fig. 3

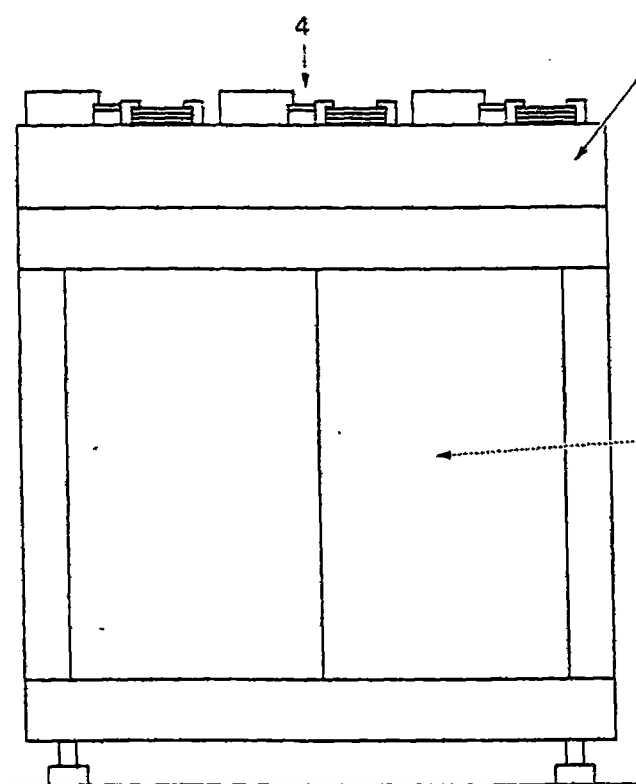


Fig. 1

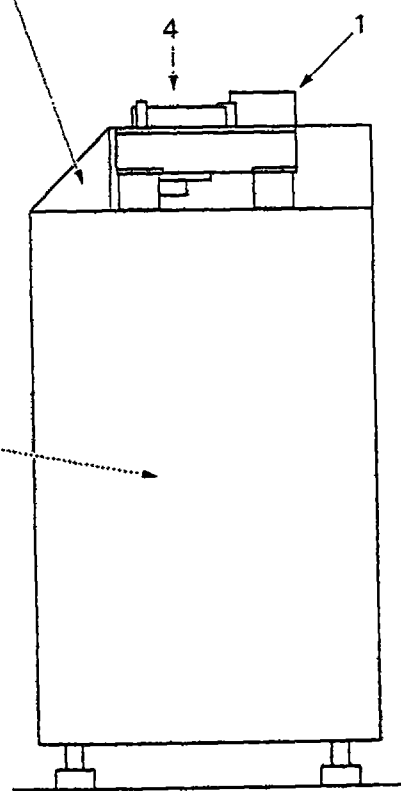


Fig. 2

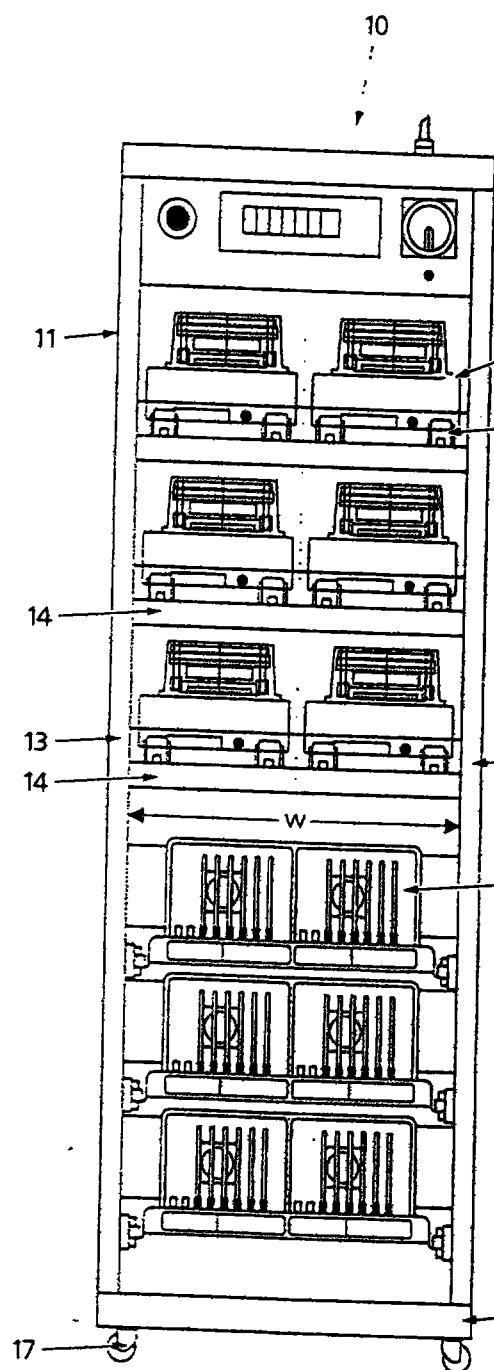


Fig. 4

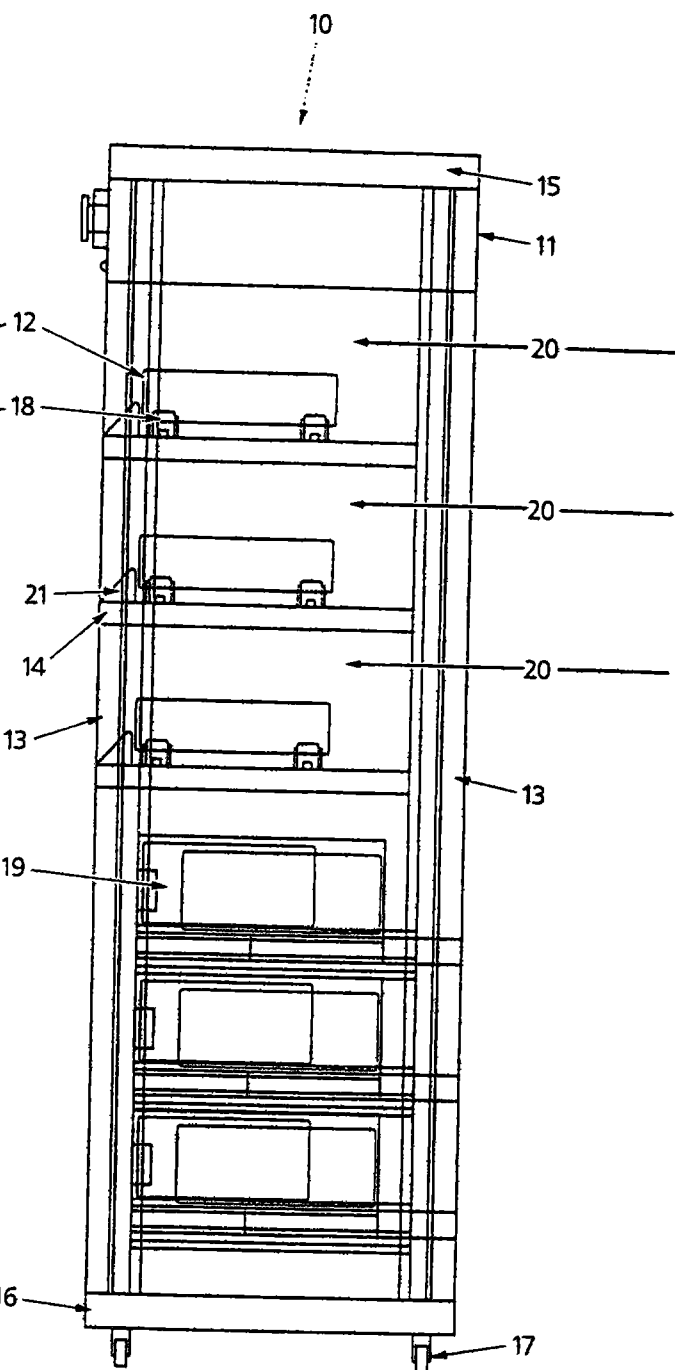
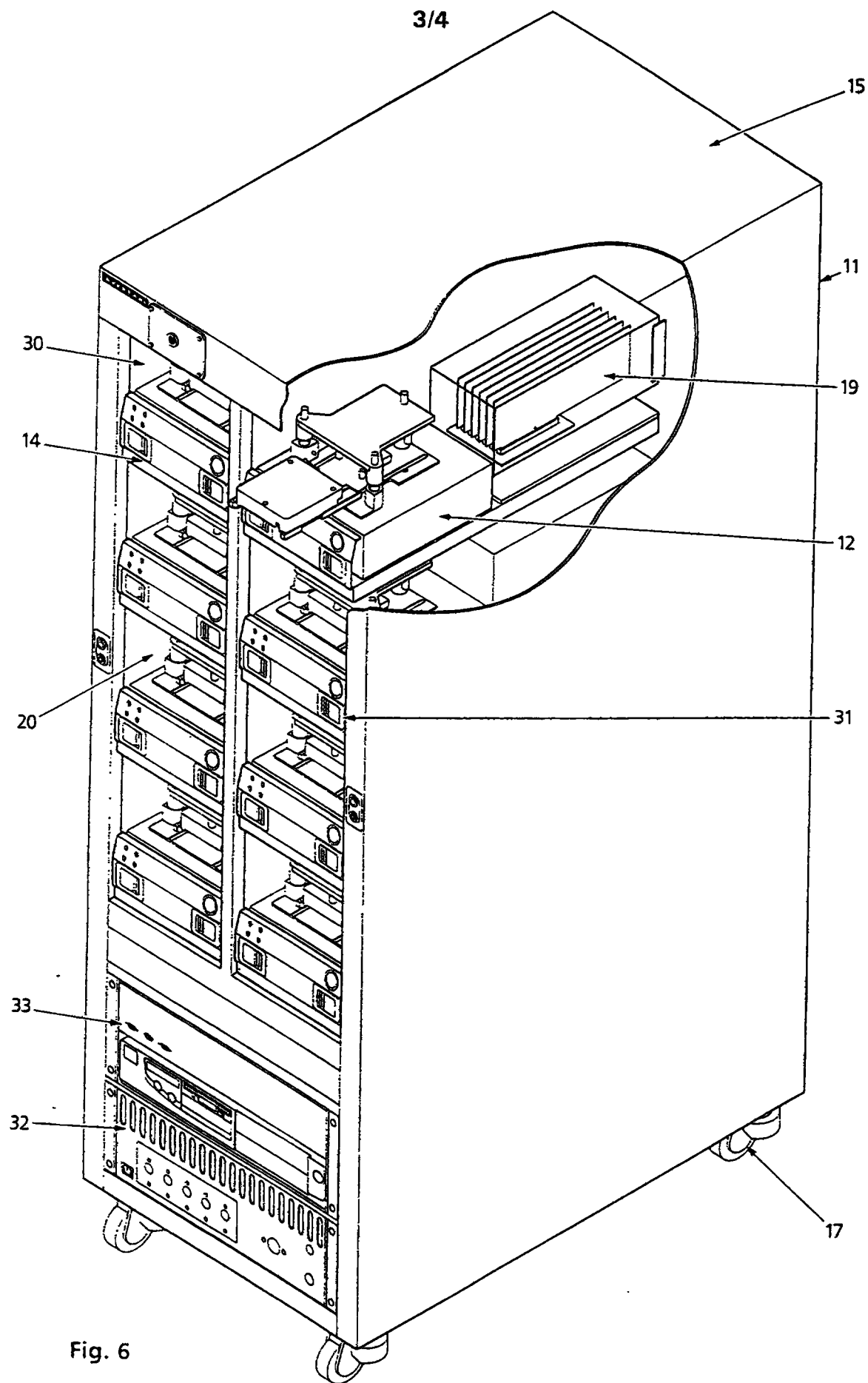


Fig. 5



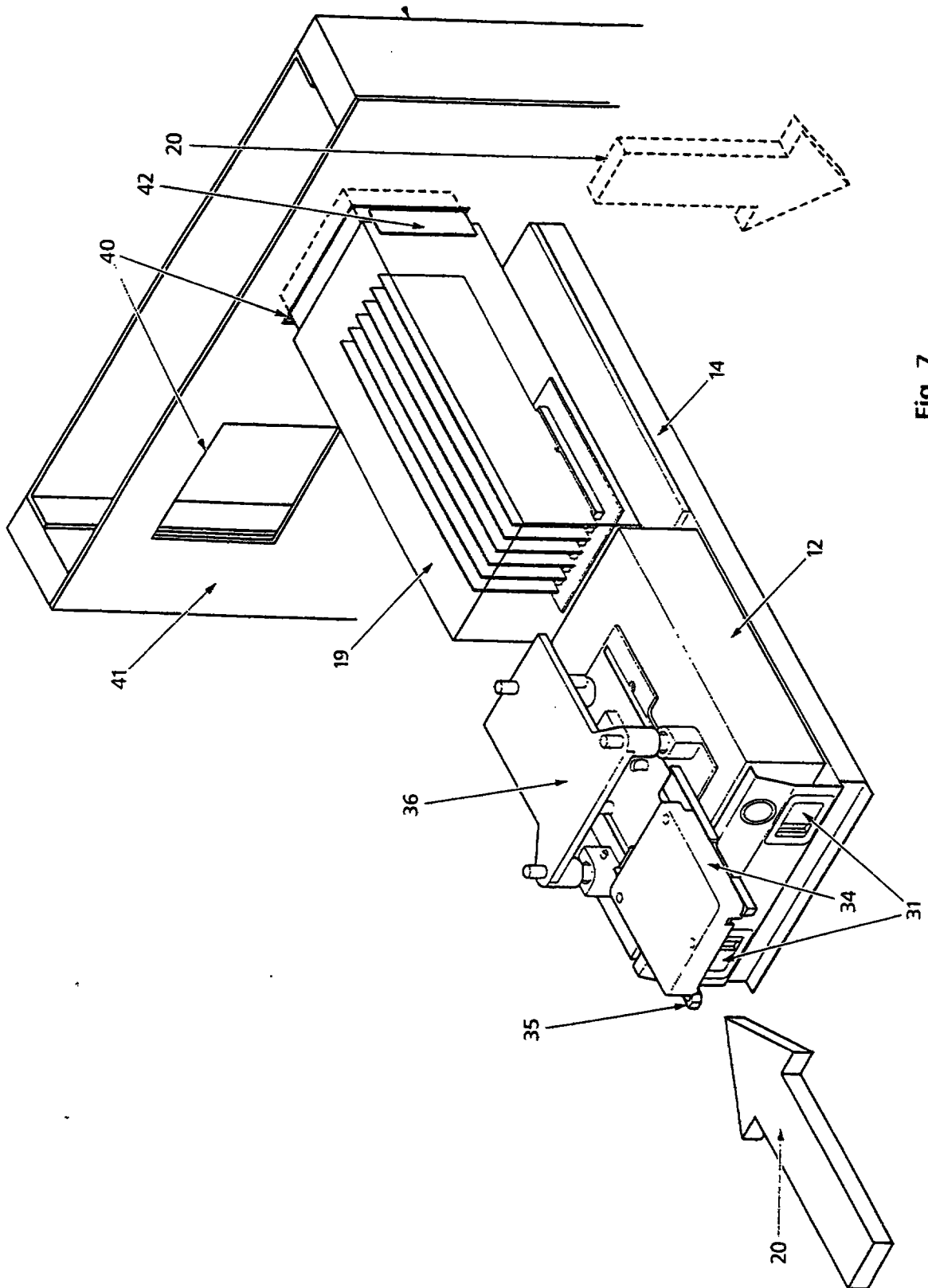


Fig. 7

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The time taken to write the servo tracks is increasing greatly each year. There are several reasons for this. Improved manufacturing techniques and improved control of the read/write heads leads to an increase in the number of tracks per inch on the disk at a rate of 50% more tracks per inch each year. For example, in 1996, on average there were 8,000 tracks per inch. In 1997, on average there were 12,000 tracks per inch. Projected figures for 1998, 1999 and 2000 are 18,000, 24,000 and up to 60,000 tracks per inch respectively. The number of servo tracks per data track has also increased so that whilst previously two revolutions of the disk were required to write a servo track for each data track, now three or even four revolutions of the disk are required to write a servo track for each data track, leading to an increase in the servo write time of 50% or 100%. The servo track writing process is therefore taking longer and longer and thus there is a greatly increased demand for clean room space. Furthermore, head disk assemblies are being manufactured and assembled more and more quickly each year so that the rate at which assembled head disk assemblies come off the production line ready for servo track writing is increasing each year, again placing extra demands on clean room space. As a result of these factors, the demand for clean room space is at least doubling each year. It will be appreciated that construction, operation and maintenance of a clean room is extremely expensive and forms a significant part of the total cost of manufacturing a head disk assembly.

JP-A-05/128765 discloses an arrangement for simultaneously writing servo tracks to two hard disks. A single clock head is used to write a clock track to a first of the hard disks. That clock track is then used as a reference for writing servo tracks to the first hard disk using a first servo writing head. The first servo writing

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head is mechanically coupled to a second servo writing head which simultaneously writes servo tracks to the second hard disk.

5 US-A-5525106 discloses storage equipment for a clean room having a plurality of shelves arranged in vertically separated layers. Plural clean air supply units are provided, each having a fan and a filter.

10 US-A-5469037 discloses apparatus for mounting plural disk drives in which the disk drives are installed in cages that are mounted in on shelves of a drawer that slides out from the front of the apparatus.

15 According to a first aspect of the present invention, there is provided apparatus for writing servo tracks to a plurality of storage media, the apparatus comprising a plurality of servo track writers arranged in a vertical column.

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The apparatus preferably comprises a support supporting the servo track writers in vertically separated layers.

25 According to a second aspect of the present invention, there is provided apparatus for writing servo tracks to a plurality of storage media, the apparatus comprising a plurality of servo track writers and a support supporting the servo track writers in vertically separated layers.

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Each layer may contain plural servo track writers.

35 The layers are preferably arranged in a vertical column.

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Where a support is provided, the support may have plural shelves, at least some of the shelves supporting at least one servo track writer.

5 At least some of the shelves on which servo track writers are mounted are preferably arranged to be slidable in the support to allow access to the servo track writers from the front of the support.

10 Where a support is provided, the support is preferably arranged such that the servo track writers can be removed from the support from the front of the support.

Each servo track writer is preferably mechanically
15 substantially isolated from the support by at least one vibration-isolation mount. As the servo track writers are isolated from the support, they are effectively isolated from each other. That means for example that access can be had to one of the servo track writers without affecting the
20 operation of any of the other servo track writers in the support.

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CLAIMS

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1. Apparatus for writing servo tracks to a plurality of storage media, the apparatus comprising a plurality of servo track writers arranged in a vertical column.

2. Apparatus according to claim 2, comprising a support supporting the servo track writers in vertically separated layers.

3. Apparatus for writing servo tracks to a plurality of storage media, the apparatus comprising a plurality of servo track writers and a support supporting the servo track writers in vertically separated layers.

4. Apparatus according to claim 3, wherein each layer contains plural servo track writers.

5. Apparatus according to claim 3 or claim 4, wherein the layers are arranged in a vertical column.

6. Apparatus according to any of claims 2 to 5, wherein the support has plural shelves, each shelf supporting at least one servo track writer.

7. Apparatus according to any of claims 2 to 6, wherein at least some of the shelves on which servo track writers are mounted are arranged to be slidable in the support to allow access to the servo track writers from the front of the support.

8. Apparatus according to any of claims 2 to 7, wherein the support is arranged such that the servo track writers can be removed from the support from the front of the support.



AMENDED SHEET



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(54) Title: **SERVO TRACK WRITERS**

(57) Abstract

A plurality of servo track writers (12) is mounted in a support rack (11) such that the servo track writers (12) are arranged in a vertical column. This provides an enormous saving in clean room space.

