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TITLE OF THE INVENTION

PERPENDICULAR MAGNETIC HEAD AND PERPENDICULAR MAGNETIC
DISK APPARATUS

BACKGROUND OF THE INVENTION

5 The present invention relates to a perpendicular
magnetic head and a perpendicular magnetic disk
apparatus.

 In recent years, magnetic disk apparatuses have
been severely required to have sufficient external
10 magnetic field resistance in accordance with reduction
in size and weight.

 Conventionally, in order to improve the external
field resistance of the magnetic disk apparatus, it
has been proposed, for example, to provide a magnetic
15 shield member surrounding the main pole of the write
head by which an external magnetic field is prevented
from penetrating into the main pole so as to reduce
adverse effect of the external field (see Jpn. Pat.
Appln. KOKAI Publication No. 2004-185672).

20 The present inventor has found that, when an
external field intrudes into the magnetic head, a
magnetic flux leaks from edge portions of the shields
of the read head facing the magnetic disk, so that
data already recorded to the magnetic disk may be
25 miserased. Also, it has been found that the adverse
effect of the external field through the shields of
the read head is rather profound than that through the



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main pole. However, since the conventional magnetic disk apparatus has the magnetic shield member surrounding the main pole only, it cannot avoid the above problem and has an insufficient external field resistance.

BRIEF SUMMARY OF THE INVENTION

A perpendicular magnetic head according to an aspect of the present invention comprises: a write head including a main pole, a return yoke, and a recording coil; a read head including a magnetoresistive film, and a pair of shields arranged so as to sandwich the magnetoresistive film; and a soft magnetic film arranged so as to surround side faces and a top face of the read head.

A perpendicular magnetic disk apparatus according to another aspect of the present invention comprises: a perpendicular magnetic head comprising: a write head including a main pole, a return yoke, and a recording coil; a read head including a magnetoresistive film, and a pair of shields arranged so as to sandwich the magnetoresistive film; and a soft magnetic film arranged so as to surround side faces and a top face of the read head; and a magnetic disk including a substrate, and a soft magnetic underlayer and a perpendicular recording layer formed on the substrate.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a perspective view showing a principal

part of a perpendicular magnetic disk apparatus
according to a first embodiment;

FIG. 2 is a front view of the perpendicular
magnetic disk apparatus according to the first
5 embodiment viewed from the head trailing side;

FIG. 3 is a bottom view of the magnetic head
according to the first embodiment viewed from the air
bearing surface;

FIG. 4 is a plan view showing a shape of another
10 soft magnetic film used in the first embodiment;

FIG. 5 is a front view of a perpendicular
magnetic disk apparatus according to a modified
embodiment for the first embodiment viewed from the
head trailing side;

15 FIG. 6 is a perspective view showing a principal
part of a perpendicular magnetic disk apparatus
according to a second embodiment;

FIG. 7 is a front view of the perpendicular
magnetic disk apparatus according to the second
20 embodiment viewed from the head trailing side;

FIG. 8 is a bottom view of the magnetic head
according to the second embodiment viewed from the air
bearing surface;

FIG. 9 is a front view of a perpendicular
25 magnetic disk apparatus according to a third
embodiment viewed from the head trailing side;

FIG. 10 is a front view of a perpendicular

magnetic disk apparatus according to a modified embodiment for the third embodiment viewed from the head trailing side;

FIG. 11 is a front view of a perpendicular magnetic disk apparatus according to a fourth
5 embodiment viewed from the head trailing side; and

FIG. 12 is a graph showing a relationship between s/p and permissible external field.

DETAILED DESCRIPTION OF THE INVENTION

10 Hereinafter, embodiments of the present invention will be described with reference to the drawings.

(First Embodiment)

FIG. 1 is a perspective view showing a principal part of the perpendicular magnetic disk apparatus according to the first embodiment, FIG. 2 is a front
15 view of the perpendicular magnetic disk apparatus viewed from the head trailing side, and FIG. 3 is a bottom view of the magnetic head viewed from the air bearing surface (ABS).

20 The magnetic disk (a so-called perpendicular double-layer media) mounted to the perpendicular magnetic disk apparatus has a structure that the soft magnetic underlayer 2 and the perpendicular recording layer 3 are formed on the substrate 1. The
25 perpendicular recording layer 3 has magnetic anisotropy in the perpendicular direction to the media surface.

The magnetic head 10 installed in the perpendicular magnetic disk apparatus has a read head and a write head. The read head has a structure that the magnetoresistive film (GMR film) 12 is sandwiched
5 between the shields 11 and 13 formed of a soft magnetic material. The write head includes the main pole 15, the return yoke 16 that is provided on the leading side with respect to the main pole 15, and the recording coil 17. Further, the soft magnetic film 21
10 is provided so as to surround the side faces and the top face (the face remote from the ABS) of the read head. The bottom surfaces of the soft magnetic film 21 are arranged up to the vicinity of the magnetic disk. The soft magnetic film 21 can be easily formed
15 as a pattern of a soft magnetic film on the end surface of the head slider (not shown).

Thus, the soft magnetic film 21 surrounds the side faces and the top face of the read head except the ABS and exerts a function of shielding the entire
20 read head against an external field, making it possible to prevent the external field from intruding into the read head.

Further, the apparatus is designed such that the distance s between the soft magnetic film 21 and the
25 shields 11 and 13 in the read head is made greater than the distance p between the soft magnetic film 21 and the soft magnetic underlayer 2 in the magnetic

disk. Here, the distance $\underline{s}$ between the soft magnetic film 21 and the shields 11 and 13 in the read head means the smallest distance therebetween. For the present embodiment, the distance $\underline{s}$ is the distance
5 between the inner side face of the soft magnetic film 21 and the sides of the shields 11 and 13. In such a design, because the external field is made to flow from the soft magnetic film 21 to the soft magnetic underlayer 2 in the magnetic disk, there is no case
10 where the external field reaches the shields 11 and 13 through the soft magnetic film 21. Accordingly, miserase of recorded data by the leakage magnetic fluxes from the edge portions of the shields 11 and 13 in the read head due to the intrusion of the external
15 field can be prevented. Likewise, misread of read signals can be prevented.

Here, it is preferable that the ratio s/p between the distance $\underline{s}$ and the distance $\underline{p}$ satisfy the following relationship: $1 < s/p \leq 50$. Because the
20 distance $\underline{s}$ between the soft magnetic film and the shields included in the read head should be greater than the distance $\underline{p}$ between the soft magnetic film and the soft magnetic underlayer of the magnetic disk, s/p is greater than 1. However, if the distance $\underline{s}$ is too
25 large, the external field resistance is degraded.

FIG. 12 shows a relationship between s/p and permissible external field based on experiments. The

following empirical formula is given from the graph:

$$\text{Permissible external field} = 250 \times \exp(-s/50p).$$

Provided that the external field resistance required in the market is 100 Oe, the ratio s/p should preferably be 50 or less.

In the present embodiment, it is preferable that obtuse-angled portions (for example, θ_1 and θ_2 in FIG. 4) are provided by beveling the edge portions on the ABS of the soft magnetic film 21 as shown in FIG. 4. When the edge portions of the soft magnetic film 21 are processed in such a manner, concentration of the external field can be suppressed, and thus magnetic fluxes are allowed to flow smoothly from the soft magnetic film 21 to the soft magnetic underlayer 2.

It should be noted that the shape of the soft magnetic film shielding the entire read head is not particularly limited. For example, the soft magnetic film 22 having the shape shown in FIG. 5 can be used. In FIG. 5, the smallest distance $\underline{s}$ between the soft magnetic film 22 and the shields 11 and 13 is the read head is the distance between the bottom face of the upper portion of the soft magnetic film 22 and the top face of the shields 11 and 13.

(Second Embodiment)

FIG. 6 is a perspective view showing a principal part of the perpendicular magnetic disk apparatus

according to the second embodiment, FIG. 7 is a front view of the perpendicular magnetic disk apparatus viewed from the head trailing side, and FIG. 8 is a bottom view of the magnetic head viewed from the ABS.

5 The perpendicular double-layer media mounted to the perpendicular magnetic disk apparatus has the similar structure to that shown in FIGS. 1 and 2. The magnetic head installed in the perpendicular magnetic disk apparatus has a read head and a write head. The
10 read head has a structure that the GMR film 12 is sandwiched between the shields 11 and 13 formed of a soft magnetic material. The write head includes the main pole 15, the return yoke 18 that is provided on the trailing side with respect to the main pole 15,
15 and a recording coil 17. Further, the soft magnetic film 23 is provided so as to surround the side faces and the top face of the read head. The bottom surfaces of the soft magnetic film 23 are arranged up to the vicinity of the magnetic disk. Thus, the soft
20 magnetic film 23 surrounds the side faces and the top face of the read head except the ABS and exerts a function of shielding the entire read head against an external field, making it possible to prevent the external field from intruding into the read head.

25 Also, the apparatus is designed such that the distance s between the soft magnetic film 23 and the shields 11 and 13 in the read head is made greater

than the distance p between the soft magnetic film 23 and the soft magnetic underlayer 2 in the magnetic disk. In the present embodiment as well, because the external field is made to flow from the soft magnetic film 23 to the soft magnetic underlayer 2 in the magnetic disk, there are no case where the external field reaches the shields 11 and 13 through the soft magnetic film 23. Accordingly, miserase of recorded data and misread of read signals can be prevented.

In the present embodiment as well, it is preferable that obtuse-angled portions are provided by beveling the edge portions on the ABS of the soft magnetic film 23, in the same way as in FIG. 4.

(Third Embodiment)

FIG. 9 is a front view of the perpendicular magnetic disk apparatus according to the third embodiment viewed from the head trailing side.

The perpendicular double-layer media, the read head, and the write head in this perpendicular magnetic disk apparatus have the similar structures to those shown in FIGS. 6 and 8. In the present embodiment, the soft magnetic films 24a and 24b divided into two parts are provided so as to surround the side faces and the top face of the read head. The bottom surfaces of the soft magnetic films 24a and 24b are arranged up to the vicinity of the magnetic disk. Further, the apparatus is designed such that the

distance s between the soft magnetic films 24a and 24b and the shields 11 and 13 in the read head is made greater than the distance p between the soft magnetic films 24a and 24b and the soft magnetic underlayer 2 in the magnetic disk. In this way, even when the soft magnetic films 24a and 24b divided into two parts are provided, the external field can be prevented from intruding into the read head, and thus miserase of recorded data and misread of read signals can be prevented.

FIG. 10 shows a modified embodiment for FIG. 9. In the embodiment of FIG. 10, the soft magnetic films 25a and 25b divided into two parts are formed, and these soft magnetic films 25a and 25b have shapes, heights and areas different from each other. In this case, the soft magnetic film 25a with a larger area is formed in a region where an external field easily intrudes. In this case as well, the same effect as that of FIG. 9 can be obtained.

Also in the present embodiment, it is preferable that obtuse-angled portions are provided by beveling the edge portions on the ABS of the soft magnetic films, in the same way as in FIG. 4.

(Fourth Embodiment)

FIG. 11 is a front view of the perpendicular magnetic disk apparatus according to the fourth embodiment viewed from the head trailing side.

The perpendicular double-layer media, the read head, and the write head in this perpendicular magnetic disk apparatus have the similar structures to those shown in FIGS. 1 to 3. In the present

5 embodiment, the cap-shaped soft magnetic film 26 is formed so as to surround the side faces and the top face of the read head. The bottom surfaces of the soft magnetic film 26 are arranged up to the vicinity of the magnetic disk. Further, the apparatus is
10 designed such that the distance $\underline{s}$ between the soft magnetic film 26 and the shields 11 and 13 in the read head is made greater than the distance $\underline{p}$ between the soft magnetic film 26 and the soft magnetic underlayer 2 in the magnetic disk. In the present embodiment as
15 well, the external field can be prevented from intruding into the read head, and thus miserase of recorded data and misread of read signals can be prevented. Further, because the soft magnetic film 26 is cap-shaped, magnetic fluxes can be prevented from
20 being concentrated.

Also in the present embodiment, it is preferable that obtuse-angled portions are provided by beveling the edge portions on the ABS of the soft magnetic film 26, in the same way as in FIG. 4.

25 Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to

the specific details and representative embodiments
shown and described herein. Accordingly, various
modifications may be made without departing from the
spirit or scope of the general inventive concept as
5 defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A perpendicular magnetic head comprising:
a write head including a main pole, a return
yoke, and a recording coil;

5 a read head including a magnetoresistive film,
and a pair of shields arranged so as to sandwich the
magnetoresistive film; and

a soft magnetic film arranged so as to surround
side faces and a top face of the read head.

10 2. The perpendicular magnetic head according to
claim 1, wherein the soft magnetic film is divided
into a plurality of parts.

3. The perpendicular magnetic head according to
claim 2, wherein the parts of the divided soft
15 magnetic film have areas different from one another.

4. A perpendicular magnetic disk apparatus
comprising:

a perpendicular magnetic head comprising: a write
head including a main pole, a return yoke, and a
20 recording coil; a read head including a
magnetoresistive film, and a pair of shields arranged
so as to sandwich the magnetoresistive film; and a
soft magnetic film arranged so as to surround side
faces and a top face of the read head; and

25 a magnetic disk including a substrate, and a soft
magnetic underlayer and a perpendicular recording
layer formed on the substrate.

5 5. The apparatus according to claim 4, wherein a distance $\underline{s}$ between the soft magnetic film and the shields included in the read head is greater than a distance $\underline{p}$ between the soft magnetic film and the soft magnetic underlayer in the magnetic disk.

6. The apparatus according to claim 5, wherein a ratio s/p between the distance $\underline{s}$ and the distance $\underline{p}$ satisfies the following relationship: $1 < s/p \leq 50$.

10 7. The apparatus according to claim 4, wherein portions of the soft magnetic film facing the magnetic disk are beveled.

8. The apparatus according to claim 4, wherein the soft magnetic film is divided into a plurality of parts.

15 9. The apparatus according to claim 8, wherein the parts of the divided soft magnetic film have areas different from one another.