US 20020089780A1

(19) **United States**
(12) **Patent Application Publication**
Soda et al.
(10) **Pub. No.: US 2002/0089780 A1**
(43) **Pub. Date: Jul. 11, 2002**

(54) **MAGNETIC STORAGE RECORDING MEDIUM AND MAGNETIC RECORDING AND PLAYBACK DEVICE**

(76) Inventors: **Yutaka Soda**, Kanagawa (JP); **Nobuyuki Nagai**, Miyagi (JP); **Katsuhiro Kasuga**, Kanagawa (JP); **Hiroshi Meguro**, Miyagi (JP); **Tadashi Ozue**, Kanagawa (JP)

Correspondence Address:
RADER FISHMAN & GRAUER PLLC
LION BUILDING
1233 20TH STREET N.W., SUITE 501
WASHINGTON, DC 20036 (US)

(21) Appl. No.: **10/013,859**

(22) Filed: **Dec. 13, 2001**

(30) **Foreign Application Priority Data**

Dec. 15, 2000 (JP) P2000-381721
Dec. 26, 2000 (JP) P2000-394507

Publication Classification

(51) **Int. Cl.**[7] **G11B 15/00**
(52) **U.S. Cl.** **360/96.3**

(57) **ABSTRACT**

A pair of reels of a magnetic cassette tape and a pair of reel supports of a magnetic tape drive comprise a conductive material as an antistatic treatment. Further, a head substrate and a projection substrate of a head drum comprise a conductive material having a resistance of 1×10^{10} Ω or less and are connected to a metal base so as to be at the ground potential via the metal base and a rotating drum. These antistatic treatments allow static electricity charged on a magnetic tape to be discharged to the head substrate and the protection substrate without flowing to a magneto-resistive (MR) element, thereby preventing the electrostatic discharge breakdown of the MR element.

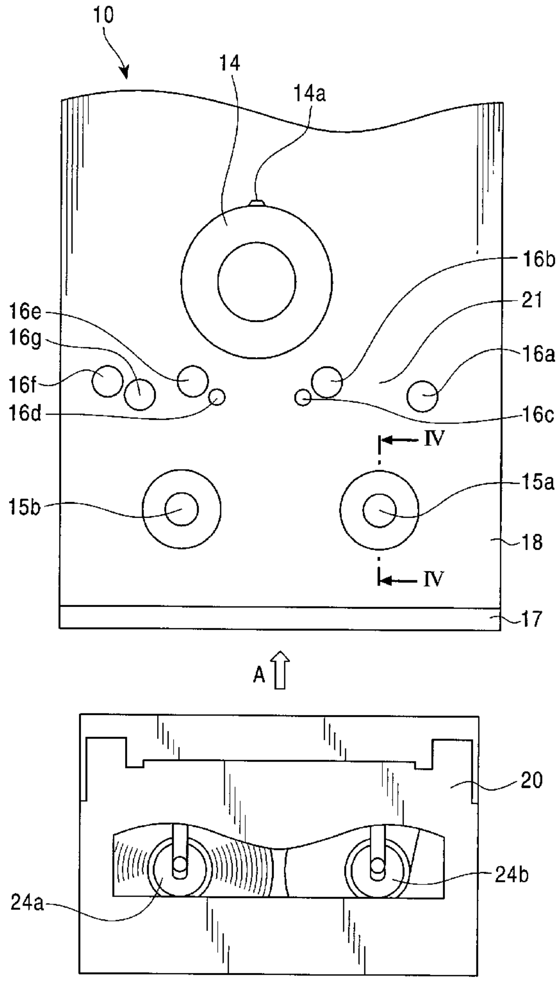


FIG. 1A

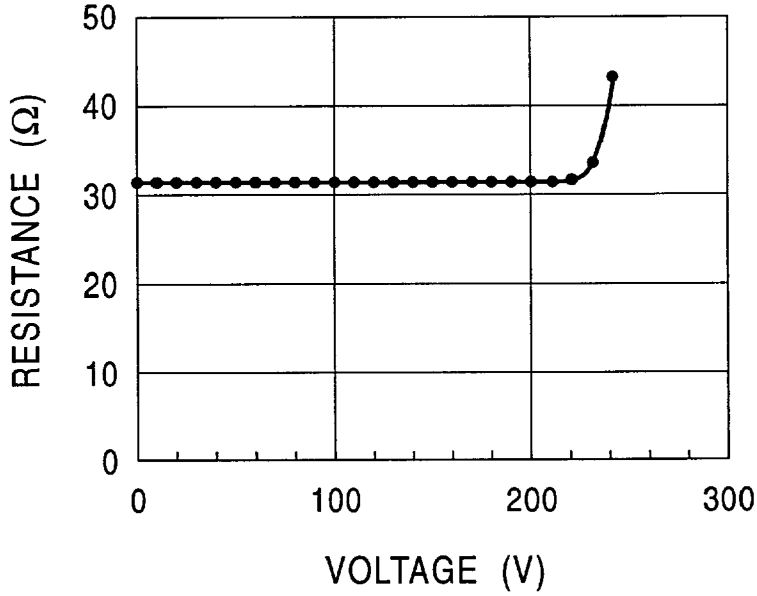

50
40
30
20
10
0
RESISTANCE (Ω)
0
100
200
300
VOLTAGE (V)

FIG. 1B

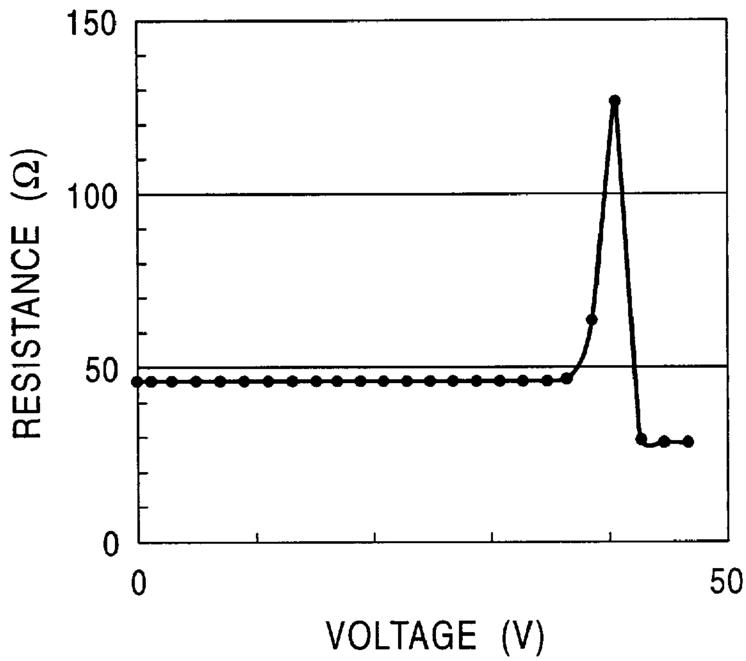

150
100
50
0
RESISTANCE (Ω)
0
50
VOLTAGE (V)

FIG. 2

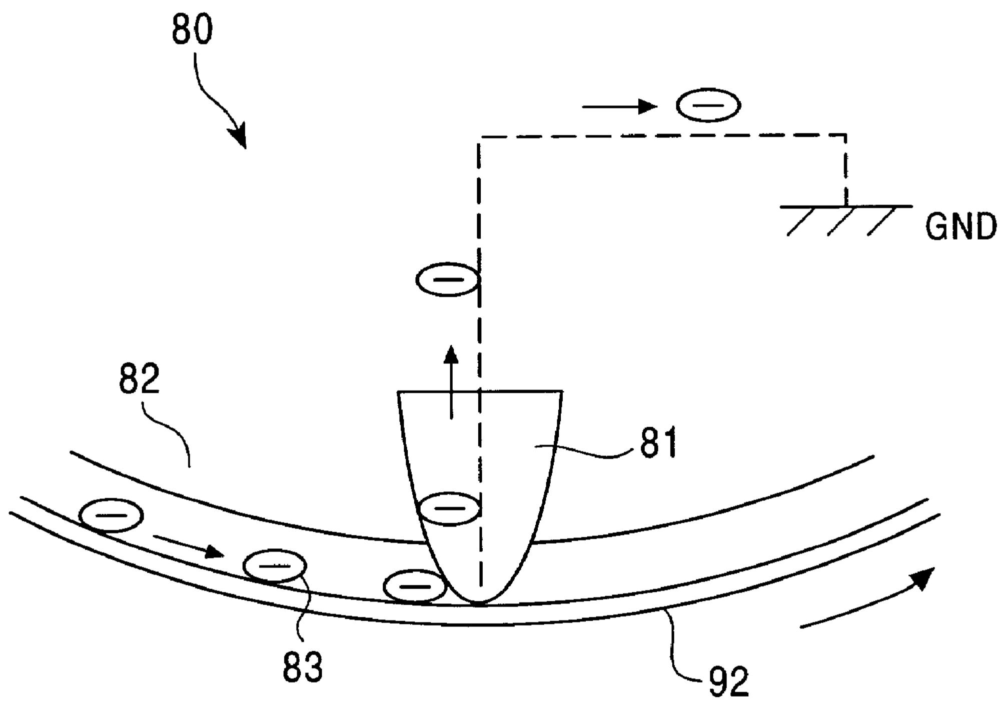


FIG. 3

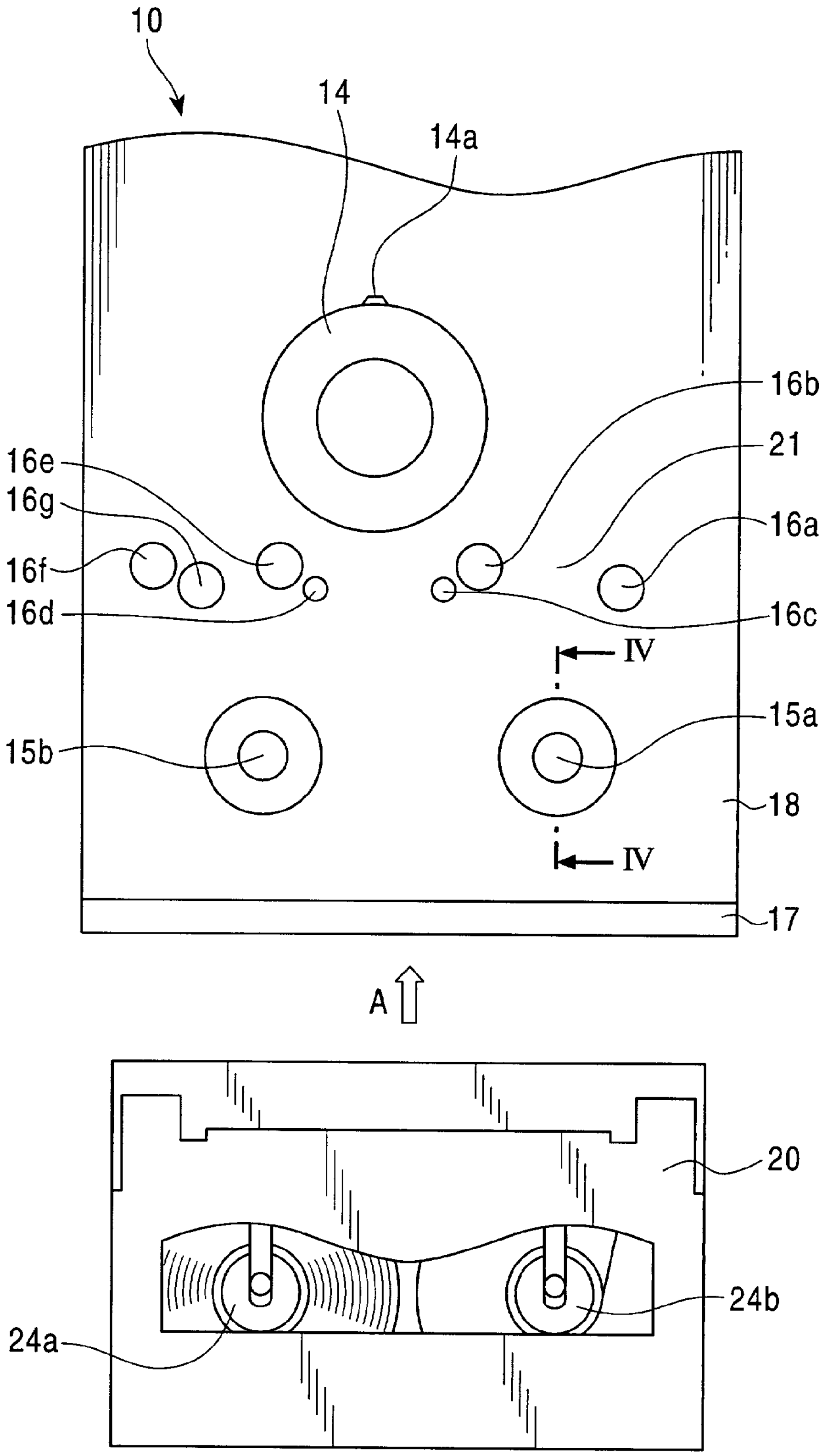

10
14
14a
16b
21
16a
16e
16g
16f
16d
16c
IV
15a
15b
18
IV
17
A
20
24a
24b

FIG. 4

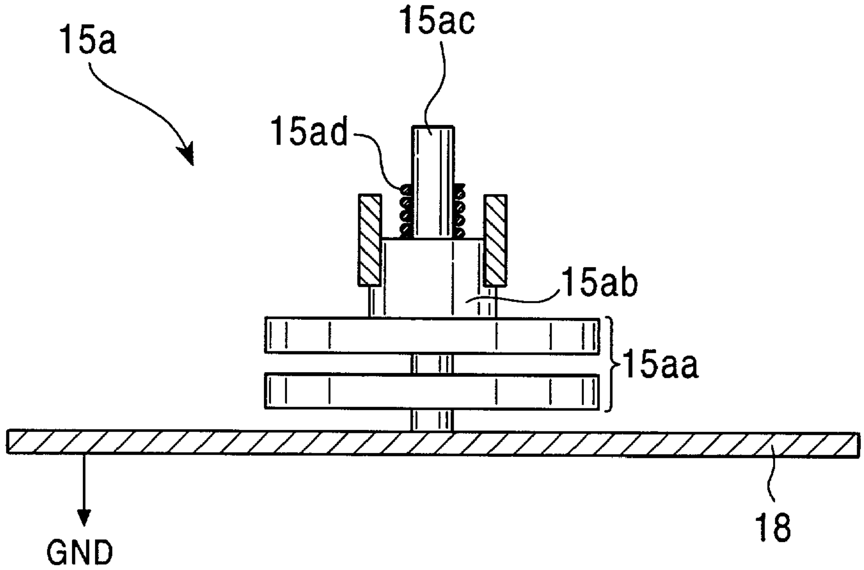


FIG. 5A

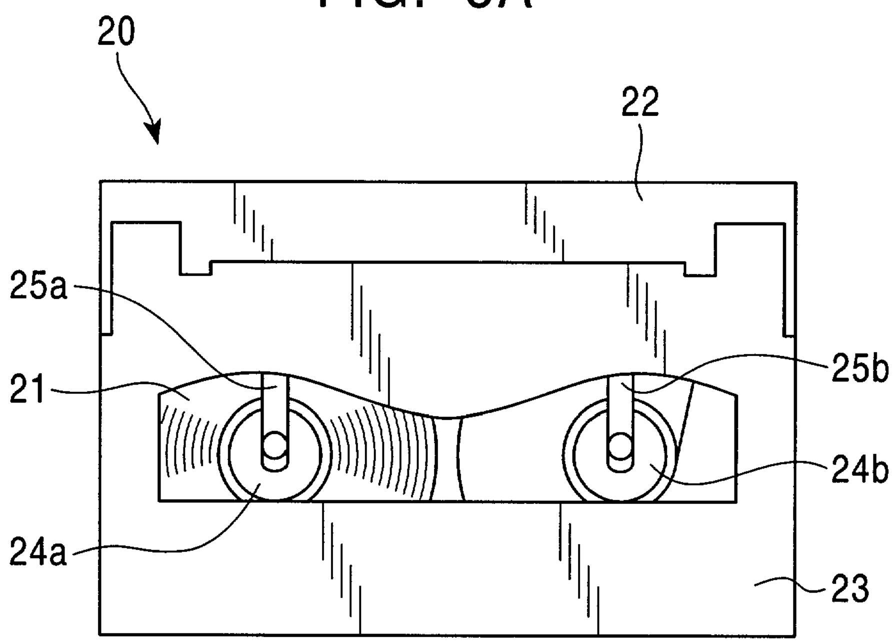


FIG. 5B

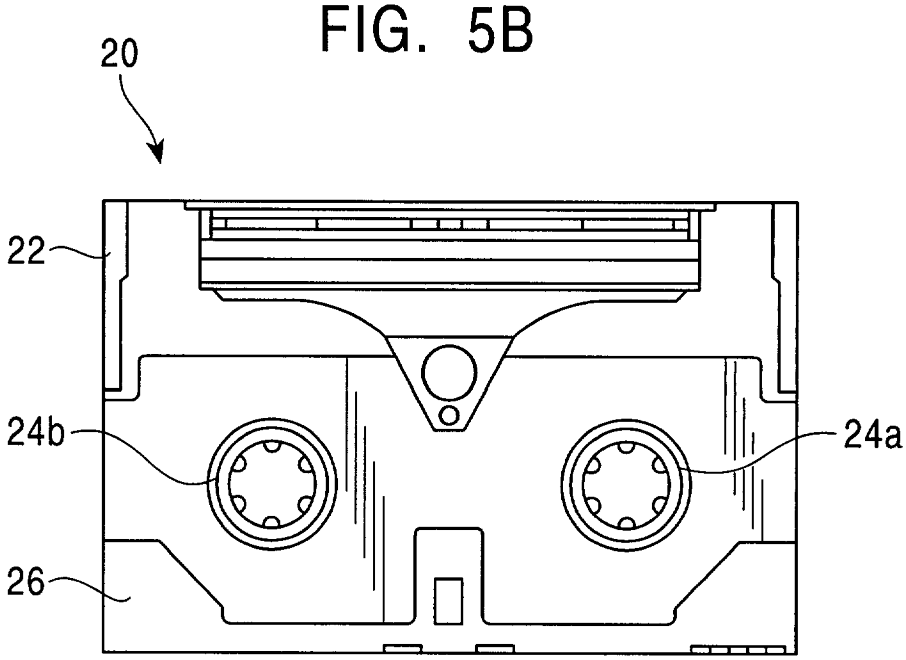


FIG. 6

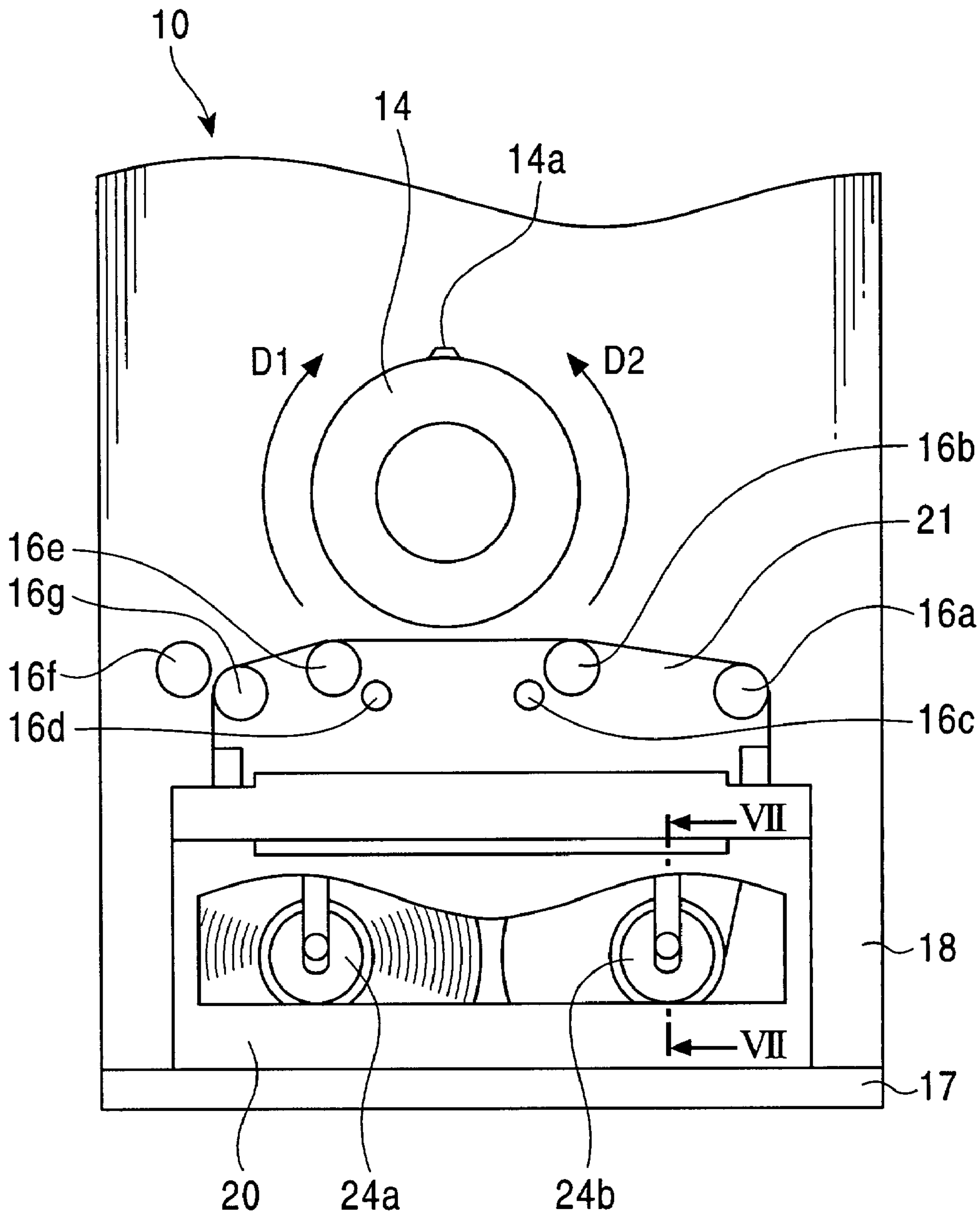

10
14
14a
D1
D2
16b
21
16e
16g
16a
16f
16c
16d
VII
18
VII
17
20
24a
24b

FIG. 7

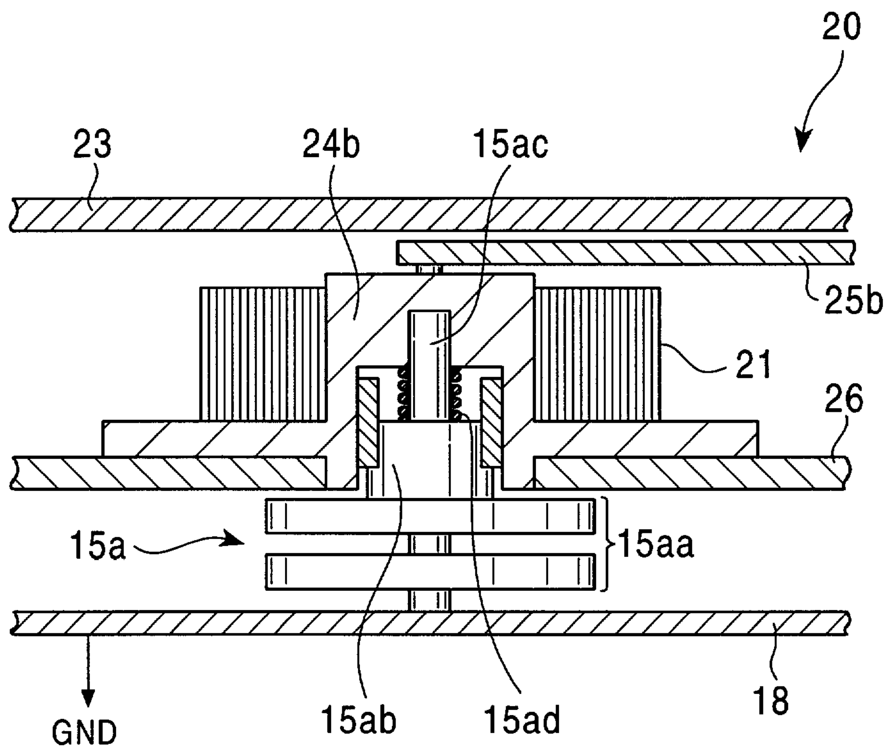


FIG. 8

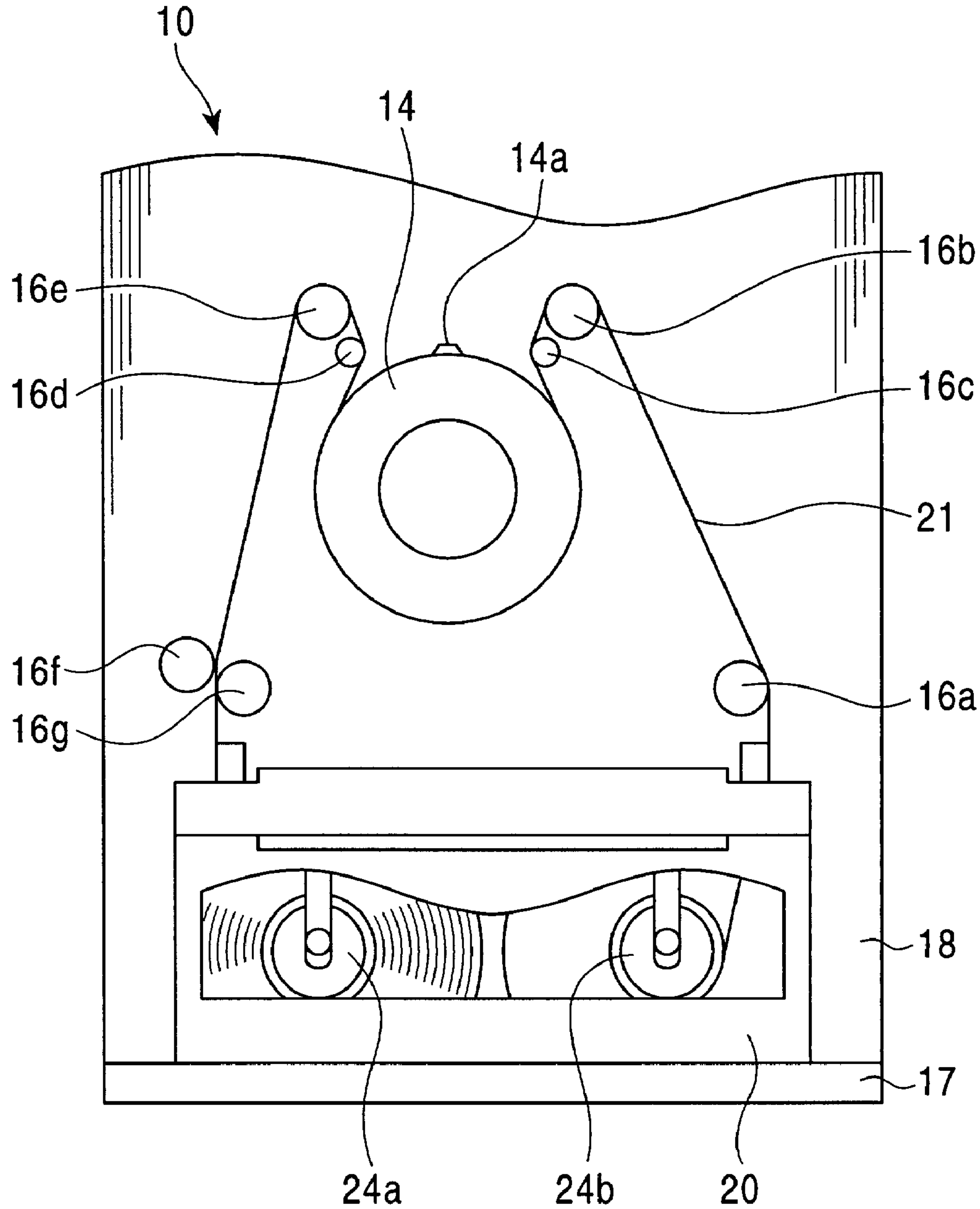


FIG. 9

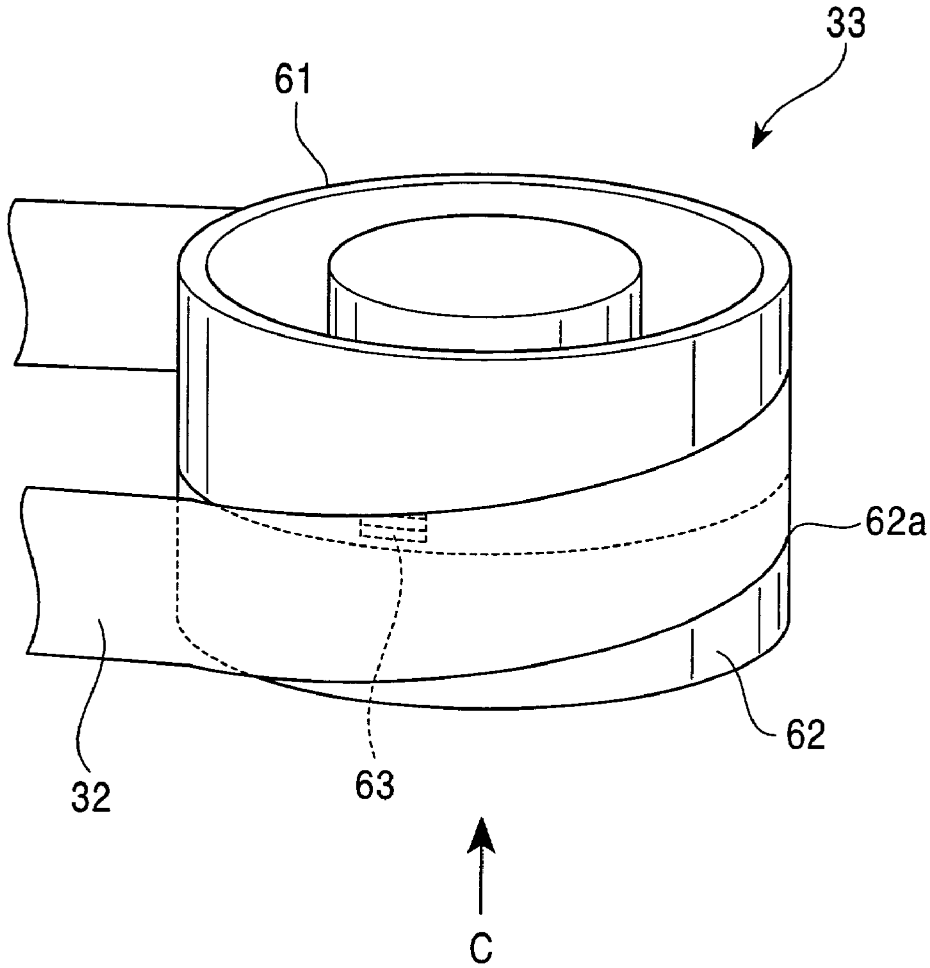


FIG. 10

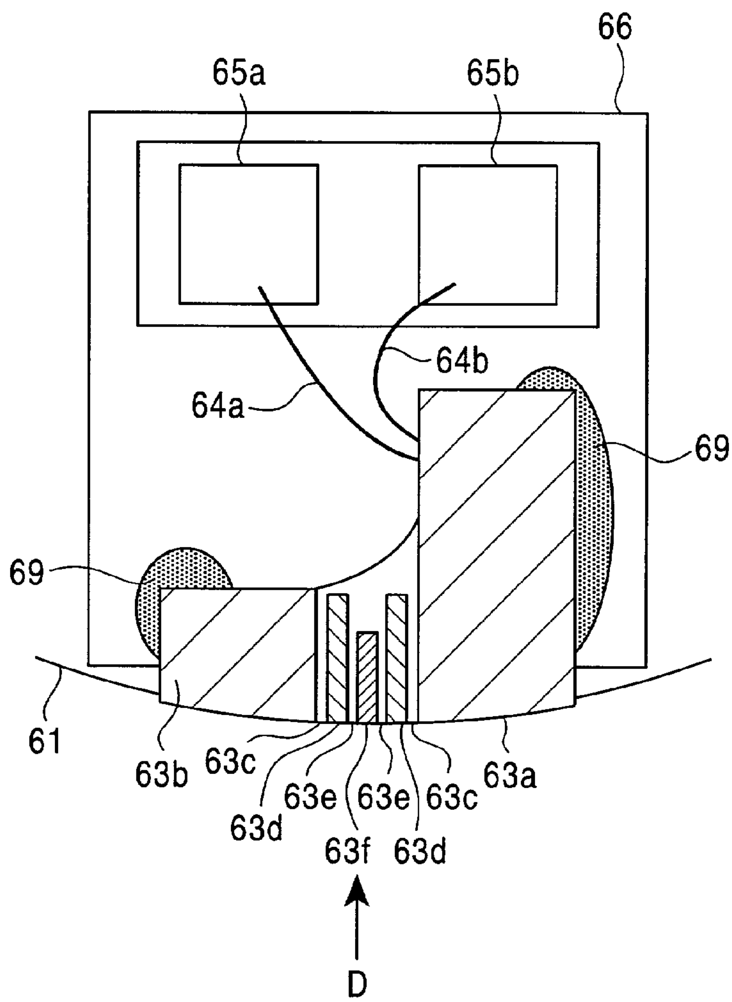

66
65a
65b
64b
64a
69
69
61
63b
63c
63e
63e
63c
63a
63d
63f
63d
D

FIG. 11

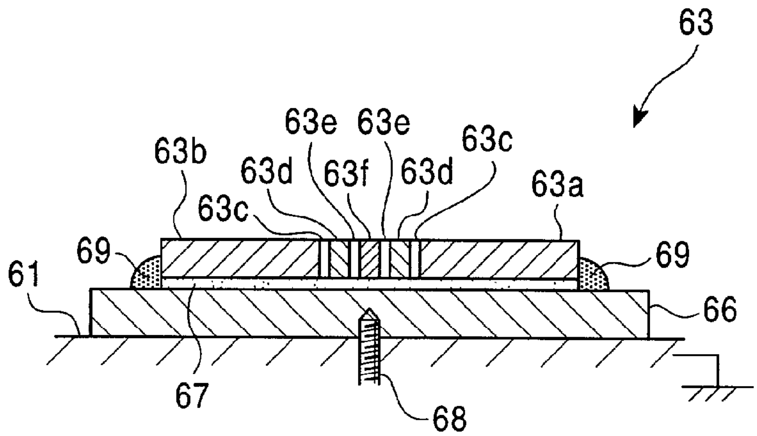

63
63e
63e
63b
63c
63d
63f
63d
63a
63c
69
69
61
66
67
68

FIG. 12

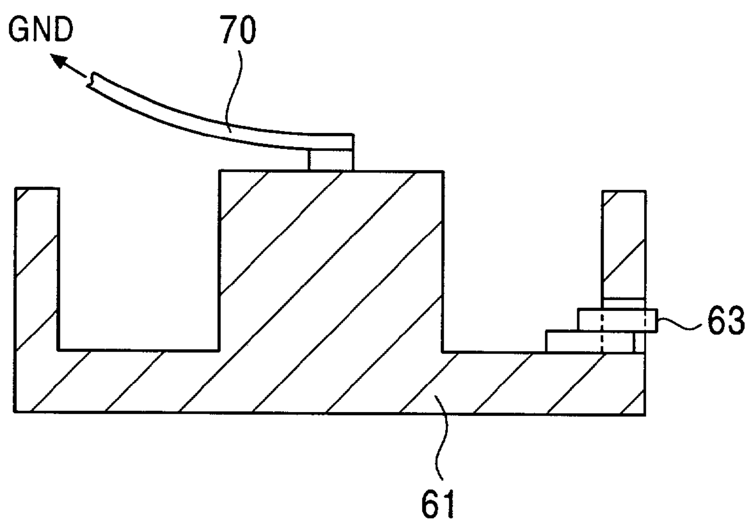
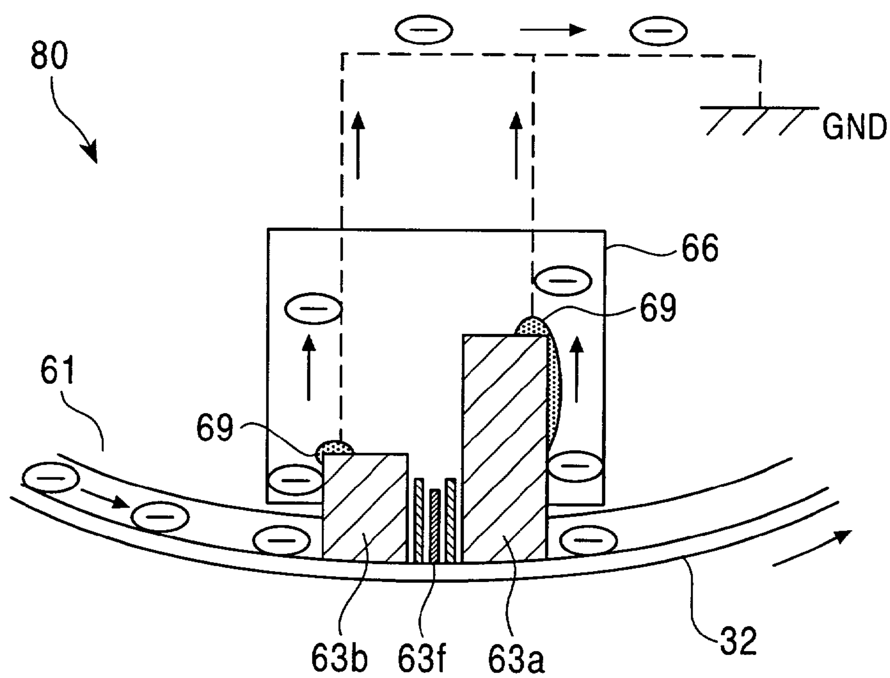


FIG. 13



MAGNETIC STORAGE RECORDING MEDIUM AND MAGNETIC RECORDING AND PLAYBACK DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention The present invention relates to magnetic storage media, from and to which information is read and written, and magnetic recording and playback devices for reading and writing information. More particularly, the present invention relates to a magnetic storage medium, from and to which information is read and written by using a magneto-resistive head, and also to a magnetic recording and playback device, having the magneto-resistive head, for reading and writing information.

[0002] 2. Description of the Related Art

[0003] As the volume of information to be processed in a magnetic recording and playback device, which records and reads data by using a magnetic tape, has been increasing recently, the magnetic tape is required to have a larger storage density. Accordingly, a magneto-resistive head (hereinafter, referred to as MR head) is essential as a magnetic head for reading signals instead of a conventional inductive head. Because the MR head is one type of magnetic head for reading signals stored in a magnetic storage medium by using a magneto-resistive effect (hereinafter, referred to as MR effect) of a magneto-resistive element (hereinafter, referred to as MR element), the MR head is highly capable of detecting signals for providing large reading outputs, thereby allowing the magnetic tape to easily have a reduced recording track-width and an increased recording density in a line direction. This allows the magnetic recording and playback device to perform recording and reading data densely.

[0004] Also, a known recording and playback device using a magnetic tape is based on a helical scan principal arranged such that the magnetic tape for recording and reading signals is wound in a helical manner around a head drum, which is rotatable together with the magnetic head mounted on the rim thereof. In the helical scan-type recording and playback device, the magnetic head records and reads signals while sliding on the running magnetic tape at a high speed, that is, the magnetic tape and the magnetic head have a high relative sliding speed, thereby realizing an improved data transfer rate.

[0005] In general, however, the MR head is more sensitive to static electricity and heat than the inductive head. **FIGS. 1A and 1B** show measured values of an electrostatic discharge breakdown voltage (hereinafter, referred to as ESD breakdown voltage) of an anisotropic magneto-resistive head (hereinafter, referred to as AMR head) and a giant magneto-resistive head (hereinafter, referred to as GMR head), respectively.

[0006] To obtain values of EDS breakdown voltage, a human body model is used in which the voltage and the resistance across the MR heads, i.e., the AMR head and the GMR head, are measured as shown in **FIGS. 1A and 1B** for every time when charges stored in a capacitor having a capacitance of 100 pF are discharged while the capacitor is connected to a resistor having a resistance of 1.5 kΩ. The graphs indicate that the EDS breakdown voltages of the AMR head and the GMR are about 230 to 240 V and about 30 to 40 V, respectively. In the meantime, as will be described next, friction, contact, induction, or the like causes a charged insulator such as plastic including nylon and vinyl in a normal condition to easily have a voltage of higher than several kV, which far exceeds the EDS breakdown voltages of the MR heads.

[0007] Many known cassette cases for winding and housing a magnetic tape are formed of high-resistance synthetic resin materials. These cassette cases are likely charged with static electricity due to friction with, e.g., a packing material or a glove made of synthetic fiber when handled by users, or by friction with a component of the magnetic recording and playback device when loaded in the device. The electrification voltage of a charged synthetic material such as ABS resin having a surface-resistance of about 1×10^{16} Ω/inch^2 used for the cassette cases is 1500 to 2000 V or higher and the half-life of the voltage is at least three minutes. Since the electrification voltage exceeds far beyond the withstand voltage of the MR head and further, the half life is long, the electrostatic charges once generated take a long period of time to decay. Therefore, when the charged cassette case is loaded in the magnetic recording and playback device and also the magnetic tape therein contacts the MR head, a large amount of current flows into the MR head through the magnetic tape, possibly causing the ESD breakdown of the MR head.

[0008] **FIG. 2** is a conceptual illustration of a charge flow when the magnetic tape contacts the MR head. A head drum **80** mounted in the magnetic recording and playback device comprises a rotating drum **82** having the magnetic head, e.g., on the rim thereof and a fixed drum (not shown). A magnetic tape **92** travels around the head drum **80** in a helical manner, and the rotating drum **82** rotates. This rotation allows the magnetic head to scan the magnetic tape **92** so as to record and read signals. **FIG. 2** illustrates a part of the head drum **80** in an enlarged scale, and an MR head **81** mounted on the rotating drum **82** as a magnetic head for recording and reading signals detects stored signals in contact with the traveling magnetic tape **92**.

[0009] When the cassette case for winding and housing the magnetic tape **92** is charged with static electricity, electric charges **83** start to flow from the surface of the magnetic tape **92** to the ground of the head drum **80** through the contacted MR head **81**. For example, at the time of starting the reading operation of the magnetic recording and playback device, the cassette case is loaded in the device and then the magnetic tape **92** comes close to the rotating drum **82** in accordance with the movement of a guide mechanism of the device. At the instant of the magnetic tape **92** contacting the MR head **81**, a large amount of electric current flows to an MR element, causing the ESD breakdown of the MR element, thereby resulting in failure of reading signals in the magnetic tape **92**. With this, the MR head **81** has not been available as a magnetic head of the recording and playback device using the magnetic tape **92**.

SUMMARY OF THE INVENTION

[0010] The present invention is made in view of the above problems. Accordingly, it is an object of the present invention to provide a magnetic storage medium and a magnetic recording and playback device which prevent the ESD breakdown to an MR head.

[0011] To this end, in accordance with one aspect of the present invention, there is provided a magnetic storage medium, from and to which information is read and written by an MR head. The magnetic storage medium comprises a magnetic tape and a pair of reels for winding and rewinding the magnetic tape, wherein the reels are provided with an antistatic treatment.

[0012] The antistatic treatment performed on the reels suppresses the generation of static electricity to the reels, thereby preventing the ESD breakdown of the MR head. Further, the reels of the magnetic storage medium according to the present invention preferably may comprise a conductive material as the antistatic treatment.

[0013] Further, the reels of the magnetic storage medium according to the present invention are preferably connected to the ground when the magnetic storage medium is loaded in a magnetic recording and playback device. Further, the surface-resistance of the conductive material for the reels of the magnetic storage medium according to the present invention preferably ranges from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

[0014] In accordance with another aspect of the present invention, there is provided a magnetic recording and playback device. The device comprises an MR head and a pair of reel supports for supporting a pair of reels of a magnetic storage medium loaded in the device, wherein the reel supports are provided with an antistatic treatment.

[0015] The antistatic treatment performed on the reel supports for supporting the reels of the magnetic storage medium loaded in the device suppresses the generation of static electricity to the reel supports, and thereby prevents the ESD breakdown of the MR head. Further, at least one part of the reel supports of the magnetic recording and playback device according to the present invention may comprise a conductive material as the antistatic treatment.

[0016] Further, at least one part of the reel supports of the magnetic recording and playback device according to the present invention is preferably connected to the ground. Further, the surface-resistance of the conductive material for at least one part of the reel supports of the magnetic recording and playback device according to the present invention preferably ranges from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

[0017] Further, in accordance with still another aspect of the present invention, there is provided a head drum for reading and writing information from and to a magnetic tap. The head drum comprises a conductive rotating drum at the ground potential, around which the magnetic tape is wound in a helical manner, a metal base fixed inside the rotating drum and electrically connected to the rotating drum, and a magnetic head fixed to the metal base. The magnetic head comprises the following components: a head substrate and a protection substrate, both having a resistance of 1×10^{10} Ω or less and electrically connected to the metal base; a pair of outer insulating films disposed between the head substrate and the protection substrate; a pair of magnetic shielding films disposed between the pair of outer insulating films; a pair of inner insulating films disposed between the pair of magnetic shielding films; and an MR head element, disposed between the pair of inner insulating films, for reading stored signals by contacting the magnetic tape.

[0018] The head substrate and the protection substrate of the head drum may comprise a conductive material having a resistance of 1×10^{10} Ω or less and may be electrically connected to the metal base so as to be at the ground potential via the metal base and the rotating drum. This treatment allows static electricity charged on the magnetic tape to be discharged to the head substrate and the protection substrate without flowing to the MR element, thereby preventing the ESD breakdown of the MR element.

[0019] As described above, the reels of the magnetic storage medium of the present invention are provided with an antistatic treatment, and thereby suppress the generation of static electricity during loading or operating the magnetic storage medium, preventing the ESD breakdown of the MR head.

[0020] Further, the reel supports of the magnetic recording and playback device of the present invention are provided with an antistatic treatment, and thereby suppress the generation of static electricity during loading or operating the magnetic storage medium, preventing the ESD breakdown of the MR head.

[0021] Still further, the head substrate and the protection substrate of the head drum of the magnetic recording and playback device according to the present invention comprise a conductive material having a resistance of 1×10^{10} Ω or less, and are electrically connected to the metal base so as to be at the ground potential via the metal base and the rotating drum. This treatment allows static electricity charged on the magnetic tape to be discharged to the head substrate and the protection substrate without flowing to the MR head, thereby preventing the ESD breakdown of the MR head.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] **FIGS. 1A and 1B** are graphs showing test results of ESD breakdown voltage of an AMR head and a GMR head, respectively;

[0023] **FIG. 2** is a conceptual illustration of a charge flow when a magnetic tape contacts an MR head;

[0024] **FIG. 3** is a plan view of an exemplary magnetic tape drive as a magnetic recording and playback device and an exemplary magnetic cassette tape as a magnetic storage medium according to a first embodiment of the present invention;

[0025] **FIG. 4** is a sectional view of a reel support taken along the line IV-IV indicated in **FIG. 3**;

[0026] **FIGS. 5A and 5B** are a plan view and a bottom view of the appearance of the magnetic cassette tape as a magnetic storage medium, respectively;

[0027] **FIG. 6** is a plan view illustrating the inside of the magnetic tape drive in which the magnetic cassette tape is loaded;

[0028] **FIG. 7** is a sectional view of a reel and the reel support taken along the line VII-VII indicated in **FIG. 6**;

[0029] **FIG. 8** is a plan view illustrating the inside of the magnetic tape drive in which the magnetic tape is wound around a rotating drum;

[0030] **FIG. 9** is a perspective view illustrating a schematic structure of a head drum of the magnetic tape drive according to a third embodiment of the present invention;

[0031] **FIGS. 10 and 11** are a bottom view and a side view illustrating the structure of a reading head according to the third embodiment of the present invention, respectively;

[0032] **FIG. 12** is a sectional view of the rotating drum; and

[0033] **FIG. 13** is a conceptual illustration of a charge flow in the head drum according to the third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Referring now to the accompanying drawings, a first embodiment of the present invention will be described.

[0035] **FIG. 3** is a plan view of a magnetic tape drive **10** as a magnetic recording and playback device and a magnetic cassette tape **20** as a magnetic storage medium according to the first embodiment. **FIG. 4** is a sectional view of a reel support **15***a* taken along the line IV-IV indicated in **FIG. 3**.

[0036] The magnetic tape drive **10** comprises, for example, a front panel **17** having a cassette slot through which the magnetic cassette tape **20** is inserted, a chassis **18** disposed at the bottom thereof, an MR head **14***a* for reading various information stored on a magnetic tape, a recording head (not shown) for writing various information to the magnetic tape, a rotating drum **14** on which the MR head **14***a* is mounted, reel supports **15***a* and **15***b* for, respectively, supporting reels **24***b* and **24***a* of the magnetic cassette tape **20** in which the magnetic tape is loaded, and a plurality of guide rollers **16***a* to **16***g* for holding the magnetic tape pulled out from the magnetic cassette tape **20** as a magnetic storage medium and also for winding the magnetic tape around the rotating drum **14**. The magnetic cassette tape **20** is inserted to the cassette slot (not shown) provided at the front panel **17** in the A direction indicated in the drawing so as to be loaded in the magnetic tape drive **10**.

[0037] The front panel **17** is formed, e.g., to be flat and has the substantially rectangular cassette slot (not shown). Any material including an insulating material such as plastic may be used to form the front panel **17** without a special limitation as long as the material has a reasonable mechanical strength; however, a conductive material is preferable from the viewpoint of antistatic treatment.

[0038] The chassis **18** is formed, e.g., to be flat disposed at the bottom of the magnetic tape drive **10**. Any material including a conductive material such as stainless steel and other metals, and an insulating material such as plastic may be used to form the chassis **18** without a special limitation as long as the material has a reasonable mechanical strength; however, a conductive material is preferable from the viewpoints of antistatic treatment and connection of the reel supports **15***a* and **15***b* to the ground. The connection will be described later. The chassis **18** is preferably connected to the ground from the same viewpoint.

[0039] As described above, the MR head **14***a* utilizing an MR effect of an MR element functions as a playback only magnetic head for reading signals recorded in the magnetic tape.

[0040] The rotating drum **14** is formed, e.g., in a cylindrical shape, and has the MR head **14***a* and a recording head (not shown) both mounted around the rotating drum **14**. The cylindrical rotating drum **14** rotates around its own axis together with the MR head **14***a* and the recording head mounted around the drum **14** so as to read and write information from and to the magnetic tape based on a helical scan principal.

[0041] The reel supports **15***a* and **15***b* are rotating bodies driven by, e.g., motors so as to rotate the reels **24***b* and **24***a* loaded in the magnetic cassette tape **20**, thereby allowing the magnetic tape to travel.

[0042] As shown in **FIG. 4**, the reel support **15***a* comprises, for example, a capstan motor **15***aa* mounted on the chassis **18**, a shaft **15***ac* driven by the capstan motor **15***aa*, a rotor **15***ab* which rotates in accordance with the rotation of the shaft **15***ac*, and a spring **15***ad* mounted on the shaft **15***ac*.

[0043] The reel support **15***a* is provided with a predetermined antistatic treatment, and thereby suppresses the generation of static electricity on the reel support **15***a* during the operation of the magnetic cassette tape **20**, preventing the ESD breakdown of the MR head **14***a* mounted on the rotating drum **14** caused by static electricity charged on the reel support **15***a*.

[0044] The reel support **15***a* is provided with the antistatic treatment, e.g., in such a manner that at least one part of the reel support **15***a*, preferably the entire reel support **15***a* is formed of a conductive material. More particularly, the reel support **15***a* is provided with the antistatic treatment, e.g., such that the capstan motor **15***aa*, the rotor **15***ab*, the shaft **15***ac*, the spring **15***ad*, and others constituting the reel support **15***a* are formed of conductive materials.

[0045] The conductive materials for the capstan motor **15***aa*, the rotor **15***ab*, the shaft **15***ac*, the spring **15***ad*, and others constituting the reel support **15***a* preferably have a surface-resistance, e.g., ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2. In other words, when the surface-resistance of these conductive materials become too large, larger amounts of static electricity are charged on the capstan motor **15***aa*, the rotor **15***ab*, the shaft **15***ac*, the spring **15***ad*, and others during the operation of the magnetic cassette tape **20**, leading to a larger possibility of the ESD breakdown of the MR head **14***a*.

[0046] Preferable examples of the above described conductive materials include metals such as stainless steel, a tin oxide doped with antimony, an indium oxide doped with tin, and a zinc oxide doped with aluminum. More specifically, a preferable conductive material is "Toyolac Parrel TP40" made by Toray Industries Inc.

[0047] At least one part of the reel support **15***a* is preferably connected to the ground. With this treatment, static electricity charged on the reel support **15***a* is discharged to the ground, and thus the generation of static electricity thereon is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*. The reel support **15***a* is connected to the ground by having an arrangement in which, e.g., one end of the shaft **15***ac* is connected to the ground by contacting the conductive chassis **18** which is connected to the ground.

[0048] The reel support **15***b* preferably has the same arrangement as the reel support **15***a* so that the reel support **15***b* is provided with the same antistatic treatment. The tape guide rollers **16***a* to **16***g* are rotating bodies formed, e.g., in a cylindrical shape, each rotating around its own axis. Any material may be used to form the tape guide rollers **16***a* to **16***g* without a special limitation as long as the material has a reasonable mechanical strength; however, a conductive material such as metal is preferable from the viewpoint of antistatic treatment.

[**0049**] **FIGS. 5A and 5B** are, respectively, a plan view and a bottom view illustrating an external structure of the magnetic cassette tape **20** as a magnetic storage medium.

[**0050**] As shown in **FIGS. 5A and 5B**, the magnetic cassette tape **20** comprises a magnetic tape **21** for storing various information which is read by, e.g., the MR head **14***a*, the pair of reels **24***a* and **24***b* around which the magnetic tape **21** is wound, a pair of shaft holders **25***a* and **25***b* for holding the shafts of the reels **24***a* and **24***b*, respectively, a lid **22**, an upper shell **23**, and a lower shell **26**, the latter three constituting a case for housing the magnetic tape **21**.

[**0051**] The magnetic tape **21** has a structure in which a ferromagnetic metal thin film composed of such as Co, Co—Ni, Co—Fe, Co—Cr, Co—Ti, Co—Mo, Co—Ni—O, Co—Ni—P, or Co—Cr—Nb is formed on a polymer film having, e.g., polyethylene naphthalete, polyether ether ketone, polyphenylene sulphide, polyamide, or polyimide. Recording of various information is performed by magnetizing the ferromagnetic metal thin film.

[**0052**] Any material including an insulating material such as plastic including polyester may be used to form the lid **22**, the upper shell **23**, and the lower shell **26** without a special limitation as long as the material has a reasonable mechanical strength; however, a conductive material is preferable from the viewpoint of antistatic treatment.

[**0053**] Any material may be used to form the shaft holders **25***a* and **25***b* without a special limitation as long as the material has a reasonable mechanical strength; however, a conductive material such as stainless steel is preferable from the viewpoint of antistatic treatment.

[**0054**] The reels **24***a* and **24***b* have, e.g., substantially cylindrical portions around which the magnetic tape **21** is wound. Substantially gear-like structures are provided inside the cylindrical portions so that a respective torque of the reel supports **15***a* and **15***b* is effectively transmitted to the reels **24***b* and **24***a*.

[**0055**] The reels **24***a* and **24***b* are provided with a predetermined antistatic treatment, and thereby suppress the generation of static electricity on the reels **24***a* and **24***b* during the operation of the magnetic cassette tape **20**, preventing the ESD breakdown of the MR head **14***a* mounted on the rotating drum **14** due to static electricity charged on the reel support **15***a*.

[**0056**] As the antistatic treatment, for example, at least one part of the reels **24***a* and **24***b*, preferably the entire part thereof comprises a conductive material.

[**0057**] The conductive material for the reels **24***a* and **24***b* preferably has a surface-resistance, e.g., ranging from 0 $\Omega/inch^2$ to 1×10^{12} $\Omega/inch^2$. In other words, when the surface-resistance of this conductive material becomes too large, larger amounts of static electricity are charged on the reels **24***a* and **24***b*, leading to a larger possibility of the ESD breakdown of the MR head **14***a*.

[**0058**] Preferably examples of the above described conductive material include a metal such as stainless steel, a tin oxide doped with antimony, an indium oxide doped with tin, and a zinc oxide doped with aluminum. More specifically, a preferable conductive material is "Toyolac Parrel TP40" made by Toray Industries Inc.

[**0059**] The reels **24***a* and **24***b* are preferably connected to the ground when the magnetic cassette tape **20** is loaded in the magnetic tape drive **10**. With this treatment, static electricity charged on the reels **24***a* and **24***b* is discharged to the ground, and thus the generation of static electricity on the reels **24***a* and **24***b* is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*.

[**0060**] The connection of the reels **24***a* and **24***b* to the ground will now be described in detail.

[**0061**] **FIG. 6** is a plan view illustrating the inside of the magnetic tape drive **10** in which the magnetic cassette tape **20** is loaded. **FIG. 7** is a sectional view of the reel **24***b* and the reel support **15***a* taken along the line VII-VII indicated in **FIG. 6**. As shown in **FIG. 7**, the magnetic cassette tape **20** loaded in the magnetic tape drive **10** is arranged such that the reel support **15***a* is inserted in the reel **24***b*, and one end of the shaft **15***ac* is contacted to the inside of the reel **24***b*. Forming the shaft **15***ac* and the chassis **18** with a conductive material, and connecting one end of the shaft **15***ac* to the chassis **18** and the chassis **18** to the ground allows the reel **24***b* to be connected to the ground through the shaft **15***ac* and the chassis **18**. **FIG. 7** illustrates that the reel **24***b* is connected to the ground through the reel support **15***a*; likewise, the reel **24***a* may be connected to the ground through the reel support **15***b*.

[**0062**] After the magnetic cassette tape **20** is inserted in the magnetic tape drive **10** as shown in **FIG. 7**, the magnetic tape **21** is wound around the rotating drum **14** in the following manner. As shown in **FIG. 6**, the tape guide rollers **16***a* to **16***e* and **16***g* pull the magnetic tape **21** out from the inside of the magnetic cassette tape **20** loaded in the magnetic tape drive **10**, hold the pulled out portion of the magnetic tape **21**, and move so as to surround the rotating drum **14** in the D1 and D2 directions indicated in the drawing. The series of these movements of the rollers **16***a* to **16***e* and **16***g* completes the winding of the magnetic tape **21** around the rotating drum **14**.

[**0063**] **FIG. 8** is a plan view illustrating the inside of the magnetic tape drive **10** in which the magnetic tape **21** is wound around the rotating drum **14**. The magnetic tape **21** wound around the rotating drum **14** travels in accordance with the rotations of the reels **24***a* and **24***b* which are driven by the reel supports **15***b* and **15***a*, respectively. Thus, the recording head and the MR head **14***a* mounted on the rotating drum **14** read and write various information from and to the magnetic tape **21**, respectively.

[**0064**] The reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* are provided with the foregoing antistatic treatments, thereby suppressing the generation of static electricity on the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* when the magnetic tape **21** is wound around the rotating drum **14** or when information is read from or written to the magnetic tape **21**. Test results of an exemplary structure of the reels **24***a* and **24***b* formed of a conductive material "Toyolac Parrel TP40" made by Toray Industries Incorporation reveal that the absolute values of the electrification voltages across these components measured at a temperature of 27° C. and a humidity of 60% decrease to 20 V or smaller.

[0065] By connecting the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* to the ground, static electricity charged thereon when the magnetic tape **21** is wound around the rotating drum **14** or when information is read from or written to the magnetic tape **21** is discharged to the ground, and thus the generation of static electricity thereon is suppressed.

[0066] According to the first embodiment, as described above, the reels **24***a* and **24***b* are provided with a predetermined antistatic treatment, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0067] Further, the reels **24***a* and **24***b* are formed of a conductive material as an antistatic treatment, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0068] Further, since the reels **24***a* and **24***b* are arranged to connect to the ground when the magnetic cassette tape **20** is loaded in the magnetic tape drive **10**, static electricity charged thereon is discharged to the ground, and thus the generation of static electricity thereon is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*.

[0069] Further, the reels **24***a* and **24***b* are formed of a conductive material having a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0070] Further, the reels **24***a* and **24***b* are formed of a metal, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0071] Further, the reel supports **15***a* and **15***b* for, respectively, supporting the reels **24***b* and **24***a* of the magnetic cassette tape **20** loaded in the magnetic tape drive **10** are provided with an antistatic treatment, and thereby suppress the generation of static electricity on the reel supports **15***a* and **15***b*, preventing the ESD breakdown of the MR head **14***a*.

[0072] Further, at least one part of the reel supports **15***a* and **15***b* is formed of a conductive material as an antistatic treatment, and thereby suppresses the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0073] Further, by connecting at least one part of the reel supports **15***a* and **15***b* to the ground, static electricity charged on the reel supports **15***a* and **15***b* is discharged to the ground, and thus the generation of static electricity thereon is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*.

[0074] Further, the reel supports **15***a* and **15***b* are formed of a conductive material having a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0075] Further, the reel supports **15***a* and **15***b* are formed of a metal, and preventing is suppressed the generation of static electricity thereon, the ESD breakdown of the MR head **14***a*.

[0076] The present invention is not limited to the first embodiment. Although all of the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* in the first embodiment are provided with the antistatic treatments, only some of them may be provided with the antistatic treatments.

[0077] Next, a second embodiment of the present invention will be described. The second embodiment is a modification of the first embodiment wherein the difference lies in an antistatic treatment performed on the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b*. The following description will focus mainly on this difference, and repetitive descriptions will be omitted.

[0078] In the second embodiment, antistatic films are formed on at least one portion of the surfaces of the reel supports **15***a* and **15***b* and on the surfaces of the reels **24***a* and **24***b*, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[0079] Material for the antistatic film preferably has a surface-resistance, e.g., ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2. The reason of this lies in that, when the surface-resistance of the antistatic films becomes too large, a larger amount of static electricity is charged on the reel supports **15***a* and **15***b* and on the surfaces of the reels **24***a* and **24***b*, increasing the possibility of the ESD breakdown of the MR head **14***a*.

[0080] Preferable examples of materials constituting the above described antistatic film include metal films, tin oxide doped with antimony, indium oxide doped with tin, and zinc oxide doped with aluminum. Other preferable examples of the antistatic film are the following: an antistatic film composed of a material such as water-soluble conductive polyaniline, water-soluble conductive polypyrrole, water-soluble polythiophene, water-soluble polyparaphenylene, and water-soluble polyparaphenylene vinylene, as disclosed in Japanese Unexamined Utility Model Publication No.6-20040; a conductive resin film having a composition of polyarylate, a conductive filler, and a phenolic antioxidant, as disclosed in Japanese Unexamined Patent Application Publication No. 2000-186218; an antistatic film formed by vacuum depositing a metallic element such as Cr, Cu, Fe, Co, and Ni belonging to the fourth period of the periodic table, as disclosed in Japanese Unexamined Patent Application Publication No. 2000-169685; and an antistatic film formed of (a) a cationic surfactant, e.g., a quaternary ammonium salt, an aliphatic amine or its derivative, a benzimidazole derivative, or an aliphatic amid derivative, (b) an anionic surfactant, e.g., sodium alkylphosphate, alkylphenol polyethylene glycol sulfuric acid sodium salt, or polystyrene sulfonate, and (c) a nonionic surfactant, e.g., polyoxyethylene aliphatic ether or polyoxyethylene alkyl ether, as disclosed in Japanese Patent No. 2821762.

[0081] Test results of an exemplary structure of the reels **24***a* and **24***b* having the above described anti-static films formed on the surfaces thereof reveal that the absolute values of the electrification voltages measured across these components decrease to 3 V or smaller at a temperature of 27° C. and a humidity of 60%.

[0082] The antistatic films formed on the surfaces of the reels **24***a* and **24***b* and the reel supports **15***a* and **15***b* are preferably connected to the ground in a similar fashion as in the first embodiment. This allows static electricity charged on the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* to be discharged to the ground, and thus the generation of static electricity thereon is suppressed, preventing the ESD breakdown of the MR head **14***a*.

[**0083**] According to the second embodiment, as described above, the antistatic films are formed on the surfaces of the reels **24***a* and **24***b* as an antistatic treatment, and thereby suppress the generation of static electricity thereon and prevent the ESD breakdown of the MR head **14***a*.

[**0084**] Further, since the antistatic films formed on the reels **24***a* and **24***b* are arranged to connect to the ground when the magnetic cassette tape **20** is loaded in the magnetic tape drive **10**, static electricity charged on the reels **24***a* and **24***b* is discharged to the ground, and thus the generation of static electricity thereon is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*.

[**0085**] Further, the reels **24***a* and **24***b* comprise a conductive material formed on the surfaces thereof having a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[**0086**] Further, the reels **24***a* and **24***b* have metal films formed on the surfaces thereof, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[**0087**] Further, at least one part of each of the reel supports **15***a* and **15***b* has a conductive material formed on the surface thereof as an antistatic treatment of the reel supports **15***a* and **15***b*, and thereby suppresses the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[**0088**] Further, by connecting the antistatic film formed on the surface of at least one part of each of the reel supports **15***a* and **15***b* to the ground, static electricity charged on the reel supports **15***a* and **15***b* is discharged to the ground, and thus the generation of static electricity thereon is suppressed, thereby preventing the ESD breakdown of the MR head **14***a*.

[**0089**] Further, at least one part of each of the reel supports **15***a* and **15***b* has an antistatic film, having a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2, formed on the surface thereof, an thereby suppresses the generation of static electricity on the reel supports **15***a* and **15***b*, preventing the ESD breakdown of the MR head **14***a*.

[**0090**] Further, the reel supports **15***a* and **15***b* have metal films formed on the surfaces thereof, and thereby suppress the generation of static electricity thereon, preventing the ESD breakdown of the MR head **14***a*.

[**0091**] The present invention is not limited to the second embodiment. For example, antistatic films are formed on the surfaces of all of the reel supports **15***a* and **15***b* and the reels **24***a* and **24***b* as an antistatic treatment in the second embodiment; however, a part of them may be provided with the antistatic treatment according to the second embodiment, and another part of them may be provided with that according to the first embodiment.

[**0092**] Referring now to FIGS. **9** to **13**, a third embodiment of the present invention relating to a head drum as a part of the magnetic recording and playback device will be described. **FIG. 9** is a perspective view illustrating the schematic structure of the head drum **33**. The head drum **33** is formed in a cylindrical shape generally having a smooth outer surface and comprises an upper rotating drum **61** and a lower fixed drum **62** fixed in a coaxial manner with the rotating drum **61**. The fixed drum **62** has a lead **62***a* on the outer surface thereof for guiding the traveling magnetic tape **32** so that the magnetic tape **32** travels around the head drum **33** in a helical manner. The rotating drum **61** comprises a reading head **63** for detecting signals stored in the magnetic tape **32** and a recording head (not shown) for writing information to the magnetic tape **32**. The reading head **63** is an MR head using an MR element as a head element and mounted on the outer surface of the rotating drum **61** such that it projects slightly so as to come into contact with the magnetic tape **32**. Thus, the rotation of the rotating drum **61** allows the reading head **63** to scan the magnetic tape **32** at an angle and to read signals stored therein by detecting variations of the resistance of the MR element in accordance with the corresponding recorded signals. The recording head is a so-called inductive-type magnetic head, for example, constructed such that a coil is wound around a magnetic core having a magnetic gap. Although the rotating drum **61** generally has pluralities of reading heads **63** and recording heads mounted thereon, **FIG. 9** illustrates only one of the reading heads **63**.

[**0093**] **FIGS. 10 and 11** are a bottom view and a side view of the reading head **63**. **FIG. 10** is an illustration of the mounting structure of the reading head **63**, viewed in the direction of arrow C indicated in **FIG. 9**, that is, viewed from the bottom of the head drum **33**. **FIG. 11** is an illustration of the reading head **63**, viewed in the direction of arrow D indicated in **FIG. 10**. With reference to **FIGS. 10 and 11**, the structure of the reading head **63** will be described.

[**0094**] The reading head **63** comprises the following components: a conductive head substrate **63***a* and a conductive protection substrate **63***b*; a pair of outer insulating films **63***c* disposed between the head substrate **63***a* and the protection substrate **63***b*; a pair of shielding films **63***d* composed of soft magnetic material and disposed between the pair of outer insulating films **63***c*; a pair of inner insulating films **63***e* disposed between the pair of shielding films **63***d*; and an MR element **63***f* disposed between the inner insulating films **63***e*.

[**0095**] The reading head **63** is connected to terminals **65***a* and **65***b* via wires **64***a* and **64***b*, respectively, so as to be in connection to a power source. As shown in **FIG. 11**, the reading head **63** is also bonded to a conductive metal base **66** with an adhesive **67**. The metal base **66** is fixed to the rotating drum **61** with a conductive fastening screw **68**.

[**0096**] Although the MR element **63***f* is shown in an enlarged scale in **FIGS. 10 and 11** for easy understanding of the structure of the reading head **63**, the actual MR element **63***f* is much smaller than the head substrate **63***a* and the protection substrate **63***b*.

[**0097**] The reading head **63** has a structure in which the pair of shielding films **63***d* constitute a pair of magnetic shielding members and the MR element **63***f* is disposed in the shielded space between the pair of magnetic shielding members. This structure serves to improve the frequency response and the resolution of the reading head **63**. The shield films **63***d* made of, e.g., permalloy plated films, and the pairs of insulating films **63***c* and **63***e* composed of, e.g., Al_2O_3 are deposited on the head substrate **63***a*, and the protection substrate **63***b* is bonded thereon to complete the reading head **63**. The end surface of the reading head **63**, facing outward (i.e., downward in the drawing of **FIG. 10**) at the outer surface of the rotating drum **61**, is polished as a sliding surface with the magnetic tape **32**.

[**0098**] As described above, the head substrate **63***a* and the protection substrate **63***b* are formed of a conductive material. Specifically, the conductive material is selected as the one free from static electricity and having a resistance of 1×10^{10} Ω or less, for example, Al_2O_3-TiC having a resistivity of 3×10^{-3} Ω/cm or MnZn. The head substrate **63***a* and the protection substrate **63***b* are electrically connected to the metal base **66** with, for example, a conductive paste **69** in addition to the epoxy adhesive **67** or the like. A preferable example of the conductive paste **69** is a silver paste. The metal base **66** is formed of, e.g., brass and is fixed such that it is electrically connected to the rotating drum **61** with the fastening screw **68** made of a conductive metal. The rotating drum **61** is formed of, e.g., aluminum so as to be conductive at the ground potential.

[**0099**] **FIG. 12** is a sectional view of the rotating drum **61**. The rotating drum **61** is connected to a spring **70** therein as shown in **FIG. 12**. The spring **70** is in contact with a chassis (not shown) functioning as the ground of the reading and playback device, allowing the rotating drum **61** to be at the ground potential. Thus, the head substrate **63***a* and the protection substrate **63***b* are electrically connected to the rotating drum **61** at the ground potential through the metal base **66**.

[**0100**] As described above, the cassette case for winding and housing the magnetic tape **32** is typically formed of a low-resistance synthetic resin. The cassette cases of this type easily charge static electricity, for example, by friction with the packing material or a glove both including synthetic fibers during handling, or by friction with a component of the reading and playback device when loaded in the device. When the magnetic tape **32** housed in the cassette case charged as described above comes into contact with the reading head **63**, electric charges start to flow to the ground of the device through the magnetic tape **32** and the MR element **63***f*, causing the ESD breakdown of the MR element **63***f*.

[**0101**] To prevent this, in the head drum **33** according to the present invention, the head substrate **63***a* and the protection substrate **63***b* are formed of a conductive material so as to be electrically connected to the ground of the device through the conductive paste **69**, the metal base **66**, and the fastening screw **68** for fastening the metal base **66** and the rotating drum **61**. This connection provides a flow of electrostatic charges without flowing to the MR element **63***f* when the magnetic tape **32** comes into contact with the reading head **63**.

[**0102**] **FIG. 13** is a conceptual illustration of a flow of electrostatic charges in the head drum **33**. When the magnetic tape **32** in the magnetic reading and playback device is used for playback mode, first the cassette case is inserted in the device, next the rotating drum **61** starts to rotate, subsequently the magnetic tape **32** is moved close to the rotating drum **61** and then is wound around the drum **61** by a guide mechanism of the device so as to complete the loading of the magnetic tape **32**. When the magnetic tape **32** comes into contact with the reading head **63**, static electricity charged on the cassette case flows to the ground of the electrically connected chassis or the like via the surface of the magnetic tape **32**, the head substrate **63***a*, and the protection substrate **63***b* in that order, without passing though the MR element **63***f* as shown in **FIG. 13**. Since the area of the MR element **63***f* for sliding with the magnetic tape **32** is much smaller than the head substrate **63***a* or the protection substrate **63***b*, the magnetic tape **32** also comes into contact with the head substrate **63***a* or the protection substrate **63***b* when the magnetic tape **32** comes into contact with the reading head **63** without failing to discharge the static electricity to the head substrate **63***b* and the protection substrate **63***c*, thereby preventing most of the static electricity from flowing to the MR element **63***f*. This prevents the ESD breakdown of the MR element **63***f* when the cassette case is charged, thereby assuring normal reading operation of the magnetic tape **32**.

[**0103**] Although the head substrate **63***a* and the protection substrate **63***b* of the reading head **63** are both formed of a conductive material in this embodiment, either one of them many be formed of a conductive material having a resistance of 1×10^{10} Ω or less.

[**0104**] Further, in the above description, though the magnetic reading and playback device using a magnetic tape has the head drum according to the embodiment of the present invention, the present invention is applicable to a playback device used only for reading a magnetic tape.

What is claimed is:

1. A magnetic storage medium from and to which information is read and written by a magneto-resistive head, comprising:

a magnetic tape; and

a pair of reels for winding and rewinding the magnetic tape,

wherein the reels are provided with an antistatic treatment.

2. The magnetic storage medium according to claim 1, wherein the reels comprise a conductive material as the antistatic treatment.

3. The magnetic storage medium according to claim 2, wherein the reels are connected to the ground when the magnetic storage medium is loaded in a magnetic recording and playback device.

4. The magnetic storage medium according to claim 2, wherein the conductive material has a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

5. The magnetic storage medium according to claim 2, wherein the conductive material comprises a metal.

6. The magnetic storage medium according to claim 1, wherein the reels comprise antistatic films formed on the surfaces thereof as the antistatic treatment.

7. The magnetic storage medium according to claim 6, wherein the antistatic films formed on the surfaces of the reels are connected to the ground when the magnetic storage medium is loaded in a magnetic recording and playback device.

8. The magnetic storage medium according to claim 6, wherein the antistatic films have a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

9. The magnetic storage medium according to claim 6, wherein the antistatic films are metal films.

10. A magnetic recording and playback device comprising:

a magneto-resistive head; and

a pair of reel supports for supporting a pair of reels of a magnetic storage medium loaded in the magnetic recording and playback device,

wherein the reel supports are provided with an antistatic treatment.

11. The magnetic recording and playback device according to claim 10, wherein at least one part of the reel supports comprises a conductive material as the antistatic treatment.

12. The magnetic recording and playback device according to claim 11, wherein at least one part of the reel supports is connected to the ground.

13. The magnetic recording and playback device according to claim 11, wherein the conductive material has a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

14. The magnetic recording and playback device according to claim 11, wherein the conductive material comprises a metal.

15. The magnetic recording and playback device according to claim 10, wherein at least one part of the reel supports comprises an antistatic film formed on the surface thereof as the antistatic treatment.

16. The magnetic recording and playback device according to claim 15, wherein the antistatic film formed on the surface of at least one part of the reel supports is connected to the ground.

17. The magnetic recording and playback device according to claim 15, wherein the antistatic film has a surface-resistance ranging from 0 Ω/inch^2 to 1×10^{12} Ω/inch^2.

18. The magnetic recording and playback device according to claim 15, wherein the antistatic film is a metal film.

19. A head drum for reading and writing information from and to a magnetic tape, the head drum comprising:

a conductive rotating drum at the ground potential, the magnetic tape being wound in a helical manner around the rotating drum;

a metal base fixed inside the rotating drum and electrically connected to the rotating drum; and

a magnetic head fixed to the metal base, the magnetic head comprising:

a head substrate and a protection substrate, both having a resistance of 1×10^{10} Ω or less and electrically connected to the metal base;

a pair of outer insulating films disposed between the head substrate and the protection substrate; and

a pair of magnetic shielding films disposed between the pair of outer insulating films;

a pair of inner insulating films disposed between the pair of magnetic shielding films; and

a magneto-resistive head element, disposed between the pair of inner insulating films, for reading stored signals by contacting the magnetic tape.

20. The head drum according to claim 19, wherein the head substrate and the protection substrate comprise one of Al_2O_3-TiC and MnZn ferrite.

21. The head drum according to claim 19, wherein the head substrate and the protection substrate are electrically connected to the metal base with a conductive paste.

22. The head drum according to claim 19, wherein either one of the head substrate and the protection substrate has a resistance of 1×10^{10} Ω or less and is electrically connected to the metal base.

23. A magnetic recording and playback device for recording and reading signals by using a magnetic tape, the magnetic recording and playback device comprising a head drum, the head drum comprising:

a conductive rotating drum at the ground potential, the magnetic tape being wound in a helical manner around the rotating drum;

a metal base fixed inside the rotating drum and electrically connected to the rotating drum; and

a magnetic head fixed to the metal base, the magnetic head comprising:

a head substrate and a protection substrate, both having a resistance of 1×10^{10} Ω or less and electrically connected to the metal base;

a pair of outer insulating films disposed between the head substrate and the protection substrate; and

a pair of magnetic shielding films disposed between the pair of outer insulating films;

a pair of inner insulating films disposed between the pair of magnetic shielding films; and

a magneto-resistive head element, disposed between the pair of inner insulating films, for reading stored signals by contacting the magnetic tape.

* * * * *