TITLE OF THE INVENTION

INFORMATION RECORDING MEDIUM AND METHOD OF FABRICATING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an information recording medium. This invention also relates to a method of fabricating an information recording medium.

Description of the Prior Art

Japanese published unexamined patent applications 56-163536, 57-6449, 57-212642, and 60-70543 disclose a recording medium having both a magnetic recording portion and an optical recording portion.

Japanese published unexamined patent application 2-179951 discloses a recording medium which has an optical recording portion and a magnetic recording portion at opposite sides thereof respectively. Japanese patent application 2-179951 also discloses an apparatus which includes an optical head facing the optical recording portion of the recording medium for reading out information from the optical recording portion, a magnetic head facing the magnetic recording portion of the recording medium for recording and reproducing information into and from the magnetic recording portion, and a mechanism for moving at least one of the

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optical head and the magnetic head in accordance with rotation of the recording medium. In the apparatus of Japanese patent application 2-179951, during the processing of the information read out from the magnetic recording portion, a decision is made as to whether or not the information recorded on the optical recording portion is necessary, and a step of reading out the information from the optical recording portion is executed when the information on the optical recording portion is decided to be necessary.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved information recording medium.

It is another object of this invention to provide a method of fabricating an improved information recording medium.

A first aspect of this invention provides an information recording medium comprising an optical recording portion; and a magnetic recording layer provided on a back surface of the optical recording portion, the magnetic recording layer including a magnetic layer, a concealing layer, a print layer, and a print protective layer; wherein the concealing layer includes a metal film.

A second aspect of this invention provides an information recording medium comprising an optical recording portion; and a magnetic recording layer provided on a back surface of the optical recording portion, the magnetic recording layer including a magnetic layer, a concealing layer, a print layer, and a print protective layer; wherein a surface of the print protective layer has a

roughness with Rmax equal to 0.5 μm or more.

A third aspect of this invention provides an information recording medium comprising an optical recording portion; and a magnetic recording layer provided on a back surface of the optical recording portion, the magnetic recording layer including a magnetic layer, a concealing layer, a print layer, and a print protective layer; wherein a thickness of the print protective layer varies in accordance with a distribution of a thickness of the print layer so that a variation in a distance between surfaces of the magnetic layer and the magnetic recording layer is equal to 20% or less.

A fourth aspect of this invention provides a method of fabricating an information recording medium comprising an optical recording portion; and a magnetic recording layer provided on a back surface of the optical recording portion, the magnetic recording layer including a magnetic layer, a concealing layer, a print layer, and a print protective layer; the method comprising the steps of hardening the print protective layer; and providing a surface of the magnetic recording layer with a roughness by using a grinding tape after said hardening step.

A fifth aspect of this invention provides a method of fabricating an information recording medium comprising an optical recording portion; and a magnetic recording layer provided on a back surface of the optical recording portion, the magnetic recording layer including a magnetic layer, a concealing layer, a print layer, and a print protective layer; the method comprising the

steps of placing material for the print protective layer in position; hardening the material to form the print protective layer; and levelling a surface of the magnetic recording layer after said hardening step.

A sixth aspect of this invention provides an information recording medium comprising a magnetic recording portion; and an optical recording portion provided on a back surface of the magnetic recording portion; wherein a front surface of the magnetic recording portion includes a first area used for magnetic recording and a second area not used for magnetic recording, and the first area is recessed from the second area.

A seventh aspect of this invention provides an information recording medium comprising a non-magnetic support member; and a multi-layer film provided on the non-magnetic support member and including a magnetic layer and a concealing layer; wherein the concealing layer is superposed directly on the magnetic layer.

An eighth aspect of this invention provides a method of fabricating an information recording medium which comprises the steps of dissolving dispersing agent in organic solvent; enabling the dispersing agent to be absorbed by surfaces of particles; extracting the particles by a filtering process after said enabling step; drying the particles after said extracting step; and adding binder resin to the particles to make and adjust a paint.

A ninth aspect of this invention provides a method of fabricating an information recording medium comprising a non-

magnetic support member; and-a multi-layer film provided on the non-magnetic support member and including a magnetic layer and a concealing layer; wherein the concealing layer is superposed directly on the magnetic layer; the method comprising the steps of using a compact disk as the non-magnetic support member; and applying ultraviolet rays to a surface of the compact disk to facilitate a later bonding process.

BRIEF DESCRIPTION THE DRAWINGS

Fig. 1 is a block diagram of a recording and reproducing apparatus according to a first embodiment of this invention.

Fig. 2 is an enlarged view of an optical recording head portion in the first embodiment.

Fig. 3 is an enlarged view of a head portion in the first embodiment.

Fig. 4 is an enlarged view of a head portion in the first embodiment as viewed in a tracking direction.

Fig. 5 is an enlarged view of a magnetic head portion in the first embodiment.

Fig. 6 is a timing chart of magnetic recording in the first embodiment.

Fig. 7 is a sectional view of a recording medium in the first embodiment.

Fig. 8 is a sectional view of a recording medium in the first embodiment.

Fig. 9 is a sectional view of a recording medium in the first embodiment.

Fig. 10 is a sectional view of a recording portion in the first embodiment.

Fig. 11 is a sectional view of a recording portion in the first embodiment.

Fig. 12 is a sectional view of a recording portion in the first embodiment.

Fig. 13 is a sectional view of a recording portion in the first embodiment.

Fig. 14 is a sectional view of a recording portion in the first embodiment.

Fig. 15 is a perspective view of a cassette in the first embodiment.

Fig. 16 is a perspective view of a recording and reproducing apparatus in the first embodiment.

Fig. 17 is a block diagram of a recording and reproducing apparatus according to the first embodiment.

Fig. 18 is a perspective view of a game machine in the first embodiment.

Fig. 19 is a block diagram of a recording and reproducing apparatus according to a second embodiment of this invention.

Fig. 20 is an enlarged view of a magnetic head portion in the second embodiment.

Fig. 21 is an enlarged view of a magnetic head portion in the second embodiment.

Fig. 22 is an enlarged view of a magnetic head portion in the second embodiment.

Fig. 23 is an enlarged view of a recording portion in a third embodiment of this invention.

Fig. 24 is a block diagram of a recording and reproducing apparatus according to a fourth embodiment of this invention.

Fig. 25 is an enlarged view of a magnetic recording portion in the fourth embodiment.

Fig. 26 is an enlarged view of a magneto-optical recording portion in the fourth embodiment.

Fig. 27 is a sectional view of a recording portion in the fourth embodiment.

Fig. 28 is a flowchart of a program in the fourth embodiment.

Fig. 29 is a flowchart of a program in the fourth embodiment.

Fig. 30(a) is a sectional view of conditions where a magneto-optical disk is placed in an operable position in the fourth embodiment.

Fig. 30(b) is a sectional view of conditions where a CD is placed in an operable position in the fourth embodiment.

Fig. 31 is an enlarged view of a magneto-optical recording portion in the fourth embodiment.

Fig. 32 is a block diagram of a recording and reproducing apparatus according to a fifth embodiment of this invention.

Fig. 33 is an enlarged view of a magnetic recording portion in the fifth embodiment.

Fig. 34 is an enlarged view of a magneto-optical recording portion in the fifth embodiment.

Fig. 35 is an enlarged view of a magneto-optical recording

portion in the fifth embodiment.

Fig. 36 is an enlarged view of a magnetic recording portion in the fifth embodiment.

Fig. 37 is an enlarged view of a magneto-optical recording portion in the fifth embodiment.

Fig. 38 is a block diagram of a recording and reproducing apparatus according to a sixth embodiment of this invention.

Fig. 39 is a block diagram of a magnetic recording portion in the sixth embodiment.

Fig. 40 is an enlarged view of a magnetic field modulating portion in the sixth embodiment.

Fig. 41 is a top view of a magnetic recording portion in the sixth embodiment.

Fig. 42 is a top view of a magnetic recording portion in the sixth embodiment.

Fig. 43 is an enlarged view of a magnetic recording portion in the sixth embodiment.

Fig. 44 is an enlarged view of a magnetic field modulating portion in the sixth embodiment.

Fig. 45(a) is a top view of a disk cassette in a seventh embodiment of this invention.

Fig. 45(b) is a top view of a disk cassette in the seventh embodiment.

Fig. 46(a) is a top view of a disk cassette in the seventh embodiment.

Fig. 46(b) is a top view of a disk cassette in the seventh

embodiment.

Fig. 47(a) is a top view of a disk cassette in the seventh embodiment.

Fig. 47(b) is a top view of a disk cassette in the seventh embodiment.

Fig. 48(a) is a top view of a disk cassette in the seventh embodiment.

Fig. 48(b) is a top view of a disk cassette in the seventh embodiment.

Fig. 49(a) is a top view of a liner and a portion around the liner in the seventh embodiment.

Fig. 49(b) is a top view of a liner and a portion around the liner in the seventh embodiment.

Fig. 49(c) is a top view of a liner and a portion around the liner in the seventh embodiment.

Fig. 50(a) is a top view of a liner and a portion around the liner in the seventh embodiment.

Fig. 50(b) is a top view of a liner and a portion around the liner in the seventh embodiment.

Fig. 50(c) is a transversely sectional view of a liner portion in the seventh embodiment.

Fig. 50(d) is a transversely sectional view of a disk cassette in the seventh embodiment.

Fig. 51 is a transversely sectional view of conditions where liner pin insertion is off in the seventh embodiment.

Fig. 52 is a transversely sectional view of conditions where

liner pin insertion is on in the seventh embodiment.

Fig. 53(a) is a transversely sectional view of conditions where liner pin insertion is off in the seventh embodiment.

Fig. 53(b) is a transversely sectional view of conditions where liner pin insertion is on in the seventh embodiment.

Fig. 54(a) is a transversely sectional view of conditions where magnetic head mounting is off in the seventh embodiment.

Fig. 54(b) is a transversely sectional view of conditions where magnetic head mounting is on in the seventh embodiment.

Fig. 55(a) is a transversely sectional view of conditions where magnetic head mounting is off in the seventh embodiment.

Fig. 55(b) is a transversely sectional view of conditions where magnetic head mounting is on in the seventh embodiment.

Fig. 56 is a top view of a recording medium in the seventh embodiment.

Fig. 57(a) is a transversely sectional view of conditions where liner pin insertion is off in the seventh embodiment.

Fig. 57(b) is a transversely sectional view of conditions where liner pin insertion is on in the seventh embodiment.

Fig. 58 is a sectional view of a liner pin front portion which assumes an off state in the seventh embodiment.

Fig. 59 is a sectional view of a liner pin front portion which assumes an on state in the seventh embodiment.

Fig. 60 is a transversely sectional view of a liner pin which assumes an off state in the seventh embodiment.

Fig. 61 is a transversely sectional view of a liner pin which

assumes an on state in the seventh embodiment.

Fig. 62 is a sectional view of a front portion in the case where a liner pin is off in the seventh embodiment.

Fig. 63 is a sectional view of a front portion in the case where a liner pin is on in the seventh embodiment.

Fig. 64 is a sectional view of a front portion in the case where a liner pin is off in the seventh embodiment.

Fig. 65 is a sectional view of a front portion in the case where a liner pin is on in the seventh embodiment.

Fig. 66 is a sectional view of a front portion in the case where a liner pin is off in the seventh embodiment.

Fig. 67 is a sectional view of a front portion in the case where a liner pin is off and is inactive in the seventh embodiment.

Fig. 68(a) is a top view of a disk cassette in an eighth embodiment of this invention.

Fig. 68(b) is a top view of a disk cassette in the eighth embodiment.

Fig. 69(a) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is off in the eighth embodiment.

Fig. 69(b) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is on in the eighth embodiment.

Fig. 70(a) is a top view of a disk cassette in the eighth embodiment.

Fig. 70(b) is a top view of a disk cassette in the eighth

embodiment.

Fig. 70(c) is a top view of a disk cassette in the eighth embodiment.

Fig. 71 is a transversely sectional view of a liner pin and a disk cassette in the eighth embodiment.

Fig. 72(a) is a transversely sectional view of a portion around a liner pin in the eighth embodiment.

Fig. 72(b) is a transversely sectional view of a portion around a liner pin in the case where a conventional cassette is placed in an operable position in the eighth embodiment.

Fig. 73(a) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is off in the eighth embodiment.

Fig. 73(b) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is on in the eighth embodiment.

Fig. 74(a) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is off in the eighth embodiment.

Fig. 74(b) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is on in the eighth embodiment.

Fig. 75 is a top view of a disk cassette in a ninth embodiment of this invention.

Fig. 76 is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is off in the ninth

embodiment.

Fig. 77 is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is on in the ninth embodiment.

Fig. 78(a) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is off in the ninth embodiment.

Fig. 78(b) is a transversely sectional view of a portion around a liner pin in the case where liner pin insertion is on in the ninth embodiment.

Fig. 79(a) is an illustration of a tracking principle which occurs in the absence of correction in a tenth embodiment of this invention.

Fig. 79(b) is an illustration of a tracking principle which occurs in the absence of correction in the tenth embodiment.

Fig. 80(a) is a view of tracking conditions of an optical head in the tenth embodiment.

Fig. 80(b) is a view of tracking conditions of an optical head in the tenth embodiment.

Fig. 81(a) is an illustration of an offset amount of an optical track on a disk in the tenth embodiment.

Fig. 81(b) is an illustration of an offset amount of an optical track on a disk in the tenth embodiment.

Fig. 81(c) is an illustration of a tracking error signal in the tenth embodiment.

Fig. 82(a) is a view of tracking conditions of an optical head

which occur in the absence of correction in the tenth embodiment.

Fig. 82(b) is a view of tracking conditions of an optical head which occur in the presence of correction in the tenth embodiment.

Fig. 83 is an illustration of a reference track in the tenth embodiment.

Fig. 84(a) is a side view of a slider in the case of an ON state in the tenth embodiment.

Fig. 84(b) is a side view of a slider in the case of an OFF state in the tenth embodiment.

Fig. 85(a) is a side view of a slider portion in the case where magnetic recording is OFF in the tenth embodiment.

Fig. 85(b) is a side view of a slider portion in the case where magnetic recording is ON in the tenth embodiment.

Fig. 86 is an illustration of the correspondence relation between an address and a position on a disk in the tenth embodiment.

Fig. 87 is a block diagram of a magnetic recording portion in an eleventh embodiment of this invention.

Fig. 88(a) is a transversely sectional view of a magnetic head in the eleventh embodiment.

Fig. 88(b) is a bottom view of a magnetic head in the eleventh embodiment.

Fig. 88(c) is a bottom view of another magnetic head in the eleventh embodiment.

Fig. 89 is an illustration of a spiral-shaped recording format in

the eleventh embodiment.

Fig. 90 is an illustration of a recording format of a guard band in the eleventh embodiment.

Fig. 91 is an illustration of a data structure in the eleventh embodiment.

Fig. 92(a) is a timing chart of recording in the eleventh embodiment.

Fig. 92(b) is a timing chart of simultaneous recording by two heads in the eleventh embodiment.

Fig. 93 is a block diagram of a reproducing portion in the eleventh embodiment.

Fig. 94 is an illustration of a data arrangement in the eleventh embodiment.

Fig. 95 is a flowchart of traverse control in the eleventh embodiment.

Fig. 96 is an illustration of a cylindrical recording format in the eleventh embodiment.

Fig. 97 is an illustration of the relation between a traverse gear rotation number and a radius in the eleventh embodiment.

Fig. 98 is an illustration of an optical recording surface format in the eleventh embodiment.

Fig. 99 is an illustration of a recording format in the presence of compatibility with a lower level apparatus in the eleventh embodiment.

Fig. 100 is an illustration of the correspondence relation between an optical recording surface and a magnetic recording

surface in the eleventh embodiment.

Fig. 101 is a perspective view of a recording medium in a twelfth embodiment of this invention.

Fig. 102 is a perspective view of a recording medium in the twelfth embodiment.

Fig. 103 is a transversely sectional view of a recording medium which occurs at film forming and printing steps in the twelfth embodiment.

Fig. 104 is a transversely sectional view of a recording medium which occurs at film forming and printing steps in the twelfth embodiment.

Fig. 105 is a perspective view of a manufacturing system in a state corresponding to an application step in the twelfth embodiment.

Fig. 106 is a transversely sectional view of a recording medium at application and transfer steps in the twelfth embodiment.

Fig. 107 is an illustration of steps of manufacturing a recording medium in the twelfth embodiment.

Fig. 108 is a transversely sectional view of a recording medium at application and transfer steps in the twelfth embodiment.

Fig. 109 is a perspective view of a manufacturing system in a state corresponding to an application step in the twelfth embodiment.

Fig. 110 is a block diagram of a recording and reproducing apparatus according to a thirteenth embodiment of this invention.

Fig. 111 is a transversely sectional view of a portion around a

magnetic head in the thirteenth embodiment.

Fig. 112 is an illustration of the relation between a head gap length and an attenuation amount (dB) in the thirteenth embodiment.

Fig. 113 is a top view of a magnetic track in the thirteenth embodiment.

Fig. 114 is a transversely sectional view of a portion around a magnetic head in the thirteenth embodiment.

Fig. 115 is a transversely sectional view of conditions where a recording medium is placed in an operable position.

Fig. 116 is an illustration of the relation between a relative noise amount and a distance between an optical head and a magnetic head in the twelfth and thirteenth embodiments.

Fig. 117 is a transverse sectional view of a head traverse portion in the thirteenth embodiment.

Fig. 118 is a top view of a head traverse portion in the thirteenth embodiment.

Fig. 119 is a transversely sectional view of another head traverse portion in the thirteenth embodiment.

Fig. 120 is a transversely sectional view of another head traverse portion in the thirteenth embodiment.

Fig. 121 is an illustration of the intensities of magnetic fields generated by various home-use appliances.

Fig. 122 is an illustration of a recording format on a recording medium in the thirteenth embodiment.

Fig. 123 is an illustration of a recording format on a recording

medium in a normal mode in the thirteenth embodiment.

Fig. 124 is an illustration of a recording format on a recording medium in a variable track pitch mode in the thirteenth embodiment.

Fig. 125 is an illustration of compressing magnetic recorded information by using a reference table of optical recorded information in the thirteenth embodiment.

Fig. 126 is a transversely sectional view of a head traverse portion in the thirteenth embodiment.

Fig. 127 is a flowchart of a recording and reproducing program in the thirteenth embodiment.

Fig. 128 is a flowchart of a recording and reproducing program in the thirteenth embodiment.

Fig. 129(a) is an illustration of a noise detecting head in the thirteenth embodiment.

Fig. 129(b) is an illustration of a noise detecting head in the thirteenth embodiment.

Fig. 129(c) is an illustration of a noise detecting head in the thirteenth embodiment.

Fig. 130 is an illustration of a magnetic sensor in the thirteenth embodiment.

Fig. 131 is a sectional view of a recording and reproducing apparatus according to a fourteenth embodiment of this invention.

Fig. 132 is a time-domain diagram of various signals in the fourteenth embodiment.

Fig. 133 is a perspective view of a cartridge for an optical

recording medium in the fourteenth embodiment.

Fig. 134 is a block diagram of a recording and reproducing apparatus in the fourteenth embodiment.

Fig. 135 is a time-domain diagram of various signals in the fourteenth embodiment.

Fig. 136 is a block diagram of a recording and reproducing apparatus according to a fifteenth embodiment of this invention.

Fig. 137(a) is a perspective view of the fifteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 137(b) is a perspective view of the fifteenth embodiment in which the cartridge is fixed.

Fig. 137(c) is a perspective view of the fifteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 138(a) is a perspective view of the fifteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 138(b) is a perspective view of the fifteenth embodiment in which the cartridge is fixed.

Fig. 138(c) is a perspective view of the fifteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 139(a) is a sectional view of the fifteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 139(b) is a sectional view of the fifteenth embodiment in which the cartridge is fixed.

Fig. 139(c) is a sectional view of the fifteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 140 is a block diagram of a recording and reproducing

apparatus according to a sixteenth embodiment of this invention.

Fig. 141(a) is a perspective view of the sixteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 141(b) is a perspective view of the sixteenth embodiment in which the cartridge is fixed.

Fig. 141(c) is a perspective view of the sixteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 142(a) is a perspective view of the sixteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 142(b) is a perspective view of the sixteenth embodiment in which the cartridge is fixed.

Fig. 142(c) is a perspective view of the sixteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 143(a) is a sectional view of the sixteenth embodiment in which a cartridge is inserted into the apparatus.

Fig. 143(b) is a sectional view of the sixteenth embodiment in which the cartridge is fixed.

Fig. 143(c) is a sectional view of the sixteenth embodiment in which the cartridge is ejected from the apparatus.

Fig. 144(a) is a diagram of a part of an apparatus for making a recording medium in the fourteenth embodiment.

Fig. 144(b) is a diagram of a part of an apparatus for making a recording medium in the fourteenth embodiment.

Fig. 145(a) is a top view of a recording medium in the fourteenth embodiment.

Fig. 145(b) is a top view of a recording medium in the

fourteenth embodiment.

Fig. 145(c) is a top view of a recording medium in the fourteenth embodiment.

Fig. 146(a) is a sectional view of a recording medium in the fourteenth embodiment.

Fig. 146(b) is a sectional view of a recording medium in the fourteenth embodiment.

Fig. 147 is a block diagram of an apparatus according to a seventeenth embodiment of this invention.

Fig. 148 is a flowchart of a program in the seventeenth embodiment.

Fig. 149 is a block diagram of an apparatus according to an eighteenth embodiment of this invention.

Fig. 150 is a flowchart of a program in the eighteenth embodiment.

Fig. 151 is a block diagram of an apparatus according to a nineteenth embodiment of this invention.

Fig. 152 is a diagram of an optical address table and a magnetic address table in a recording medium in the nineteenth embodiment.

Fig. 153 is a block diagram of an apparatus in the nineteenth embodiment.

Fig. 154(a) is a diagram of an address table of an optical file and a magnetic file in the nineteenth embodiment.

Fig. 154(b) is a diagram of an address link table between two files in the nineteenth embodiment.

Fig. 155 is a sectional view of an optical recording medium in the nineteenth embodiment.

Fig. 156 is a flowchart of operation of starting up an optical disk in the nineteenth embodiment.

Fig. 157(a) is a flowchart of a program in a twentieth embodiment of this invention.

Fig. 157(b) is a diagram of an address data table of a magnetic file and an optical file in the twentieth embodiment.

Fig. 157(c) is a block diagram of a bug correcting portion in the twentieth embodiment.

Fig. 158(a) is a flowchart of a program in a twenty-first embodiment of this invention.

Fig. 158(b) is a diagram of a data correction table in the twenty-first embodiment.

Fig. 158(c) is a block diagram of a bug correcting portion in the twenty-first embodiment.

Fig. 159 is a block diagram of an apparatus according to a twenty-second embodiment of this invention.

Fig. 160 is a diagram of a file structure in a computer in the twenty-second embodiment.

Fig. 161 is a flowchart of a program in the twenty-second embodiment.

Fig. 162 is a flowchart of a program in the twenty-second embodiment.

Fig. 163 is a flowchart of a program in the twenty-second embodiment.

Fig. 164(a) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 164(b) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 164(c) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 164(d) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 165 is an illustration of a display screen of a computer in the twenty-second embodiment.

Fig. 166(a) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 166(b) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 166(c) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 166(d) is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 167(a) is an illustration of a display screen of a sub computer in the twenty-second embodiment.

Fig. 167(b) is an illustration of a display screen of a sub computer in the twenty-second embodiment.

Fig. 168 is a diagram of a network in the twenty-second embodiment.

Fig. 169 is an illustration of a display screen of a main computer in the twenty-second embodiment.

Fig. 170 is an illustration of a display screen of a computer in the seventeenth embodiment.

Fig. 171 is a diagram of a recording medium in the twenty-second embodiment.

Fig. 172(a) is a perspective view of a magnetic head in the thirteenth embodiment.

Fig. 172(b) is a sectional view of a magnetic head in the thirteenth embodiment.

Fig. 172(c) is a sectional view of a magnetic head in the thirteenth embodiment.

Fig. 173(a) is a perspective view of a magnetic head in the thirteenth embodiment.

Fig. 173(b) is a sectional view of a magnetic head in the thirteenth embodiment.

Fig. 174(a) is a perspective view of a magnetic head in the thirteenth embodiment.

Fig. 174(b) is a sectional view of a magnetic head in the thirteenth embodiment.

Fig. 175(a) is a perspective view of a magnetic head in the thirteenth embodiment.

Fig. 175(b) is a sectional view of a magnetic head in the thirteenth embodiment.

Fig. 176(a) is a perspective view of a noise detection coil in the thirteenth embodiment.

Fig. 176(b) is a sectional view of a noise detection coil in the thirteenth embodiment.

Fig. 177(a) is a perspective view of a noise detection coil in the thirteenth embodiment.

Fig. 177(b) is a block diagram of a noise detection system in the thirteenth embodiment.

Fig. 178(a) is a perspective view of a noise detection coil in the thirteenth embodiment.

Fig. 178(b) is a block diagram of a noise detection system in the thirteenth embodiment.

Fig. 179 is a diagram of frequency spectrums of reproduced signals which occur before and after noise cancel in the thirteenth embodiment.

Fig. 180 is a block diagram of a recording and reproducing apparatus in the twenty-second embodiment.

Fig. 181 is a block diagram of a recording and reproducing apparatus according to a twenty-third embodiment of this invention.

Fig. 182(a) is a top view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 182(b) is a top view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 183(a) is a sectional view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 183(b) is a sectional view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 183(c) is a sectional view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 183(d) is a sectional view of the recording and

reproducing apparatus in the twenty-third embodiment.

Fig. 183(e) is a sectional view of the recording and reproducing apparatus in the twenty-third embodiment.

Fig. 184(a) is a diagram of a data structure in a recording medium in the twenty-third embodiment.

Fig. 184(b) is a diagram of a data structure in a recording medium in the twenty-third embodiment.

Fig. 184(c) is a diagram of a data structure in a recording medium in the twenty-third embodiment.

Fig. 185(a) is a top view of a recording medium in the twenty-third embodiment.

Fig. 185(b) is a sectional view of a recording medium in the twenty-third embodiment.

Fig. 185(c) is a sectional view of a recording medium in the twenty-third embodiment.

Fig. 185(d) is a sectional view of a recording medium in the twenty-third embodiment.

Fig. 185(e) is a sectional view of a recording medium in the twenty-third embodiment.

Fig. 186(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 186(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 186(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 186(d) is a sectional view of a recording and reproducing

apparatus in the twenty-third embodiment.

Fig. 186(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 187(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 187(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 187(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 187(d) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 187(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(d) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 188(f) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 189(a) is a sectional view of a recording and reproducing

apparatus in the twenty-third embodiment.

Fig. 189(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 189(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 189(d) is a diagram of mathematical relations for calculating a track pitch in the twenty-third embodiment.

Fig. 190 is a block diagram of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 191(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 191(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 191(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 191(d) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 191(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 192(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 192(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 192(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 192(d) is a sectional view of a recording and reproducing

apparatus in the twenty-third embodiment.

Fig. 192(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 193(a) is a top view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 193(b) is a top view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 194(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 194(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 194(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 194(d) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 194(e) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 195 is a diagram of the relation between a distance from a magnetic head and the intensity of a dc magnetic field.

Fig. 196(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 196(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 196(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 197 is a top view of a recording and reproducing

apparatus in the twenty-third embodiment.

Fig. 198(a) is a sectional view of a magnetic head in the twenty-third embodiment.

Fig. 198(b) is a top view of a magnetic head in the twenty-third embodiment.

Fig. 198(c) is a sectional view of a magnetic head in the twenty-third embodiment.

Fig. 198(d) is a top view of a magnetic head in the twenty-third embodiment.

Fig. 199(a) is a top view of a recording medium in the twenty-third embodiment.

Fig. 199(b) is a top view of a recording medium in the twenty-third embodiment.

Fig. 199(c) is a sectional view of a recording medium in the twenty-third embodiment.

Fig. 200 is a block diagram of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 201(a) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 201(b) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 201(c) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 201(d) is a sectional view of a recording and reproducing apparatus in the twenty-third embodiment.

Fig. 202 is a block diagram of a recording and reproducing

apparatus in the first embodiment.

Fig. 203(a) is a diagram of the distribution of the frequencies of occurrence of periods T, 1.5T, and 2T in the first embodiment.

Fig. 203(b) is a diagram of the distribution of the frequencies of occurrence of periods T, 1.5T, and 2T in the first embodiment.

Fig. 204 is a diagram of the relation between the maximum burst correction length and the correction symbol number according to the CD standards.

Fig. 205 is a diagram of the dispersion length of data on a recording medium in the first embodiment.

Fig. 206 is a diagram of the relation between the data amount of an error correction code and the error rate in the first embodiment.

Fig. 207(a) is a diagram of arrangement conversion related to interleaving in the first embodiment.

Fig. 207(b) is a diagram of the data dispersion length related to interleaving in the first embodiment.

Fig. 208 is a block diagram of a de-interleaving portion in the first embodiment.

Fig. 209(a) is a block diagram of an ECC encoder in the first embodiment.

Fig. 209(b) is a block diagram of an ECC decoder in the first embodiment.

Fig. 210 is a flowchart of a program in the first embodiment.

Fig. 211 is a block diagram of a recording and reproducing apparatus in the first embodiment.

Fig. 212(a) is a diagram of arrangement conversion related to interleaving in the first embodiment.

Fig. 212(b) is a diagram of the data dispersion length related to interleaving in the first embodiment.

Fig. 213 is a diagram of the distance and the time interval of a CD subcode.

Fig. 214 is an illustration of a table of the correspondence between a magnetic track and an optical address in the fourteenth embodiment.

Fig. 215 is a block diagram of a subcode sync signal detector and a magnetic recording portion in the fourteenth embodiment.

Fig. 216 is a block diagram of a recording and reproducing apparatus in the fourteenth embodiment.

Fig. 217 is a block diagram of a recording and reproducing apparatus in the fourteenth embodiment.

Fig. 218(a) is a time-domain diagram of an optical reproduction sync signal in the fourteenth embodiment.

Fig. 218(b) is a time-domain diagram of the conditions of magnetic recording operation in the fourteenth embodiment.

Fig. 218(c) is a time-domain diagram of a magnetic record sync signal in the fourteenth embodiment.

Fig. 218(d) is a time-domain diagram of the conditions of optical reproducing operation in the fourteenth embodiment.

Fig. 218(e) is a time-domain diagram of an optical reproduction sync signal in the fourteenth embodiment.

Fig. 218(f) is a time-domain diagram of the conditions of

magnetic reproducing operation in the fourteenth embodiment.

Fig. 218(g) is a time-domain diagram of a magnetic reproduction sync signal in the fourteenth embodiment.

Fig. 218(h) is a time-domain diagram of magnetic reproduced data in the fourteenth embodiment.

Fig. 219 is a diagram of a disk eccentricity according to the CD standards.

Fig. 220 is a diagram of a file structure in the twenty-second embodiment.

Fig. 221 is a perspective view of an information recording medium according to a twenty-fourth embodiment of this invention.

Fig. 222(a) is a diagram of a portion of a fabrication system which forms a magnetic layer in the twenty-fourth embodiment.

Fig. 222(b) is a diagram of a portion of a fabrication system which forms an aluminum alloy film in the twenty-fourth embodiment.

Fig. 222(c) is a diagram of a portion of a fabrication system which forms a concealing layer in the twenty-fourth embodiment.

Fig. 222(d) is a sectional view of an information recording medium in the twenty-fourth embodiment.

Fig. 222(e) is a sectional view of an information recording medium in the twenty-fourth embodiment.

Fig. 223(a) is a diagram of a portion of a fabrication system which forms a magnetic layer in a twenty-fifth embodiment of this invention.

Fig. 223(b) is a sectional view of an information recording

medium in the twenty-fifth embodiment.

Fig. 223(c) is a diagram of a portion of a fabrication system which forms a print protective layer in the twenty-fifth embodiment.

Fig. 223(d) is a sectional view of a print protective layer in the twenty-fifth embodiment.

Fig. 224 is a diagram of an information recording medium according to a twenty-sixth embodiment of this invention.

Fig. 225 is a sectional view of an information recording medium in the twenty-sixth embodiment.

Fig. 226 is a sectional view of an information recording medium in this invention.

Fig. 227 is a sectional view of an information recording medium.

Fig. 228 is a table of the results of experiments in a twenty-seventh embodiment of this invention.

Fig. 229 is a table of the results of experiments in a twenty-ninth embodiment of this invention.

Fig. 230 is a table of the results of experiments in the twenty-ninth embodiment.

Fig. 231 is a table of the results of experiments in a thirtieth embodiment of this invention.

Fig. 232 is a table of the results of experiments in the thirtieth embodiment.

Fig. 233 is a table of the results of experiments in a thirty-first embodiment of this invention.

Fig. 234 is a table of the results of experiments in the thirty-first embodiment.

Fig. 235 is a table of the results of experiments in the thirty-first embodiment.

Fig. 236(a) is a sectional view of an information recording medium according to a thirty-fourth embodiment of this invention.

Fig. 236(b) is a diagram of an HB identification code in the thirty-fourth embodiment.

DESCRIPTION OF THE FIRST PREFERRED EMBODIMENT

With reference to Fig. 1, a recording and reproducing apparatus 1 contains a recording medium 2 which includes a laminated structure of a magnetic recording layer 3, an optical recording layer 4, and a transparent layer 5.

During the magneto-optical reproduction, light emitted from a light emitting section is focused on the optical recording layer 4 by an optical head 6 and an optical recording block 7, and a magneto-optically recorded signal is reproduced from the recording medium 2.

During the magneto-optical recording, laser light is focused on a given region of the optical recording layer 4 by the optical head 6 and the optical recording block 7 so that a temperature at the given region increases to or above a Curie temperature of the optical recording layer 4. Under these conditions, a magnetic field applied to the given region of the optical recording layer 4 is modulated by a magnetic head 8 and a magnetic recording block 9 in response to information to be recorded, so that recording of the information on

the optical recording layer 4 is done.

During the magnetic recording, the magnetic head 8 and the magnetic recording block 9 are used in recording information on the magnetic recording layer 3.

A system controller 10 receives operating information and output information from various circuits, and drives a drive block 11 and executes control of a motor 17 and tracking and focusing control with respect to the optical head 6. The system controller 10 includes a microcomputer or a similar device having a combination of a CPU, a ROM, a RAM, and an I/O port. The system controller 10 operates in accordance with a program stored in the ROM.

In the case where an input signal fed from an exterior is required to be recorded, a recording instruction is fed to the system controller 10 from an interface 14 or a keyboard 15 in response to the reception of the input signal or the operation of the keyboard 15 by the user. The system controller 10 outputs an inputting instruction to an input section 12, and also outputs an optical recording instruction to the optical recording block 7. The input signal, for example, an audio signal or a video signal, is received by the input section 12 and is converted by the input section 12 into a digital signal of a given format such as a PCM format. The digital signal is fed from the input section 12 to an input section 32 of the optical recording block 7, being coded by an ECC encoder 35 for error correction. An output signal of the ECC encoder 35 is transmitted to the magnetic head 8 via an optical

recording circuit 37, and a magnetic recording circuit 29 and a magnetic recording circuit 29 in the magnetic recording block 9. The magnetic head 8 generates a recording magnetic field responsive to an optical recording signal, and applies the magnetic field to magneto-optical material (photo-magnetic material) in a given region of the optical recording layer 4. Recording material in a narrower region of the optical recording layer 4 is heated to a Curie temperature or higher by laser light applied from the optical head 6, so that this region of the optical recording layer 4 undergoes a magnetization change or transition responsive to the applied magnetic field. Thus, as shown in Fig. 2, narrower regions of the optical recording layer 4 are sequentially magnetized as denoted by arrows 52 while the recording medium 2 is rotated and scanned in a direction 51.

During the previously-mentioned recording of information on the optical recording layer 4, the system controller 10 receives tracking information, address information, and clock information from an optical head circuit 39 and an optical reproducing circuit 38 which have been recorded on the optical recording layer 4, and the system controller 10 outputs control information to the drive block 11 on the basis of the received information. Specifically, the system controller 10 feeds a control signal to a motor drive circuit 26 to control the rotational speed of the motor 17 for driving the recording medium 2 so that a relative speed between the optical head 6 and the recording medium 2 will be equal to a given linear velocity.

An optical head drive circuit 25 and an optical head actuator 18 execute tracking control responsive to a control signal from the system controller 10 so that a light beam will scan a target track on the recording medium 2. In addition, the optical head drive circuit 25 and the optical head actuator 18 execute focusing control responsive to a control signal from the system controller 10 so that the light beam will be accurately focused on the optical recording layer 4.

In the case where the access to another track is required, a head moving circuit 24 and a head moving actuator 23 move a head base 19 in response to a control signal from the system controller 10 so that the optical head 6 and the magnetic head 8 on the head base 19 will be moved together. Thus, the both heads reach equal radial positions on opposite surfaces of the recording medium 2 which align with a desired track.

A head elevator 20 for the magnetic head 8 is driven by a magnetic head elevating circuit 22 and an elevating motor 21 in response to a control signal from the system controller 10. During a time where a disk cassette 42 is being loaded with the recording medium 2 or where magnetic recording is not executed, the magnetic head 8 and a slider 41 are separated from the magnetic recording layer 3 of the recording medium 2 to prevent wear of the magnetic head 8.

As described previously, the system controller 10 feeds various control signals to the drive block 11, and thereby executes tracking control and focusing control of the optical head 6 and the

magnetic head 8, elevation control of the magnetic head 8, and control of the rotational speed of the motor 17.

A description will now be given of a method of reproducing a magneto-optically recorded signal. As shown in Fig. 2, laser light emitted from the light emitting section 57 is incident to a polarization beam splitter 55, being reflected and directed toward an optical path 59 by the polarization beam splitter 55. The laser light travels along the optical path 59, being incident to a lens 54 and then being focused on the optical recording layer 4 of the recording medium 2 by the lens 54. In this case, focusing and tracking control is done by driving only the lens 54 through the optical head drive section 18.

As shown in Fig. 2, the magneto-optical material of the optical recording layer 4 is in magnetized conditions depending on the optical recorded signal. Thus, the polarization angle of reflected light traveling back along an optical path 59a depends on the direction of the magnetization of the optical recording layer 4 due to the Kerr effect. The reflected light is separated from the forward light by the polarization beam splitter 55, traveling through the polarization beam splitter 55 and entering another polarization beam splitter 56. The reflected light is divided by the polarization beam splitter 56 into two beams incident to light receiving sections 58 and 58a respectively. The light receiving sections 58 and 58a convert the incident light beams into corresponding electric signals respectively. A subtractor (not shown) derives a difference between the output signals of the light receiving sections 58 and 58a. Since

the derived difference depends on the direction of the magnetization of the optical recording layer 4, the subtractor generates a signal equal to the reproduction of the optical recorded signal. In this way, the optical recorded signal is reproduced.

The reproduced signal is fed from the optical head 6 to the optical recording block 7, being processed by the optical head circuit 39 and the optical reproducing 38 and being subjected to error correction by an ECC decoder 36. As a result, the original digital signal is recovered from the reproduced signal. The recovered original digital signal is fed to an output section 33. The output section 33 is provided with a memory which stores a quantity of the recorded signal (the recorded information) which corresponds to a given interval of time. In the case where the memory 34 consists of a 1-Mbit IC memory and a compressed audio signal having a bit rate of 250 kbps is handled, a quantity of the recorded signal which corresponds to a time of about 4 seconds can be stored. In the case of an audio player, if the optical head 6 moves out of tracking by an external vibration, the recovery of tracking in a time of 4 seconds prevents the occurrence of a discontinuity in a reproduced audio signal. The reproduced signal is then transmitted from the output section 33 to an output section 13 at a final stage. In the case where the reproduced signal represents audio information, the reproduced signal is subjected to PCM demodulation before being outputted to an external device as an analog audio signal.

A description will now be given of a magnetic recording mode

of operation. In Fig. 1, an input signal applied to an input section 12 from an external device or an output signal of the system controller 10 is transmitted to an input section 21A of the magnetic recording block 9, being subjected by the ECC encoder 35 in the optical recording block 7 to a coding process such as an error correcting process. The resultant coded signal is transmitted to the magnetic head 8 via the magnetic recording circuit 29 and the magnetic head circuit 31.

With reference to Fig. 3, the magnetic recorded signal fed to the magnetic head 8 is converted by a winding 40 into a corresponding magnetic field. The magnetic material of the magnetic recording layer 3 is vertically magnetized by the magnetic field as denoted by arrows 61 in Fig. 3. In this way, magnetic recording in a vertical direction is done so that the information signal is recorded on the recording medium 2. The recording medium 2 has a vertically magnetized film. As the recording medium 2 is moved along a direction 51, time segments of the information signal is sequentially recorded on the magnetic recording medium 2. In this case, although the optical recording layer 4 is also subjected to the magnetic field, the optical recording layer 4 is prevented from being magnetized by the magnetic field since the magneto-optical material of the optical recording layer 4 has a magnetic coercive force of several thousands to ten thousands of Oe at temperatures below the Curie temperature.

In the case where a portion of the magnetic recording layer 3 which actually undergoes the magnetic recording process is

excessively close to the optical recording layer 4, the intensity of a magnetic filed applied to the optical recording layer 4 from the magnetic recording portion of the magnetic recording layer 3 sometimes reaches a level of several tens to several hundreds of Oe. Under these conditions, in the case where the temperature of the optical recording layer 4 is increased above the Curie temperature for magneto-optical recording, the optical recording layer 4 tends to undergo a magnetization change or transition in response to the magnetic field from the magnetic recording portion of the magnetic recording layer 3 so that an error rate increases during the magneto-optical recording. To resolve such a problem, it is preferable to provide an interference layer 81 of a given thickness between the magnetic recording layer 3 and the optical recording layer 4 as shown in Fig. 7. Opposite surfaces of the optical recording layer 4 are provided with protective layers 82 and 82a to prevent deterioration thereof. The sum of the thickness of the interference layer 81 and the thickness of the protective layer 82 is equal to an interference interval or distance L. In this case, an attenuation rate is given as $56.4 \times L/\lambda$ where λ denotes a magnetic recording wavelength. When $\lambda = 0.5$ μm, an interference interval L of 0.2 μm or greater can provide an adequate level of the effect.

As shown in Fig. 8, a protective layer 82 of a thickness equal to or greater than the interference interval may be provided between the magnetic recording layer 3 and the optical recording layer 4.

The magnetic recording medium 2 of Fig. 7 was fabricated as

follows. The protective layer 82 and the interference layer 81 were sequentially formed on the optical recording layer 4. Magnetic material such as barium ferrite was prepared which had vertical anisotropy. Lubricant, binder, and the magnetic material were mixed. The resultant mixture was applied to the substrate by spin coat to form the magnetic recording layer 3 while a magnetic field was applied to the substrate in the vertical direction of the substrate.

The recording and reproducing apparatus 1 can operate on a ROM disk similar to a compact disk (CD). Fig. 9 shows an example of a ROM-type recording medium 2. The recording medium 2 of Fig. 9 was fabricated as follows. A substrate 5 was provided with pits. A reflecting film 84 of suitable material such as aluminum was formed over the pits of the substrate 5. Lubricant, binder, and magnetic material were mixed. The resultant mixture was applied to the reflecting film 84 to form a magnetic recording layer 3 while a magnetic field was applied to the substrate 5 in the vertical direction of the substrate 5. The magnetic recording layer 3 had a vertical magnetic recording film. The recording medium of Fig. 9 has the function of a CD ROM at one side, and has the function of a RAM at the other side. Thus, the recording medium of Fig. 9 provides various advantages as described later. In this case, a cost increase results from only adding the magnetic substance to the material which will form a protective film through spin coat similar to that executed to fabricate a currently-used CD. Accordingly, a manufacturing cost increase corresponds to only the cost of the

magnetic substance. Since the cost of the magnetic substance is equal to a few percent of the manufacturing cost of the recording medium, the cost increase is very small.

During the magnetic recording, tracking is executed as follows. In Fig. 1, the optical head 6 and the optical head circuit 39 reproduce tracking information from the recording medium 2. The system controller 10 outputs a moving instruction to the head moving circuit 24 in response to the reproduced tracking information, driving the actuator 23 and thereby moving the head base 19 in the tracking direction. Thus, as shown in Fig. 4, light beam emitted from the optical head 6 is focused into a spot 66 near a given optical recording track 65 of the optical recording layer 4. The optical head drive section 18 for driving the optical head 6 is mechanically couped with the magnetic head 8 via the head base 19 and the head elevator 20. Therefore, the magnetic head 8 moves in the tracking direction as the optical head 6 moves. Thus, when the optical head 6 is aligned with the given optical track 66, the magnetic head 8 is moved into alignment with a given magnetic track 67 which extends at the opposite side of the optical track 66. Guard bands 68 and 68a are provided at opposite sides of the magnetic track 67. As shown in Fig. 5, when the position of the optical head 6 is controlled so as to scan a given Tn-th optical track 65, the magnetic head 8 runs along a given Mm-th magnetic track 67 extending at the opposite side of the optical track 65. In this case, the drive system for the optical head 6 suffices and it is unnecessary to provide a tracking control device for the magnetic

head 8. Furthermore, it is unnecessary to provide a linear sensor required in a conventional magnetic disk drive.

A description will now be given of a method of accessing an optical track and a magnetic track. The optical head 6 is subjected to tracking together with the magnetic head 8. Therefore, in the case where there is a difference in radial direction between an optical track currently exposed to an information recording or reproducing process from the lower surface and a magnetic track desired to be accessed from the upper surface, the two tracks can not be accessed at the same time. In the case of a data signal, this access problem causes only a delay in access and does not cause a significant problem. In the case of a continuous signal such as an audio signal or a video signal, an interruption is generally unacceptable. Thus, the magnetic recording can not be executed during an optical recording or reproducing process at a normal speed. This embodiment uses the system in which the memory 34 is provided in connection with the input section 32 and the output section 33 to store a quantity of a signal which corresponds to an interval equal to several times the maximum access time of magnetic recording.

As shown in Fig. 6, the rotational speed of the recording medium 2 is increased by n times during a recording or reproducing process, and thereby an optical recording or reproducing time T is shortened to 1/n as compared with that of a normal speed and becomes equal to T1 and T2. Thus, a time T0 between t2 and t5 which equals to n-1 times the recording or

reproducing time is a margin time. In the case where a magnetic track is accessed during an access time Ta between t2 and t3 in the margin time T0 and a magnetic recording or reproducing process is done during a recording or reproducing time TR between t3 and t4 and where head return or motion to an original optical track or a next optical track is done during a return time Tb between t5 and t6, access for the optical recording and access for the magnetic recording can be executed in time division by a single head moving section. In this case, the capacity of the memory 34 is chosen so that the memory 34 can store a continuous signal during the margin time T0.

Access to a track by the magnetic head 8 will now be described with reference to Fig. 6 and Figs. 10-16. A cassette 42 shown in Fig. 15 includes the recording medium 2. The cassette 42 is inserted into a recess in a casing of the recording and reproducing apparatus 1 shown in Fig. 16. Then, as shown in Fig. 10, a light beam emitted from the optical head 6 is focused on an optical track 65 in a TOC region on a recording surface of the recording medium 2, and TOC information is reproduced. Index information is recorded in the TOC region. During the reproduction of the TOC information, the magnetic head 8 travels on a magnetic track 67 at the opposite side of the optical track 65 so that magnetically recorded information is reproduced from the magnetic track 67. In this way, during the first process, information is reproduced from the optical track in the TOC region of the recording medium 2, and simultaneously information is reproduced

from the magnetic track. The information reproduced from the magnetic track represents the contents of previous access, conditions at the end of previous operation, or others. As shown in Fig. 16, the contents of the reproduced information are indicated on a display 16.

In the case of audio information, a final music number, an elapsed time of an interruption thereof, a reserved music number, or others are automatically recorded on the magnetic recording region. When the magnetic recording medium 2 is inserted into the recording and reproducing apparatus 1 again, information of a table of contents is reproduced from the optical track 65 and also information at the end of previous operation is reproduced from the magnetic track 67 as previously described. The reproduced information is indicated on the display 16 as shown in Fig. 16. Fig. 16 shows conditions where the previous access end time, the operator name, the final music number, the elapsed time of an interruption, the previously preset music order, and the music number are recorded and indicated. Specifically, "Continue?" is indicated. When "Yes" is inputted as a reply, the music starts to be reproduced from a point at which the previous operation ends. When "No" is inputted as a reply, the music is reproduced in the preset order. In this way, the user is enabled to enjoy the automatic reproduction of the previously-interrupted contents as they are, or to listen the music in the desired order.

In the case of a CD ROM game device 18 shown in Fig. 18, the previously interrupted game contents, for example, the stage

number, the acquired points, and the item attainment number, are recorded and reproduced. Upon the start of the game a certain time after the previous end of the game, the game can be started from the place same as the previous place and the conditions same as the previous conditions. This advantage can not be provided by a prior art CD ROM game device.

The above-mentioned simple method of accessing the magnetic track in the TOC region has an advantage in that the structure is simple and the cost is low although the memory capacity is small.

A description will now be given of access to a track outside the TOC region. Fig. 11 shows conditions where the optical head 6 accesses a given optical track 65a. At this time, the magnetic head 8 which moves together with the optical head 6 accesses a magnetic track 67a at the opposite side of the optical track 65a. In the case where required information is on a magnetic track 67b separate from the magnetic track 67a, it is necessary to move the magnetic head 8 to the magnetic track 67b. In this case, as previously described with reference to Fig. 6, it is necessary to complete the head movement, the recording, and the head return in a margin time T0. List information representing the correspondence between the magnetic track numbers and the optical track numbers is previously recorded on a TOC region or another given region of the optical recording layer 4. The list information is read out, and the optical track number corresponding to the required magnetic track number is calculated by referring to the list information.

Then, as shown in Fig. 12, during an access time Ta, the head base 19 is moved and fixed so that the optical head 6 can access an optical track 65b corresponding to the calculated optical track number. Thus, the magnetic head 8 will follow the required magnetic track 67b. In this way, the magnetic recording or reproduction can be executed. In this case, as shown in Fig. 13, while the optical track 65a is being scanned, the magnetic head 8 remains lifted to an upper position well separated from the magnetic recording layer 3 by the elevating motor 21. In addition, during the access time Ta, as denoted by the character "ω" in Fig. 6, the rotational speed of the motor 17 is lowered. While the rotational speed remains low, the magnetic head 8 is moved downward into contact with the magnetic recording layer 3. Thereby, it is possible to prevent the magnetic head 8 from being damaged. During an interval TR, the rotational speed is increased and the magnetic recording is done. During an interval Tb, the rotational speed is lowered and the magnetic head 8 is lifted. Then, the rotational speed is increased again, and the optical head 6 is returned to the optical track 65a as shown in Fig. 13. During an interval T2, optical recording and reproduction is done. Since the data stored in the memory 34 is reproduced during the margin time T0, the reproduced signal or the reproduced music will not be interrupted. As shown in Fig. 14, during access to the TOC region, the magnetic head 8 is not moved downward in the presence of an instruction representing that magnetic recording on the TOC region is unnecessary. Thereby, even if a recording medium 2 having no

magnetic recording layer 3 is inserted into the recording and reproducing apparatus, the magnetic head 8 can be prevented from contacting the recording medium 2 and being thus damaged. In this way, the execution of the upward and downward movement of the magnetic head 8 during a period of the occurrence of a lowered rotational speed provides an advantage such that a damage to the magnetic head 8 can be prevented and wear thereof can be remarkably reduced.

Fig. 15 shows the cassette 42 which contains the recording medium 2. The cassette 42 is provided with a shutter 88, a magnetic recording prevention click 89, and an optical recording prevention click 89a. The magnetic recording prevention and the optical recording prevention can be set separately. In the case of a ROM cassette, only a magnetic recording prevention click 89a is provided thereon.

Fig. 17 shows a recording and reproducing apparatus for reproduction of optically recorded information. An optical recording circuit and an ECC encoder are omitted from an optical recording block 7 in the recording and reproducing apparatus of Fig. 17 as compared with that of Fig. 1. The recording and reproducing apparatus of Fig. 17 additionally includes a magnetic head elevator 20, a magnetic head 8, and a magnetic recording block 9 as compared with a conventional reproduction player such as a CD player. All the parts of the recording and reproducing apparatus of Fig. 17 can be used in common to the parts of the recording and reproducing apparatus of Fig. 1. Their costs are very

low relative to optical recording-parts, and the resultant cost increase is small. Although the memory capacity is smaller than that of a floppy disk, information can be recorded and reproduced on and from a ROM-type recording medium at such a low cost. Thus, in the case of a game device or a CD player requiring only a small memory capacity, various advantages are provided as previously described. According to estimation, in the case of a recording medium disk having a diameter of 60 mm, a magnetic recording memory capacity of about 1 KB to 10 KB is obtained by using a magnetic head for modulating a magnetic field. A memory of a 2-KB or 8-KB SRAM is provided on a typical game ROM IC, and thus the above-mentioned memory capacity is sufficient. Thus, there is an advantage such that the recording medium disk can replace a ROM IC.

The error correction encoder 35 and the error correction decoder 36 of Fig. 1 will now be described in detail. With respect to a normal magnetic disk such as a 3.5-inch floppy disk of the 2HD type or the 2DD type, an error correcting process is not executed. In the case of the 3.5-inch 2HD floppy disk, the error rate is close to 10^{-12} when record and reproduction are done at 135 TPI. Accordingly, in the case where this floppy disk is used in a cartridge, it is unnecessary to execute error correction including interleaving. A CD ROM having a magnetic recording layer on a medium front surface or back surface is used without any cartridge. In the case of such a CD ROM, dust and a scratch cause a burst error.

The recording medium of this invention is designed so that Hc=1900 Oe. The magnetic recording layer is applied to the CD label side in which the space loss by the print layer and the protective layer is 9 to 10 micrometers. During experiments, this recording medium was subjected 10^6 times to recording and reproducing processes by a magnetic head of the amorphous lamination (multilayer) type through MFM modulation at 500 BPI, that is, a wavelength of 50 μm, and a pulse width was measured. Fig. 203(a) and Fig. 203(b) show the results of the measurement. Fig. 203(a) shows the results of the measurement of the pulse with up to 1 ms. Fig. 203(b) shows the enlarged measurement data of the pulse width up to 100 μs.

As denoted by the arrow 51a of Fig. 203(a), a burst error having a long period occurs with respect to 10^6 times. Thus, interleaving is done as shown in the error correcting portion 35 of Fig. 1 or Fig. 202. Specifically, as shown in Fig. 207, ECC encoding is done before and after the interleaving.

As shown in Fig. 203(b), the intervals of 1T, 1.5T, and 2T in MFM modulation are adequately large. Thus, it is thought that an error rate of about 10^{-5} to 10^{-6} occurs under bad conditions.

Burst errors more frequently occur in comparison with a disk in a cartridge such as a floppy disk. In addition, more random error occur by several orders. Accordingly, to use such a recording medium without any cartridge, interleaving and good correction are necessary. As the amount of error correction code increases, the degree of redundancy increases but the amount of data decreases. A

target value of burst error countermeasure is determined with reference to the allowable standard (reference) of scratch of a CD. The probability of the occurrence of a scratch on the optical recording surface is equal to that on the label surface. Fig. 204 shows the ability of error correction with respect to a scratch on the optical recording layer of a CD. In the case of correction of 4 symbols, it is possible to compensate for a scratch corresponding to 14 frames or less, that is, a scratch having a length of 2.38 mm or less. The interleaving length is set to correspond to 108 frames, that is, a length of 18.36 mm. Thus, with respect to the magnetic recording layer, it is necessary to provide error correcting ability containing interleaving which can compensate for a scratch having a length of 2.38 mm or less. Therefore, even if the magnetic recording portion of this recording medium is subjected to such a scratch, the resultant errors are corrected by the encoder 35 and the decoder 36 so that data errors do not occur. Thus, the user can handle the recording medium of this invention similarly to a CD or a CD ROM.

According to this invention, it was experimentally confirmed that a scratch of 7 mm at an outermost portion and a scratch of 3 mm at an innermost portion were compensated under conditions where the interleaving corresponded to a length of 18 mm or more and Reed-Solomon error correction was used, and the degree of redundancy corresponded to a factor of 1.2 in the range of upper and lower 10% as shown in Fig. 206. Thus, a scratch of 2.38 mm could be compensated under these conditions. The interleaving

length Ld on the data is defined as shown in Fig. 205, and a physical interleaving length LM on the medium surface is set to 18 mm or more. In addition, as shown in Fig. 206, the data amount of error correction code such as Reed-Solomon code is set equal to the original data amount multiplied by a value of 0.08 to 0.32. Thereby, it is possible to attain error correction against a scratch which is comparable with that in a CD.

Fig. 202 shows the details of the error correction encoder 35 and the error correction decoder 36. The magnetic record signal is ECC-encoded by a Reed-Solomon encoder 35a for executing an operation of Reed-Solomon encoding, and is then dispersed by an interleaving portion 35b as shown in Figs. 207(a) and 207(b) before being subjected to Reed-Solomon magnetic recording. With respect to the reproduced signal, in a de-interleaving portion 36b shown in Fig. 208, the data is mapped onto a RAM 36x and is then subjected to address conversion reverse to that of Fig. 207 so that the data is returned to the original arrangement (sequence).

Then, the reproduced data is processed by a Reed-Solomon decoder 36a of Fig. 209(b) as follows. As shown in Fig. 210, at a step 452b, P and Q parities and the data are inputted. At a step 452c, syndromes S1 and S2 are calculated. Only when S1=S2=0 at a step 452d, an advance to a step 452g is done so that the data is outputted. In the presence of an error, calculation for error correction is executed at a step 452e. Only when the error is corrected by a step 452f, the data is outputted at the step 452g. In this invention, the demodulation clock speed (rate) in the magnetic

recording and reproducing portion is equal to 30 Kbps (see Fig. 203) which is a data rate equal to 1/100 of the CD data rate. In view of this small data processing amount, error correction of the optical reproduced signal is done by an exclusive IC while the signal processing in the error correction encoder 35 and the error correction decoder 36 of Fig. 202 is executed by a microcomputer 10a in the system controller 10 through a time division technique. Specifically, the interleaving of Fig. 207 and the error correction in Fig. 210 are done by the microcomputer 10a. Thus, it is unnecessary to newly add an interleaving circuit and an error correcting circuit.

Fig. 211 shows an arrangement using a method in which error correction is performed both before and after an interleaving process. The arrangement of Fig. 211 is similar to the arrangements of Fig. 1 and Fig. 202 except for design changes indicated hereinafter.

In the arrangement of Fig. 211, magnetic record data is ECC-encoded by a Reed-Solomon C2 error correction encoder 35a in an error correcting portion 35, and a C2 parity 45 is added thereto. Then, the resultant data is processed by an interleaving portion 35b as follows. Specifically, as shown in Fig. 212(a), data in a transverse direction 51a is read out along a longitudinal direction 51b so that the data is outputted as shown in Fig. 212(b). For example, data segments A1 and A2 are dispersed and separated by a dispersion length L1. Subsequently, a Reed-Solomon C1 error correction encoder 35c subjects the data to error correction encoding in the

longitudinal direction, and a C1 parity is added thereto. The resultant data is magnetically recorded onto a recording medium.

In the arrangement of Fig. 211, during reproduction, data demodulated by an MFM demodulator 30d is subjected by a Reed-Solomon C1 error correcting portion to random error correction responsive to the C1 parity. Then, the data is mapped by the RAM 36x of the de-interleaving portion 36b in Fig. 208, being subjected to address conversion reverse to that of Fig. 212. Therefore, the data is re-arranged into the original data along the transverse direction before being outputted. In this way, a burst error is dispersed and made into random errors. The random errors are corrected by a Reed-Solomon C2 error correcting portion 36a of Fig. 212, and the error-free resultant data is recovered and outputted.

Since the arrangement of Fig. 212 executes the error correction at two stages, that is, before and after the interleaving, burst errors can be effectively compensated. Although the single-stage error correction in Fig. 202 suffices as shown by the experimental data, it is preferable to use such two-stage error correction in recording and reproducing very important data.

DESCRIPTION OF THE SECOND PREFERRED EMBODIMENT

Fig. 19 shows a recording and reproducing apparatus according to a second embodiment of this invention which is similar to the recording and reproducing apparatus of Fig. 1 except that a magnetic head 8a and a magnetic head circuit 31a are added thereto.

As shown in Fig. 20, a magnetic head 8 executes magnetic recording on an entire region of a magnetic recording layer 3, the magnetic recording having a long recording wavelength. This process is similar to the corresponding process in the first embodiment. Subsequently, the magnetic head 8a executes magnetic recording on a surface portion 3a, the magnetic recording having a short recording wavelength. Consequently, the surface portion 3a and a deep layer portion 3b are subjected to the magnetic recordings of independent sub and main channels having a shorter wavelength and a longer wavelength respectively. In the case where a magnetic recording layer subjected to two-layer recording as shown in Fig. 20 undergoes a reproducing process by use of a magnetic head for a long wavelength such as the magnetic head for modulating the magnetic field in the first embodiment, information can be reproduced from the main channel. Thus, provided that summary information is recorded on the main channel while detailed information is recorded on the sub channel, the summary information can be reproduced by the system of the first embodiment and thus there will be an advantage such that the compatibility can be ensured between the apparatus of the first embodiment and the apparatus of the second embodiment.

Fig. 21 shows a case where only a short-wavelength magnetic head 8 is provided. In this case, a signal of the sub channel, on which a signal of the main channel is superimposed, is reproduced so that information of both the main and sub channels can be reproduced. When the structure of Fig. 21 is applied to an

apparatus exclusively for reproduction, its cost can be low.

An upper part of Fig. 22 shows a case where recording is done by a magnetic head for modulating a magnetic field, that is, a magnetic head 8 for a long wavelength. As shown in the drawing, in the case where an N-pole portion is set "1" and a non-magnetized portion is set "0", recording is done as "0" in magnetization regions 120a and 120b and recording is done as "1" in a magnetization region 120c. Thus, a data sequence of "101" is obtained. As shown in a lower part of Fig. 22, in the case where an N-pole portion is set "1" and a non-magnetized portion is set "0" by using a short-wavelength magnetic head 8b for vertical, a data sequence of "10110110" is obtained. In this case, 8-bit information can be recorded on a region 120d equal in size to a region 120a in the upper part of the drawing. When the information is reproduced from the region 120d by the magnetic head 8, the reproduced information is decided to be "1" since there are only N-pole portions. This is the same as the region 120a. Thus, "1" in the data sequence 122a can be reproduced. In the case where an S-pole portion is defined as "0" and a non-magnetized portion is defined as "1" in a region 120e, 8-bit information, that is, a data sequence of "01001010", can be recorded. When this information is reproduced by the magnetic head 8, the reproduced information is decided to be "0" since there are only S-pole portions. This is one bit, and a signal equal in polarity to the signal on the region 120b is reproduced with a slightly-smaller amplitude. Thus, as shown in Fig. 22, the short-wavelength magnetic head 8b records and

reproduces the signal of the data sequence 122a of the main channel D1 and the signal of the data sequence 122 of the sub channel D2, while the magnetic head 8 for modulating the magnetic field reproduces the data sequence 122a of the main channel D1. Accordingly, there will be an advantage such that the compatibility can be ensured. The gap of the magnetic head 8 for modulating the magnetic field is preferably equal to 0.2 to 2 μm.

DESCRIPTION OF THE THIRD PREFERRED EMBODIMENT

Fig. 23 shows a recording portion of a third embodiment of this invention. In the third embodiment, a reflecting film 84 provided with pits as shown in Fig. 9 was formed on a transparent substrate 5 for a recording medium 2, and a magnetic recording film 3 was provided. This process is similar to the corresponding process in the first embodiment except that a film of Co-ferrite was formed by plasma CVD or others. This material has a transparency, and it has a high light transmissivity when its thickness is small.

As shown in Fig. 23, light emitted from an optical head 6 is focused into a spot 66 on the recording medium from the back side thereof. The optical head 6 has a lens 54 which is connected to a slider 41 by a connecting portion 150. The connecting portion 150 has a spring effect. The slider 41 is made of transparent material. A magnetic head 8 is embedded into the slider 41. Thus, the optical head 6 reads the pits in the reflecting film 84 from the back side, and thereby tracking and focusing are controlled. Thus, the slider 41 connected thereto is subjected to tracking control so that the optical head 6 can follow a given optical track. A positional

error between the lens 54 and the slider 41 is caused by only the spring effect of the connecting portion 150, and the slider 41 is controlled with an accuracy of a micron order. Upward and downward head movement is done together with the focusing control, and the movement is controlled with an accuracy of an order of several microns to several tens of microns.

Segments of information are sequentially recorded on the magnetic recording layer 3 by magnetic recording. In this embodiment, since optical tracking is enabled, there is a remarkable advantage such that a track pitch of several microns can be realized. Since the slider 41 and the magnetic head 8 are moved upward and downward according to the focusing control, a given track can be correctly followed by the magnetic head 8 even when the surface accuracy of the substrate 5 of the recording medium 2 is low. Thus, it is possible to use a substrate having a low surface accuracy. Accordingly, there is an advantage such that an inexpensive substrate, for example, a plastic substrate or a non-polished glass substrate, can be used which is much cheaper than a polished glass substrate.

Fig. 23 shows the case where the optical head 6 executes the information reproduction on the recording medium 2 from the back side thereof. The information reproduction can also be done on the recording medium 2 by a mechanism such as a conventional optical disk player from the upper side thereof, and thus there is an advantage such that the compatibility can be ensured. In addition, there is a notable advantage such that a memory capacity greater

than that in a conventional case by one or more orders can be realized by using the optical tracking.

DESCRIPTION OF THE FOURTH PREFERRED EMBODIMENT

Fig. 24 shows a recording and reproducing apparatus according to a fourth embodiment of this invention which is similar to the recording and reproducing apparatus of Fig. 1 except for design changes indicated hereinafter. In the first embodiment, the magnetic head 8 uses the magneto-optical recording head for modulating the magnetic field as it is, and the vertical recording is done as shown in Fig. 3. On the other hand, in the fourth embodiment, as shown in Fig. 25, a magnetic head 8 has the function of horizontal magnetic recording and also the function of magneto-optical recording magnetic-field modulation, and the magnetic head 8 is used to execute horizontal recording on a magnetic recording layer 3 of a recording medium 2.

An equivalent head gap of the magnetic-field modulating head in the first embodiment, for example, a head for an MD (a mini-disk), is generally 100 μm or greater, so that the recording wavelength λ is several hundreds of μm. In this case, a counter magnetic field is generated and thus a magnetism effectively used for actual recording is reduced, so that the level of a reproduced output is lowered. The first embodiment has a remarkable advantage such that a cost increase is prevented since a change of the structure is unnecessary, but the level of a reproduced output tends to be low.

In the case where a high level of a reproduced output is

required with respect to long-wavelength recording, horizontal recording is preferable. In order to realize the horizontal recording, the fourth embodiment is modified from the first embodiment in a manner such that the structure of a magnetic head is changed and a recording system is changed from vertical recording to horizontal recording.

As shown in Fig. 25, the magnetic head 8 of the fourth embodiment has a main magnetic pole 8a, a sub magnetic pole 8b, a head gap 8c, and a winding 40. The main magnetic pole 8a has the function of a magnetic head for modulating a magnetic field. The sub magnetic pole 8b serves to form a closed magnetic circuit. The head gap 8c has a gap length L. During horizontal recording, the magnetic head 8 is regarded as a ring head having a gap length L. The magnetic head 8 is designed so as to apply a uniform magnetic field to an optical recording layer 4 during the magneto-optical recording of the magnetic field modulation type.

In the case of a magnetic recording mode of operation which is shown in Fig. 25, light emitted from the optical head 6 is focused into a spot 66 on the optical recording layer 4, and the optical head 6 reads out track information or address information therefrom. The optical head 6 is subjected to tracking control so that a given optical track can be scanned. Thus, the magnetic head 8 connected to the optical head 6 travels on a given magnetic track. As shown in Fig. 25, while the recording medium 2 is moved in a direction 51, horizontal magnetic signals 61 are sequentially recorded in the magnetic recording layer 3 in accordance with an electric

information signal fed from a magnetic recording block 9. When the gap length is denoted by L and the recording wavelength is denoted by λ, there is a relation as $\lambda>2L$. Thus, as the gap length L is decreased, a recording capacity is greater. In the case where the gap length L is reduced, a region subjected to a uniform magnetic field is narrowed during the generation of a modulation magnetic field for the magneto-optical recording. Thus, in this case, the recordable region with respect to the light spot 66 provided by the optical head 6 is narrowed and it is necessary to increase the accuracy of the sizes of the recording medium and the tracking mechanism, and thus the cost tends to be increased.

In the case of the execution of the magneto-optical recording as shown in Fig. 26, a spot 66 of laser light from the optical head 6 heats the corresponding point of the optical recording layer 4 to a temperature equal to or higher than a Curie temperature thereof. The point of the optical recording layer 4 which is exposed to the light spot 66 is magnetized in accordance with a modulation magnetic field generated by the magnetic head 8, and segments of an information signal 52 are sequentially recorded on the optical recording layer 4. The positional relation between the optical head 6 and the magnetic head 8 is affected by the accuracy of the size of the tracking mechanism which includes a head base 19. In the case of an MD, to lower the cost, the standard of the size accuracy is lenient. Thus, when worst conditions are considered, there is a chance that the positional relation between the optical head 6 and the magnetic head 8 is greatly out of order. Accordingly, it is

preferable that the area of a region 8e exposed to a uniform magnetic field is as large as possible.

As shown in Fig. 26, the main magnetic pole portion 8a of the magnetic head 8 is formed with a tapered condensing section 8d, and thereby right-hand magnetic fluxes 85a and 85b are condensed so that a magnetic field is strengthened. Thus, the magnetic fluxes 85a and 85b are made equivalent to magnetic fluxes 85c, 85d, 85e, and 85f, and there is an advantage such that the region 8e exposed to a uniform magnetic field is enlarged. In this way, even when the relative position between the optical head 6 and the magnetic head 8 moves out of the correct position so that the relative position between the light spot 66 and the magnetic head 8 also moves out of the correct position, an optimal modulation magnetic field is applied to the optical recording layer 4 provided that the light spot 66 exists within the region 8e exposed to the uniform magnetic field. Accordingly, the magneto-optical recording is surely executed, and an error rate is prevented from being worse.

As shown in Fig. 31, magnetic fluxes of the magnetically recorded signal 61 on the magnetic recording layer 3 are formed as magnetic fluxes 86a, 86b, 86c, and 86d. During the magneto-optical recording, the portion of the magneto-optical recording material which is heated by the light spot 66 to a temperature equal to or higher than the Curie temperature thereof is subjected to the magnetic field of the magnetic flux 86a by the magnetically recorded signal 61 and also the modulation magnetic field from the magnetic head 8. When the magnetic field of the magnetic flux 86a

is stronger than the modulation magnetic field from the magnetic head 8, the magneto-optical recording responsive to the modulation magnetic field can not be correctly done. Thus, it is necessary to limit the magnitude of the magnetic flux 86a to a given level or less. Accordingly, an interference layer 81 having a thickness d is provided between the magnetic recording layer 3 and the optical recording layer 4 to reduce the adverse influence of the magnetic flux 86a. When the shortest recording wavelength is denoted by λ, the strength of the magnetic flux 66 at the optical recording layer 4 is attenuated by about $54.6 \times d/\lambda$. In the case of a recording medium, it can be thought that various recording wavelengths λ are used. It is general that the shortest recording wavelength is equal to 0. 5 μm. In this case, when the thickness d is 0.5 μm, attenuation of about 60 dB is obtained so that the adverse influence of the magnetically recorded signal 61 hardly occurs.

As previously described, by using an interference film of a thickness of 0.5 μm or greater between the magnetic recording layer 3 and the optical recording layer 4, there is provided an advantage such that the magnetically recorded signal hardly affects the magneto-optical recording. The interference film is preferably made of non-magnetic material or magnetic material having a weak coercive force.

In the case where the magneto-optical recording and the magnetic recording are done by using a magneto-optical recording medium, a modulation magnetic field is prevented from injuring a recorded magnetic signal provided that the modulation magnetic

field for the magneto-optical recording is sufficiently weaker than the coercive force of magnetic material for a magnetic recording layer. When a ring-type head is used as in the previously-mentioned case, a strong magnetic field occurs in a head gap portion. Thus, even if the modulation magnetic field is weak, there is a chance that the modulation magnetic field adversely affects a recorded magnetic signal and thus an error rate is increased. This problem is resolved as follows. In the case of recording on a magneto-optical recording medium, as shown in Fig. 27, before the optical head 6 records a main information signal on the optical recording layer, an information signal magnetically recorded on a magnetic track 67g at the opposite side of an optical track 65g to be scanned is transferred to the memory 34 in the recording and reproducing apparatus or written on the optical recording layer to be saved. The saving prevents a problem even when recorded data in the magnetic recording layer are damaged by the modulation magnetic field during the magneto-optical recording.

A system controller 10 operates in accordance with a program stored in an internal ROM. Fig. 28 is a flowchart of this program. The program of Fig. 28 is divided into six large blocks. A decision block 201 decides the character of a disk. In the case of a ROM disk, an exclusive-reproduction block 204 is used. In the case of reproduction on an optical RAM disk, a reproduction block 202 is executed and sometimes a reproduction/transfer block 203 is executed. In the case of recording on an optical RAM disk, a recording block 205 is used and sometimes a recording/transfer

block 206 is used. In the presence of a free time, only transfer is executed by a transfer block 207.

The program of Fig. 28 will now be described in more detail. In the decision block 201, a step 220 places a recording medium 2, that is, a disk, into a correct position or an operable position. A step 221 decides the type of the disk by detecting a click on a disk cassette such as shown in Fig. 16. There are various disk types such as a ROM, a RAM, an magneto-optical recording medium, an optical recording prevention disk, and a magnetic recording prevention disk. A subsequent step 222 moves the optical head 6 to a position aligned with an inner most optical track 65a and an innermost magnetic track 67a. A step 223 reads out magnetic information data and optical information data from a TOC region of the recording medium. In the case of a music disk, data is inputted which represents a music number at the end of previous operation. In the case of a game disk, data is inputted which represents a stage number at the previous end of the game. As shown in Fig. 16, when the user desires continuation in response to the inputted data, conditions at the end of previous operation are retrieved. A step 224 reads out an un-transfer flag from the magnetic TOC region. The un-transfer flag being "1" represents that magnetic data which is not transferred to an optical data section remains. The un-transfer flag being "0" represents it does not remain. A step 225 decides whether the disk is a magneto-optical disk or a ROM disk. When the disk is a ROM disk, an advance toward a step 238 is done. When the disk is a magneto-optical disk, an advance toward a step

226 is done. When the step 238 detects the presence of a reproducing instruction, a step 239 reproduces an optically recorded signal and a magnetically recorded signal. When the operation ends at a step 240, a step 241 writes information into the TOC region of the magnetic track. The written information represents various changes occurring during the reproduction, for example, changes in the music reproduction order, and the music number at the end of the operation. After writing the information is completed, a step 242 ejects the disk.

As previously described, when the disk is a magneto-optical disk, an advance toward a step 226 is done. In the presence of a reproducing instruction, an advance to a step 227 is done. Otherwise, an advance to a step 243 is done. The step 227 executes reproducing a main recorded signal on an optical recording surface at a speed higher than a normal reproduction speed, and sequentially stores the reproduced information into a memory. In the case of a music signal, an amount of data which corresponds to several seconds can be stored. Thus, even if the reproduction is interrupted, reproduced music can be continued. When a step 228 detects that the memory is completely filled with the reproduced information, a step 229 is executed. When the step 229 decides that an un-transfer flag is "1", the reproduction of the main recorded signal is interrupted and an advance to a step 230 in the reproduction/transfer block 203 is done. A check is made as to whether or not all of a sub recorded signal on a magnetic recording surface has been reproduced. When the result of the check is Yes,

an advance to a step 234 is done. Otherwise, an advance to a step 231 is done, and the sub recorded signal on the magnetic recording surface is reproduced and the reproduced information is stored into the memory. A step 232 checks whether or not outputting the stored main recorded signal such as the music signal is still possible. When the result of the check is No, a return to the step 227 is done and reproducing and storing the main recorded information are executed. In the case where the result of the check is Yes, at the moment at which the sub recorded signal reaches a preset memory amount in a step 233, the step 234 again checks whether or not storing and reproducing the main recorded signal can be done. When the result of the check is Yes, a step 235 transfers and writes the sub recorded signal from the memory into a transfer region on the optical recording surface. Then, a step 236 checks whether or not transferring all the data is completed. When the result of the check is No, a return to the step 230 is done and the transfer is continued. When the result of the check is Yes, a step 237 changes the un-transfer flag from "1" to "0" and then a return to the step 226 is done.

In the case of recording on the optical recording layer, an advance to a step 243 in the recording block 205 is done, and a check is given with respect to a recording instruction. When the result of the check is Yes, a step 244 executes storing the main recorded signal into the memory and the optical recording is not executed. A step 245 checks whether or not the memory has a free area. When the result of the check is No, a step 245a executes the

optical recording of the main recorded signal and a return to the step 243 is done. When the result of the check is Yes, an advance to a step 246 is done. When the un-transfer flag is not "1", a return to the step 243 is done. Otherwise, an advance to a step 247 in the recording/transfer block 206. The step 247 stores the main recorded signal into the memory and simultaneously reproduces a sub recorded signal on a magnetic track 67g at the opposite side of an optical track 65g of Fig. 27 which is planned to be subjected to the optical recording at this time. In addition, the step 247 stores the reproduced sub recorded signal into the memory. A step 248 checks whether or not the memory has a free area. When the result of the check is Yes, a step 248a transfers and writes the sub recorded signal into the optical recording layer. When the result of the check is No, a return to the step 245a is done and the optical recording is executed. A step 249 checks whether or not transferring all the data has been completed. When the result of the check is Yes, a step 250 changes the un-transfer flag from "1" to "0" and then a return to the step 243 is done. Otherwise, nothing is done and a return to the step 243 is done.

The step 243 checks whether or not a recording instruction is present. When the result of the check is No, an advance to a step 251 in the transfer block 207 is done. Here, recording and also reproducing the main recorded signal are unnecessary, and thus only the transfer of a sub recorded signal from a magnetic data surface to an optical data surface is executed. The step 251 executes reproducing the sub recorded information and storing the

reproduced sub recorded information into the memory. A step 252 executes the transfer of the sub recorded signal from the memory to the optical recording layer. A step 253 checks whether or not transferring all the data has been completed. When the result of the check is No, a return to the step 251 is done so that the transfer is continued. Otherwise, a step 254 changes the un-transfer flag from "1" to "0", and then a step 255 checks whether or not all the operation has been ended. When the result of the check is No, a return to the first step 226 is done. Otherwise, an advance to a step 256 is done, and the information which has been changed by this work and other information such as information representing that the un-transfer flag is "0" are magnetically recorded on the TOC region of a magnetic track. Then, a step 257 ejects the disk, and the work regarding this disk is ended.

It should be noted that the step 256 may again write all the sub recorded signal into the magnetic recording layer from the memory to return the magnetic recording layer to the conditions which occur before the execution of the optical recording.

As previously described, only the data in the magnetic track among the data on the magnetic recording surface, which might be damaged by a modulation magnetic field during the optical recording, is transferred and saved into the memory or the optical recording surface. Thus, there is an advantage such that a damage to the data on the magnetic recording surface can be substantially prevented.

Optical recording may be done by recording saved data on a

magnetic track again and retrieving the saved data after the work of optical recording. In this case, there is an advantage such that data on a magnetic recording surface is retrieved upon the ejection of a disk.

The design of Fig. 28 uses a method where data on a magnetic recording surface, which might be damaged, is transferred to an optical recording surface before magneto-optical recording is done. On the other hand, a design of Fig. 29 uses a method where data transfer to an optical recording surface is not executed. A decision block 201, a reproduction block 202, and an exclusive reproduction block 204 of Fig. 29 are similar to those of Fig. 28, and a description thereof will be omitted. Since the data transfer is not executed, it is unnecessary to provide a reproduction/transfer block 203, a recording/transfer block 206, and a transfer block 207. A recording block 205 of Fig. 29 differs from that of Fig. 28, and a detailed description thereof will be given hereinafter.

A step 226 in the reproduction block 202 checks whether or not a reproducing instruction is present. When the result of the check is No, an advance to a step 264 is done. Otherwise, an advance to a step 260 is done. The step 260 manages a processed optical track in unit of a magnetic track, and a calculation is given of a magnetic track at the opposite side of an optical track which may be damaged by magneto-optical recording. In addition, a check is made as to whether or not the present track is the same as the track subjected to previous saving. When the result of the check is Yes, a step 263 executes magneto-optical recording on the optical

track. Otherwise, a step 261 writes the saved data into the previous magnetic track, and thereby the data on the previous magnetic track can be fully retrieved. Next, a step 262 reads out data from the magnetic track which may be damaged at this time, and saves the readout data into the memory. Then, a step 263 executes recording on the optical track, and a return to a step 243 is done. When the result of a check by the step 243 is No, a step 261a retrieves the previous conditions of the magnetic track. Thereafter, a step 264 in an end block 206A checks whether or not the operation is ended. When the result of the check is No, a return to the step 226 is done. Otherwise, a step 265 executes magnetically recording information which has been changed during the interval from the placement of the disk to the end, for example, information of the ending music number. Then, a step 266 ejects the disk. In this way, the work is ended. When a next disk is placed into an apparatus, the work is started again at the step 220.

In the design of Fig. 28, all the magnetic data is transferred to the optical recording layer to cope with a damage to the magnetic data by the magneto-optical recording. On the other hand, in the design of Fig. 29, magnetic data is managed in unit of a magnetic track, and reading is given on only magnetic data from a magnetic track which may be damaged by the magneto-optical recording. The readout data is stored into the memory. When the magnetic track is damaged by the magneto-optical recording and optical recording on another magnetic track is done, the former magnetic track is completely retrieved. Thereby, a memory capacity which

corresponds to one magnetic track to three magnetic tracks suffices, and the capacity of the memory can be relatively small. As made clear from Fig. 29, the design of this drawing has an advantage such that a simple process can protect magnetic data from being damaged by the magneto-optical recording.

As shown in Fig. 30(a) and Fig. 30(b), a reproducing process can be given on a magneto-optical disk and a CD by using a same mechanism. In the case of a CD, since a protective cartridge is absent, the CD tends to be affected by an external magnetic field. By setting a magnetic coercive force in a magnetic recording layer 3 of a CD to 1,000 to 3,000 Oe and thus making it much stronger than that in a magnetic recording layer of a magneto-optical recording medium, there is provided an advantage such that magnetic data can be prevented from being damaged by an external magnetic field. In the case of a magneto-optical disk, if a magnetic coercive force is increased to a level near the magnitude of a modulation magnetic field, the magnetic coercive force can provide an adverse influence. Thus, the magnetic coercive force is set to 1,000 Oe or less.

DESCRIPTION OF THE FIFTH PREFERRED EMBODIMENT

Fig. 32 shows a recording and reproducing apparatus according to a fifth embodiment of this invention which is similar in basic operation to the apparatus of Fig. 1 and Fig. 24 related to the first embodiment and the fourth embodiment. The fifth embodiment differs from the first embodiment in the following points.

As shown in Fig. 33, the fifth embodiment includes two

windings, that is, a magnetic-field modulating winding 40a and a magnetically recording winding 40b. With reference to Fig. 32, during the magnetic recording or reproduction, a magnetic head circuit 31 feeds or receives a current to or from the magnetic recording winding 40b to execute the magnetic recording or reproduction.

During the execution of the magneto-optically recording of the magnetic-field modulation type, a magnetic-field modulating circuit 37a in an optical recording circuit 37 feeds a modulation signal to the magnetic-field modulating winding 40a to realize the magneto-optical recording.

With reference to Fig. 33, a description will now be given of operation of the recording and reproducing apparatus which occurs during the magnetic recording and reproduction. A recording current fed from the magnetic head circuit 31 flows in a direction denoted by the arrow in the drawing. Thus, a magnetic closed circuit of magnetic fluxes 86c, 86a, and 86b is formed, and time segments of an information signal 61 are sequentially recorded on a magnetic recording layer 3. The magnetic recording is done in a horizontal direction. In this case, no current is basically fed to the magnetic-field modulating winding 40a. In this structure, a closed magnetic circuit including a gap 8c is formed, and optimal designing of a reproduction sensitivity is enabled.

With reference to Fig. 34, a description will now be given of operation of the recording and reproducing apparatus which occurs during the magneto-optical recording. The magnetic-field

modulating winding 40a is wound on a main magnetic pole 8a and a sub magnetic pole 8b of a yoke in equal directions. Thus, when a modulating current flows from the magnetic-field modulating circuit 37a in a direction 51a, downward magnetic fluxes 85a, 85b, 85c, and 85d occur. Magneto-optically recording material in a point of an optical recording layer 4, which is exposed to a light spot 66 and which is heated to a Curie temperature thereof or higher, undergoes magnetization inversion in response to the magnetic field so that an information signal 52 is recorded. In this case, the strength of the magnetic field at the light spot 66 is generally set to 50-150 Oe in a region 8e exposed to a uniform magnetic field. As shown in Fig. 25, it is preferable to provide an interference layer 81 to prevent the magneto-optical recording material from being subjected to magnetization inversion in response to an information signal 61. It is good to set the thickness d of the interference layer 81 as $\lambda > d$.

The structure of Fig. 34 has an advantage such that the region 8e exposed to the uniform magnetic field can be wide. In addition, since recording heads can be independently designed with respect to the two windings, there is provided an advantage such that optimal magnetic-field modulating characteristics, optimal magnetic recording characteristics, and optimal magnetic reproducing characteristics can be attained. Since the head gap 8c of Fig. 33 can be small, it is possible to shorten the wavelength which occurs during the magnetic recording. Since optimal designing of the formation of a closed magnetic field is enabled, the reproduction sensitivity can be enhanced. As shown in Fig. 34, during the

magnetic-field modulation, the magnetic flux 85a of the main magnetic pole 8a and the magnetic flux 85d of the sub magnetic pole 8b extend in the equal directions, so that a strong magnetic field does not occur in the gap 8c but only a weak magnetic field corresponding to the modulation magnetic field occurs. Since a magnetic coercive force in the magnetic recording layer 3 is 800-1,500 Oe and is adequately stronger than the modulation magnetic field and since there is an easily magnetized axis in a horizontal direction, there is provided an advantage such that a magnetically recorded signal 61 is prevented from being damaged by the modulation magnetic field. Thus, by setting the magnetic coercive force Hc of the magnetic recording layer 3 stronger than the recording magnetic field Hmax applied to the magneto-optical recording material, a damage to the data is prevented. In the case of the provision of an allowance corresponding to double, it is good to maintain a relation as $Hc<2Hmax$. In addition, it is good to fabricate a recording medium 2 shown in Fig. 8. As shown in Fig. 35, in a magnetic head 8, windings 40a and 40b may be separately wound on a main magnetic pole 8a and a sub magnetic pole 8b respectively. In this case, during the magnetic-field modulation, a modulating current is also driven through the magnetic recording winding 40b in a direction 51b by using a magnetic head circuit 31, and thereby a magnetic flux 85d occurs which extends in a direction equal to the directions of the magnetic fluxes 85c, 85b, and 85a. Thus, it is possible to obtain an advantage similar to the advantage of the design of Fig. 34.

As shown in Fig. 36, a tap 40c may be provided to a single winding to form two divided sub windings having three terminals. During the magnetic recording, the tap 40c and a tap 40e are used. During the magneto-optical recording, as shown in Fig. 37, a tap 40d and a tap 40e are used to generate a modulating magnetic field for the magneto-optical recording. In this way, three taps enable the formation of a magnetic head, and thus there is an advantage such that wiring is simple.

DESCRIPTION OF THE SIXTH PREFERRED EMBODIMENT

Fig. 38 shows a recording and reproducing apparatus according to a sixth embodiment of this invention which is similar in basic operation to the apparatus of Fig. 1, Fig. 24, and Fig. 32 related to the first embodiment, the fourth embodiment, and the fifth embodiment. The sixth embodiment differs from the fifth embodiment in the following points.

As shown in Fig. 38, a magnetic head 8 is formed with two gaps 8c and 8e. In addition, two windings 40b and 40f are connected to a magnetic head circuit 31, and one is used for recording and the other is used for erasing. Thus, erasing and recording can be done by a single head.

As shown in Fig. 39, the magnetic head 8 includes a first sub magnetic pole 8b and a second sub magnetic pole 8d. Before the magnetic recording is done by a magnetically recording winding 40b as described with reference to Fig. 33, the magnetic head circuit 31 feeds an erasing current via the second sub magnetic pole 8d. Thus, before the recording, erasing magnetization from a

magnetic recording layer 3 can be done by the gap 8e. Therefore, ideal magnetic recording can be done by using the gap 8c, and there is provided an advantage such that C/N and S/N are enhanced while an error rate is reduced.

As shown in Fig. 41, guard bands 67f and 67g are provided along opposite sides of a recording track 67. First, the gap 8e of the second sub magnetic pole 8d executes an erasing process with a width of an erased region 210. As a result, an entire region of the recording track 67 and portions of the guard bands 67f and 67g are subjected to the erasing process. Thus, even if the magnetic head 8 has an tracking error, the gap 8c will not move out of the erased region 210 and the gap 8c can execute good recording.

As shown in Fig. 42, an erasing gap may be divided into two gaps 8e and 8h. In this case, a recording medium 2 is driven in a direction 51, and the magnetic recording is done by a gap 8c having a width greater than the width of a recording track 67 so that recording on portions of guard bands 67f and 67g is executed in an overlapped manner. Magnetization is erased from the overlapped portions by two erased regions 210a and 210b. Therefore, guard bands 67f and 67g are fully maintained. As a result, there is an advantage such that crosstalk between recording tracks is reduced and an error rate is lowered.

With reference to Fig. 40, a description will now be given of the case where magnetic-field modulation for magneto-optical recording is done by using the magnetic head 8. The magnetic-field modulating winding 40a is wound on the main magnetic pole 8a, the

first sub magnetic pole 8b, and the second sub magnetic pole 8d so that magnetic fluxes 85a, 85b, 85c, 85d, and 85e uniformly occur in the respective magnetic poles. Thus, there is an advantage such that a wide region 8e exposed to a uniform magnetic field can be provided. In addition, even if an accuracy of track positions is low, a light spot 66 can be prevented from being out of an optical recording track 65.

Fig. 43 shows a magnetic head 8 having a modified winding. As shown in the drawing, a magnetic-field modulating winding 40d is extended and is used in common to a magnetic recording winding, and a central tap 40c is provided. Magnetic recording can be executed by using the tap 40c and a tap 40e. As shown in Fig. 44, currents are driven into the tap 40d and the tap 40e in directions 51a and 51b respectively while a current is driven into a tap 40f in a direction 51c, and thereby magnetic fluxes 85a, 85b, 85c, 85d, and 85e in equal directions occur so that a uniform modulation magnetic field results. In this case, there is an advantage such that the number of taps is reduced by one and the structure is simplified.

As previously described, according to the sixth embodiment, a single head can be used as an erasing head, a magnetic recording head, and a magnetic-field modulating head for the magneto-optical recording.

DESCRIPTION OF THE SEVENTH PREFERRED EMBODIMENT

A seventh embodiment of this invention relates to a disk cassette containing a recording medium. With reference to Fig.

45(a), a disk cassette 42 has a movable shutter 301 which can cover an opening 302 for a head and holes 303a, 303b, and 303c for a liner. As shown in Fig. 45(b), the shutter 301 is opened to unblock the opening 302 and also the holes 303a, 303b, and 303c in accordance with the insertion of the disk cassette 42 into a body of a recording and reproducing apparatus.

As shown in Fig. 46, a single rectangular opening 303 for a liner may be provided.

As shown in Fig. 47 and Fig. 48, an opening for a liner may be provided in a direction opposite to an opening 302 for a head. In this case, as shown in Figs. 49(a), 49(b), and 49(c), a liner 304 except a movable portion 305a is fixed to a disk cassette 42 by a liner support portion 305 and liner support fixing portions 306a, 306b, 306c, and 306d. The liner support portion 305 is made of a leaf spring or a plastic sheet. As shown in Fig. 49(c), a cassette half is formed with a groove 307 for a liner. The liner movable portion 305a is accommodated in the groove 307, and is held by an auxiliary liner support portion 305b. The liner 304 is held in a flat state by the return spring force of the liner support portion 305 as long as an external force is not applied thereto. The liner 304 being in this state separates from a recording layer at a surface of a recording medium 2. Thus, it is possible to prevent wear of the recording layer 3.

When an external force is applied in a direction toward the interior of the disk cassette 42 by a liner pin 310 through the opening 303, the liner support portion 305 and the liner 304 are

pressed against the surface of the recording medium 2.

Another disk cassette will now be described. As shown in Figs. 50(a), 50(b), and 50(c), a leaf spring of a liner support portion 305 is previously deformed toward the upper surface of a disk cassette 42. Thereby, as shown in Fig. 50(d), when the liner support portion 305 is fixed to the disk cassette 42, the liner support portion 305 continuously abuts against an upper cassette half 42a. Thus, as long as the liner support portion 305 is not depressed by a liner pin 310, a liner 304 and a recording medium 2 remain out of contact with each other. According to this design, it is possible to omit the auxiliary liner support portion 305b.

A description will now be given of a way of moving the liner and the disk into and out of contact with each other by operating the liner pin 310. Fig. 51 shows conditions where the liner pin 310 is raised along a direction 51a in a liner pin guide 311, and thus the liner 304 and the recording layer 3 of the recording medium 2 are out of contact with each other. Therefore, the recording medium 2 receives a weak frictional force and can be rotated by a weak drive force.

As shown in Fig. 52, when the liner pin 310 is moved downward by an external force in a direction 51a, the liner 304 is pressed against the magnetic recording layer 3 of the recording medium 2 via the liner support portion 305. As the recording medium 2 is moved or rotated in a direction 51, dust is removed from the surface of the magnetic recording layer 3 by the liner 304. The liner 304 is made of, for example, cloth. Thus, in the case

where the magnetic recording, the magnetic reproduction, or the magnetic-field modulation for the magneto-optical recording is executed by a recording head 8 in the head opening 301 of Fig. 46, there is provided an advantage such that an error rate is remarkably reduced. The material of the liner 304 may be the same as the material of a liner for a conventional floppy disk. As shown in Fig. 45(a), the liner pin 310 is located above the portion of the magnetic recording layer 3 which precedes the magnetic head 8 with respect to the rotation of the recording medium 2 in the direction 51, and thus there is an advantage such that the cleaning effect is enhanced.

In the case where the liner control method of this invention is applied to a disk cassette 42 for a contact-type magneto-optical recording medium having no magnetic recording layer 3, dust is removed and thus there is provided an advantage such that an error rate is improved during the magneto-optical recording.

As shown in Fig. 53(b), the control of the liner pin 310 is designed so that the liner pin 310 can be moved together with the magnetic head 8. When the magnetic head 8 falls into a contact state, the liner 304 is surely moved into contact with the recording medium 2. Thus, a single actuator can be used in common. In the case where the magnetic head 8 separates from the contact state, the line pin 310 is generally raised to move the liner 304 out of contact with the recording medium 2. As shown in Figs. 53(a) and 53(b), in the case where the liner pin 310 and the magnetic head 8 are moved together, the liner 304 and the recording medium 2 can be out of contact with each other when the identification hole for

the magnetic recording layer is absent from the cassette 42. Thus, the liner 304 less wears the surface of the magnetic recording layer 3. In addition, the frictional force on the recording medium 2 is reduced, and thus there is an advantage such that a weaker rotational torque of a drive motor suffices and the rate of consumption of electric power is decreased. When a recording medium 2 which does not have any magnetic recording layer is inserted into the apparatus, the magnetic head 8 and the recording medium 2 remain out of contact with each other so that a damage to the two can be prevented as shown in Fig. 75.

In the case where the disk cassette 42 of this invention is placed into a conventional recording and reproducing apparatus, the liner 304 does not contact the recording medium 2 as shown in Fig. 54(b) since the conventional apparatus does not have the liner pin 310 and the related elevating function as shown in Figs. 54(a) and 54(b). Thus, the recording medium 2 can be stably rotated by the conventional apparatus which generally provides a weak disk drive torque. Accordingly, there is an advantage such that the compatibility between the disk cassette 42 of this invention and conventional disk cassettes can be maintained.

In the case where a conventional disk cassette 42 which does not have the liner 304 and the opening 303 is placed into the recording and reproducing apparatus of this invention, the liner pin 310 is not inserted since the opening 303 is absent as shown in Figs. 55(a) and 55(b). Thus, the liner pin 310 does not contact the recording medium 2 and the liner 304, and there occurs no

problem. Accordingly, there is an advantage such that the compatibility between the disk cassette 42 of this invention and conventional disk cassettes can be maintained. In this case, lubricant on the conventional recording medium is liable to adhere to the contact surface of the magnetic head 8 so that the error rate tends to be increased. To remove this problem, a cleaning track 67x is set as shown in Fig. 56. In the case where the conventional recording medium 2 is placed into and ejected from the recording and reproducing apparatus of this invention and then the recording medium 2 of this invention is inserted thereinto, the magnetic head 8 is forced to travel on the cleaning track 67x at least once. Thereby, the lubricant is transferred from the magnetic head 8 to the cleaning track 67x. Then, the lubricant is removed from the cleaning track 67x by the liner 304 which contacts the recording medium 2. In this way, the lubricant or dust is removed from the contact surface of the magnetic head 8. Thus, there is an advantage such that the error rate is small and reliable recording and reproduction are enabled.

The liner pin 310 can be moved between an OFF position and an ON position as shown in Figs. 57(a) and 57(b). The mechanism for elevating the liner 304 has a structure such as shown in Fig. 58 and Fig. 59.

A modified liner pin 310 will now be described. As shown in Fig. 60 and Fig. 61, a liner pin 310 is of a leaf spring type. As shown in Fig. 62 and Fig. 63, the liner pin 310 can be moved between an OFF position and an ON position. The liner pin 310 is driven in

directions 51 and 51a by an elevating motor 21 via a pin drive lever 312, being moved between the ON position and the OFF position.

In the case of use of a single rectangular opening 303, a liner pin 310 can be moved between an OFF position and an ON position as shown in Fig. 64 and Fig. 65. In this case, the area of contact between the liner pin and the liner attachment portion is large, and thus there is an advantage such that dust can be surely removed.

According to a liner pin shown in Fig. 66 and Fig. 67, a liner guide 311 is provided with a protective portion 314. As shown in Fig. 66, a disk cassette 42 of this invention has a recognition hole 313. In the case where the disk cassette 42 of this invention is inserted into a recording and reproducing apparatus, the liner pin 310 is placed in an opening 303. In the case where a conventional disk cassette 42 which does not have a recognition hole 313 is inserted into the recording and reproducing apparatus, the protective portion 314 contacts an outer shell of the disk cassette 42 so that the liner pin 310 remains out of contact with the outer shell of the disk cassette 42. Thus, there is an advantage such that the liner pin 310 can be prevented from becoming dirty or being damaged.

DESCRIPTION OF THE EIGHTH PREFERRED EMBODIMENT

An eighth embodiment of this invention relates to a mechanism for elevating a liner pin to move a liner.

As shown in Figs. 68(a) and 68(b), an upper surface of a disk cassette has no opening for a liner. A back side of the disk cassette has recognition holes 313a, 313b, and 313c, and an opening 303 for

a liner. The opening 303 extends near the recognition holes 313a, 313b, and 313c. A liner pin is inserted into the disk cassette through the opening 303 from the back side, and thereby a liner is moved vertically.

Fig. 69(a) shows conditions where a liner pin 310 is in an OFF position so that a liner 304 separates from a recording medium 2. As shown in Fig. 69(b), when a liner pin 310 is inserted into the opening 303, a liner drive member 316 is deformed by the liner pin 310 toward a right-hand side and is thus rotated counterclockwise about a pin shaft 315. Thereby, a liner support portion 305 is forced downward by the liner drive member 316 so that the liner 304 is brought into contact with the recording medium 2. As the recording medium 2 rotates, the liner 304 removes dust from the recording medium 2. The liner drive member 316 is made of a leaf spring.

The liner has a structure such as shown in Figs. 70(a), 70(b), and 70(c). The liner structure is basically similar to the liner structure previously described with reference to Fig. 49 except for the following design changes. An edge of the liner drive member 316 is provided with a movable portion 305a. In addition, as shown in Fig. 70(c), a groove 30a is added for accommodating the liner drive member 316.

The drive mechanism for the liner 310 will be further described. The liner pin 310 and a motor 17 are in a positional relation such as shown in Fig. 71. As shown in Fig. 72(a), in the case where a disk cassette 42 of this invention is inserted into a

recording and reproducing apparatus in a direction 51, the liner 304 is moved vertically together therewith even if an actuator for the liner pin 310 is not provided. As shown in Fig. 72(b), in the case where a conventional disk cassette 42 having no opening 303 is inserted into the recording and reproducing apparatus, the liner pin 310 is automatically moved downward against the force of a spring 317 since the opening 303 is absent. Thus, there is an advantage such that the conventional disk cassette 42 is prevented from being damaged by the liner pin 310. In the case of use in an apparatus such as a game machine where the frequency of access to a disk is very low, the structure of the apparatus can be simplified since it is unnecessary to provide an actuator for the liner pin 310.

As shown in Figs. 73(a) and 73(b), an elevating motor 21 for a magnetic head 8 may be used also to drive a liner pin 310 via an elevator 20 and a connecting portion 318. In this design, when the magnetic head 8 contacts a recording medium 2, a liner 304 always contacts the recording medium 2. Thus, there is an advantage such that a single actuator can be used in common for the magnetic head 8 and the liner pin 310.

Figs. 74(a) and 74(b) show another disk cassette 42 which is basically similar to the disk cassette of Fig. 69 except that a liner drive member 316 is extended and a pin shutter 319 is added. Thus, as shown in Fig. 74(a), the pin shutter 319 is closed when a liner pin 310 assumes an OFF state, and thus there is an advantage such that external dust is prevented from entering the disk cassette 42. According to this design, since the part near a recognition hole

in the disk cassette is used, the addition of only one small hole through a conventional disk cassette suffices. Thus, there is an advantage such that the degree of the compatibility between the disk cassette of this invention and the conventional disk cassette can be enhanced. The structure of Fig. 69 has an advantage such that an occupied space in a horizontal direction can be small. Therefore, as shown in Fig. 68, even in the case where only a small usable space is present, an opening 303a for the liner can be provided. Thus, the degree of freedom in designing of a disk cassette is enhanced.

DESCRIPTION OF THE NINTH PREFERRED EMBODIMENT

Fig. 75 shows a disk cassette according to a ninth embodiment of this invention. A liner 304 and a liner attachment portion 305a are approximately similar in structure to those in Fig. 49. In this embodiment, as shown in Fig. 76 and Fig. 77, the liner attachment portion 305 has a movable section 305a provided with a liner elevator 305c. As the liner elevator 305c is depressed by a liner drive portion 316, the liner 304 is moved vertically. In the case where a liner pin 310 assumes an OFF state, a pin shutter 319 is pressed against a cassette lower wall by a spring 317 so that external dust is prevented from entering the disk cassette. The liner support portion 305 and the movable section 305a are pressed against a cassette upper wall by a leaf spring effect and an auxiliary liner support portion 305b. Thus, in this case, the liner 304 remains out of contact with a recording medium 2.

As shown in Fig. 77, when the liner pin 310 assumes an ON

state, the pin shutter 319 forces the liner drive portion 316 to rotate clockwise about a pin shaft 316 so that the liner drive portion 316 depresses the liner elevator 305c. Therefore, the movable section 305a of the liner attachment portion 305 is lowered so that the liner 304 is brought into contact with the recording medium 2. As the recording medium 2 rotates in a direction 51, the liner 304 removes dust from the surface of the recording medium 2. Thus, there is an advantage such that an error rate can be reduced. In addition, the ninth embodiment has an advantage such that the structure thereof is relatively simple and the upward and downward movement of the liner 304 can be surely executed. Since it is unnecessary to provide a groove in the disk cassette 42, there is an advantage such that the durability of the disk cassette 42 can be high.

In the case where this embodiment is applied to the design of Fig. 68(a), the liner elevating mechanism has a structure such as shown in Figs. 78(a) and 78(b). The operation of the structure of Figs. 78(a) and 78(b) is similar to the operation of the structure of Figs. 76 and 77. As shown in Fig. 78(a), when a liner pin 310 is in an OFF position, an opening for a liner is closed by a pin shutter 319. As shown in Fig. 78(b), when the liner pin 310 assumes an ON position, a liner drive portion 316 is rotated counterclockwise and depresses a liner elevator 305c. Thus, a liner attachment portion 305a and a liner 304 are lowered so that the liner 304 is brought into contact with a recording medium 2. This design has an advantage over the design of Fig. 76 such that the liner elevating

mechanism occupies a smaller space.

In a design where a liner and a recording medium separate from each other when a liner pin 310 is inserted into a disk cassette 42, there is an advantage such that the liner contacts the recording medium and prevents the recording medium from being rotated and damaged during unuse conditions of the disk cassette 42.

DESCRIPTION OF THE TENTH PREFERRED EMBODIMENT

A recording and reproducing apparatus according to a tenth embodiment of this invention is similar to the recording and reproducing apparatus of Fig. 38 except for design changes indicated later.

First, tracking will be described. As shown in Fig. 79, under ideal conditions, a magnetic head 8 vertically aligns with an optical head 6. Thus, when the optical head accesses an optical track 65 of a given address, the magnetic head 8 accesses a corresponding magnetic track 67 at the opposite side of the optical track 65. In this case, a DC offset voltage is absent from a tracking error signal outputted by an optical head actuator 18. However, in fact, a variation in a spring constant of the optical actuator 18 and an influence of gravity cause the center of the optical head actuator 18 to be subjected to a positional offset of several tens of μm to several hundreds of μm. In addition, during assembly, a positional error is offered to the center of the magnetic head 8. Thus, as shown in Fig. 79(b), there occurs a positional offset $\Delta\ell$ between the center of the magnetic head 8 and the center of the optical head actuator 18.

Even when an optical track of a given address is scanned by the optical head 6, there is a chance that an unrelated magnetic track is scanned by the magnetic head 8 since a correspondence relation with a magnetic track scanned by the magnetic head 8 is absent. Specifically, a pitch of magnetic tracks is generally set to 50 to 200 μm. A possible maximum offset between the center of the optical head 6 and the magnetic head 8 is equal to several hundreds of μm. Thus, under bad conditions, there is a chance that the magnetic head 8 travels on a magnetic track neighboring a desired magnetic track and thereby wrong recording of data is executed.

To prevent such a problem, this invention adopts a method in which an offset voltage ΔVo is provided to a tracking control signal to compensate for the positional offset of the optical head 6 so that the optical head 6 can accurately face the opposite side of a reference (currently-scanned) magnetic track 67. According to this design, the magnetic head 8 and the optical head 6 reliably remain in vertical alignment with each other, and the positions of the optical track 65 and the magnetic track 67 are more highly correlated. In general, the offset between the magnetic head 8 and the optical head 6 falls in a range well covered by a normal tracking error of several μm to several tens of μm. Even in the case where the track pitch is set to 50 μm, the magnetic head 8 can be held in good tracking conditions with respect to a desired magnetic track by referring to the address of a currently-scanned optical track.

In the case where an offset voltage ΔVo is applied as shown in Fig. 80(b), the offset of the optical head 6 is corrected so that the

magnetic head 8 can access a desired magnetic track 67 by accessing the address of a currently-scanned optical track 68.

A description will now be given of calculation of a desired value of the offset voltage ΔVo. According to the standards for a CD or an MD (a mini-disk), a maximum possible offset of an optical track 65 is 200 μm. A pitch of magnetic tracks 67 corresponds to 2DD and is thus equal to 200 μm in the case of a 135-TPI class. Thus, if no countermeasure is provided, it is generally difficult to access a desired magnetic track 67 by referring the address of an optical track 65 at the opposite side thereof.

As shown in Fig. 81(a), there occurs an offset Δrn between a pre-mastered optical track 65PM and a locus 65T of the optical head 6 free from servo control. Here, in the case where a traverse is held fixed and the optical head 6 is subjected to tracking servo control, the offset of the optical track causes a tracking error signal such as shown in Fig. 81(b).

In the case where an optical track address is read out and is set as a reference point when $\theta=0^{o}$, the tracking radius is made equal to $rn-\Delta rn$ by the offset and is thus smaller than a designed tracking radius rn. On the other hand, in the case where an optical track address is read out and is set as a reference point when $\theta=180^{o}$, the tracking radius is made equal to $rn+\Delta rn$ by the offset and is thus greater than the designed tracking radius rn.

In the case where the track pitch is equal to 100-200 μm and the offset of the optical track is equal to $\pm$200 μm, the tracking radius tends to deviate from a desired radius if tracking servo

control is absent.

As shown in Fig. 81, the error is minimized when $\theta=90^{o}$ and $\theta=270^{o}$. Accordingly, the address of an optical track 65PM which occurs when $\theta=90^{o}$ or $\theta=270^{o}$ is used as a reference and the position of the center of an optical track is determined on the basis of the reference, and thereby the radius rn of an n-th track corresponding to a setting value is determined.

As made clear from Fig. 81, $\Delta rn=0$ when $\theta=90^{o}$ and $\theta=270^{o}$, and a standard (reference) tracking radius rn is determined. The positions of $\theta=90^{o}$ and $\theta=270^{o}$ are determined by referring to the tracking error signal. The address of an optical track 65 in a position on a line of extension of these angles is used, and the optical head is subjected to tracking control with respect to this optical track address 65s. Thereby, there is provided an advantage such that a standard (reference) tracking radius rn is obtained and more accurate tracking by the magnetic head is enabled. It should be noted that the optical track address information is recorded on a first track of a magnetic track 67 or a TOC track.

In the case of the CD or MD format, the number of pieces of address information per round of an optical track is relatively small. Thus, 360 addresses can not be obtained for one degrees of 360^{o}. As shown in Fig. 86, it can be known what degrees of an angle θ a block in a given order number in an address 1 corresponds to. Thereby, for example, an angular resolution in unit of degree can be obtained. Thus, by executing management in unit of block, it is possible to obtain optical address information of an arbitrary radius

and an arbitrary angle. A table representing the correspondence between optical address information and a magnetic track number will be referred to as an address correspondence table.

Next, a description will be given of methods of providing the correspondence between a magnetic track radius rm and an optical track radius ro. A positional offset between the optical head and the magnetic head has a first component caused during manufacture and assembly and a second component caused during operation. Positions and sizes vary parts by parts or devices to devices, and therefore the offset components can not be uniquely determined. To maintain the compatibility, it is important to clarify the correspondence between the magnetic track radius and the optical track radius.

According to a first method, a reference track is not provided on a magnetic surface of a recording medium. As shown in Fig. 79(b), during the formatting of a magnetic surface, a positional offset is always present between the magnetic head 8 and the optical head 6. If the formatting is done under these conditions, a track with a positional offset is recorded. In the case where recording and reproduction are done on a same disk by a same drive, there is no problem since an equal positional offset is always present.

In the case where tracking is moved to a given track, a traverse is required to be moved always in a same direction, for example, a direction from an inside toward an outside, in view of the fact that an actuator for the traverse has a backlash. In the case

where tracking is done again on an n-th track, an offset distance is present between the magnetic track 8 and the optical head 6 as shown in Fig. 79(b) if an offset voltage is not applied during the tracking. Thus, when an optical track same as the optical track during the recording is accessed, tracking is done with respect to a magnetic track same as the magnetic track during the recording so that data can be recorded and reproduced into and from the desired magnetic track.

In the case where the recording medium which has been formatted is operated by another drive and the drive has characteristics such that an offset equals zero in the absence of an offset voltage as shown in Fig. 82(a), an optical track and a magnetic track are out of alignment by an offset distance as compared with the previous recording so that data will be recorded and reproduced into and from a wrong magnetic track.

In this invention, to remove such a problem, the traverse is controlled and moved so that a reference magnetic track will be accessed first as shown in Fig. 82(a). Then, under conditions where the traverse is fixed, an offset voltage ΔV is varied so that the optical track 6 will access an optical track 65 containing a reference address signal. As a result, the offset voltage ΔVo is determined. Thereby, the relation of the correspondence between the optical track and the magnetic track is provided similar to the drive which has executed the previous formatting.

The offset voltage ΔVo is continuously applied to the actuator for the optical head 6. Thereby, a simple structure can produce an

advantage such that all the magnetic tracks and the optical tracks correspond to each other with an accuracy of several μm to several tens of μm. Thus, by applying the offset voltage, it is possible to automatically access a given magnetic track when a given optical track is accessed. Since this advantage is obtained by the structure having no position sensor for the lens of the optical head 6, there is an advantage such that the number of parts can be reduced.

Next, a description will be given of a second method in which a reference track is previously recorded on a magnetic recording surface. As shown in Fig. 83, during the fabrication of a disk, one magnetic track 67 is provided which records an embedded servo track. With respect to this servo magnetic track 67s, as shown in the left-hand part of Fig. 83, two magnetic tracks are recorded while they are partially overlapped. Carriers of frequencies fa and fb are recorded on the two magnetic tracks respectively.

When the magnetic head 8 executes tracking on the center of the servo magnetic track during the reproduction, the magnitudes of reproduced signals of the frequencies fa and fb are equal to each other. When the tracking deviates inwardly from the center, the output signal of the frequency fa is greater. On the other hand, when the tracking deviates outwardly from the center, the output signal of the frequency fb is greater. Thus, the traverse is moved so that the magnetic head 8 can be positionally controlled at the center of the track.

Although the provision of the servo magnetic track causes a slight increase in the cost of a recording medium, there is an

advantage such that the offset voltage ΔVo can be more accurately calculated in connection with Fig. 80(a). In addition, eccentricity information of an optical track can be more accurately determined.

As shown in Figs. 84(a) and 84(b), a slider 41 of the magnetic head 8 is made of soft material such as teflon other than metal, and is formed by molding. Thereby, there is an advantage such that the slider 41 less damages a magnetic recording layer 3.

As shown in Figs. 85(a) and 85(b), when the magnetic recording is not executed, a slider actuator inclines the slider 41 so that the magnetic head 8 is separated from the magnetic recording layer 3 and a part of an edge of the slider 41 is brought into contact therewith.

As shown in Fig. 85(b), only when the magnetic recording is executed, the actuator inclines the slider into parallel with the magnetic recording layer so that the magnetic head 8 moves into contact with the magnetic recording layer 3. Thus, the magnetic recording is possible. In this case, there is an advantage such that wear of the magnetic head 8 can be reduced during unexecution of magnetic recording.

DESCRIPTION OF THE ELEVENTH PREFERRED EMBODIMENT

A recording and reproducing apparatus according to an eleventh embodiment of this invention is similar to the recording and reproducing apparatus of Fig. 38 except for design changes indicated later. The eleventh embodiment uses a non-tracking system in which tracking servo control is not executed on a magnetic head. The eleventh embodiment includes a recording

circuit such as shown in Fig. 87.

As shown in Figs. 88(a) and 88(b), recording is done by using two magnetic heads 8a and 8b, that is, an A head 8a and a B head 8b, which have different azimuth angles respectively. As shown in Fig. 88(b), the track pitch Tp of a magnetic track 67 and a head width TH have a relation as $Tp<TH<2Tp$. Normally used conditions are as $TH=1.5\sim2.0Tp$. Thus, in the case of recording on an n-th track, recording is also done on a region of an (n+1)-th track in an overlapped manner. The overlapped portion is subjected to overwriting record during the recording on the (n+1)-th track, and therefore a recording track is formed which has a width corresponding to the width Tp.

As shown in Fig. 89, recording is done while the two heads, that is, the A head 8a and the B head 8b, which have the different azimuth angles are changed at $\theta=0^{o}$ and data is overwritten thereby alternately in a spiral shape. Thus, as shown in Fig. 88, the formed track width Tp is smaller than the head width TH. Since A tracks 67a and B tracks 67b having different azimuth angles alternate with each other, crosstalk between tracks is absent during the reproduction. As shown in Fig. 90, guard bands 325 are provided between neighboring track groups 326, and thus independent recording and reproduction can be done on each of the track groups.

As shown in Fig. 91, data of respective tracks such as A1, B1, and A2 is composed of a plurality of blocks 327, and one track group is set by combining a plurality of tracks. Guard bands 325 are

provided between track groups so that rewriting can be done in unit of track group. A plurality of blocks which compose one track have a sync signal 328, an address 329, a parity 330, data 331, and an error detection signal 332.

Operation which occurs during the recording will now be described. Input data related to a designated address is fed to an input circuit 21. In the eleventh embodiment, data is rewritten while a track group 326 of Fig. 91 is used as a unit. Thus, simultaneous recording is done with respect to a plurality of tracks. Since track groups 326 are separated by guard bands 325 as shown in Fig. 90, an adverse influence on other track groups is prevented even if the recording and reproduction is done in this unit.

In the case where the input data contains only information of a part of a plurality of tracks, the data is insufficient and thus rewriting can not be done on the whole of one track group 326. Accordingly, in the case of rewriting on an n-th track group, reproduction is previously done on the n-th track group and all the data is stored into a buffer memory 34 of a magnetic reproducing circuit 30. The data is transmitted to the input circuit 21 as an address and data during the writing, and data of an address equal to the input data address is replaced by the input data. In this case, data of an address equal to the address related to the input data in the buffer memory 34 may replace the input data.

All the data of the n-th track group 326n which should be written is transmitted from the input circuit 21 to a magnetic recording circuit 29 and is modulated by a modulating circuit 334,

and a separating circuit 333 generates data for the A head 8a and data for the B head 8b.

As shown in Fig. 92(a), recording A track data 328a1 is done by the A head 8a at t=t1. At t=t2 where a disk is rotated through 360°, recording B track data 328b1 is done by the B head 8b.

With respect to a timing signal for the change between the A head and the B head, a rotation signal for a disk motor 17 is used or 360°-revolution is detected by using optical address information from an optical reproducing circuit 38. The timing signal is transmitted from a disk rotation angle detecting portion 335 to the magnetic recording circuit 29. An end of each track data 328 is provided with a non-signal part 337, and a signal guard band results which prevents A track data 328a and B track data 328b from overlapping.

The guard bands are present on the disk. To prevent data from being recorded on a track group 326 adjacent to a desired track group while being passed over a guard band 325, it is necessary to accurately set a record starting radius and a record ending radius. This invention adopts a method in which a given optical address is used as a reference point and a permanent absolute radius is attained.

In Fig. 87, an optical address is read out by the optical head 6 and the optical reproducing circuit 38. The method of optical head offset correction which has been described with reference to Figs. 80 and 82 is used to increase an accuracy. According to the same method, an offset corrective amount is calculated, and is stored into

an offset corrective quantity memory 336. The offset corrective amount is read out therefrom when needed. Under conditions where an optical head drive circuit 25 offers an offset to the optical head 6, a traverse actuator 23a is driven by a traverse moving circuit 24a while an optical address is referred to, and a traverse is moved. In this way, an optical address of the optical track is referred to, and tracking can be accurately executed on a magnetic track 67. According to the example where the recording is done by alternately using the two magnetic heads 8a and 8b which have the different azimuth angles, the recording time tends to be long.

As shown in Fig. 88(c), the radial positions of two heads are offset by Tp. In addition, A track data and B track data are simultaneously outputted and transmitted from the separating circuit 333 of Fig. 87, and the traverse is fed or moved at a pitch twice Tp every round. Thereby, as shown in Fig. 92(b), recording on one track group can be executed in a time half the time of the above-mentioned case, and there is an advantage such that higher-speed recording can be done.

In this way, the input data is recorded on the tracks in a spiral shape.

An example of specific designing will now be described. Even in the case where an offset of an optical track is $\pm$200 μm, the offset correcting arrangement removes adverse affection of the offset and the offset falls into a range of a chucking offset amount which equals $\pm$25 μm. An offset of the rotational shaft of a motor can be limited to within a range corresponding to $\pm$ several μm. In this case, by

setting the guard band width equal to 50 μm or more, a track can be recorded which has a width of an error within ± several μm. Thus, there is an advantage such that a large amount of data can be recorded by the non-tracking system.

A description will now be given of traverse control which occurs in the case of spiral recording. With reference to Fig. 89, a record starting point optical address 320a and a record ending point optical address 320e are set as reference points. In the design of Fig. 89, it is good that while the disk is rotated four times, the traverse is driven at an equal pitch from the starting point to the ending point. This invention adopts a structure in which a rotational motor rotates a screw and thereby feeds or moves the traverse. Rotation pulses from the rotational motor can be obtained.

As shown in Fig. 97, the traverse is moved from the starting point optical address 320a to the ending point optical address 320e. During this period, the rotation number no of a traverse drive gear is measured. Since the disk is rotated four times, a system controller 10 calculates a rotational speed corresponding to no/4T r.p.s. The system controller 10 outputs an instruction for rotating the traverse drive gear at this speed (rotation number). The magnetic head executes data recording with an accurate track pitch. At the end of the recording, since the magnetic head 8 lies near the ending point optical address 320e, passing over the guard band and reaching the starting point optical address 320x of a neighboring track group can be prevented. It is sufficient that measuring the rotational speed of the traverse drive gear is executed once each

time disks are changed. This information may be recorded on a disk. By doing traverse control while counting the line number of an optical track, it is possible to execute smoother and more accurate feed of the traverse.

Fig. 96 shows designing which uses coaxial tracks. In this case, during the recording on respective tracks, the traverse is moved each time so that six points corresponding to optical addresses 320a, 320b, 320c, 320d, 320e, and 320f will be accessed by the optical head. Thereby, cylindrical tracks are formed.

In the presence of a non-address region 346 which does not have an optical address and a signal, access by referring to the optical address can not be executed. In this case, with respect to an optical address region 347, a reference radius and a disk rotational reference angle are determined, and the line number of an optical track is counted. Thereby, tracking can be done on a given relative position even in the non-address region 346. Provided that a table indicating the line numbers from reference optical address points for respective tracks is made and is written into a magnetic TOC region 348, another drive can access a target magnetic track. The method of executing access by referring to the line number is less accurate in absolute position than the method using the optical address, and is advantageous thereover in that an access speed is higher. It is preferable to use the two methods. From the standpoint of high-speed access, it is good to adopt the method which uses counting the line number during the reproduction. Drives are of a high density type and a normal density type. The

high density type has a head width TH which equals 1/2 to 1/3 of that of the normal density type. In addition, its track pitch equals 1/2 to 1/3 of the track pitch Tpo of the normal density type. In the case of non-tracking, the high density type can reproduce data of a normal density type but the normal density type can not reproduce data of a high density type.

To attain the compatibility, a compatible track is provided during the recording by using the high density type. In addition, as shown in Fig. 99, the recording is done at a track pitch equal to Tpo. Thereby, the normal density type can reproduce the recorded data. In the case where data on an optical surface is divided into three programs 65a, 65b, and 65c as shown in Fig. 100, regions for magnetic recorded data to be saved are set in magnetic tracks 67a, 67b, and 67c extending on the surface. Thus, there is an advantage such that the displacement of the traverse is small and an access time is short.

Next, a description will be given of the reproduction principle. Fig. 93 shows a reproducing section of the apparatus. The reproducing section of Fig. 93 is approximately similar to that of Fig. 87 except for a magnetic reproducing portion 30.

First, the system controller 10 transmits a reproducing instruction and a magnetic track number accessing instruction to a traverse controller 338. As in the design of Fig. 87, the magnetic head accurately accesses a target magnetic track number.

As shown in Fig. 89, tracking is done with respect to a magnetic track 67 in a spiral shape, and both the output signals of

the A head 8a and the B head 8b are simultaneously inputted into the magnetic reproducing portion 30. The input signals are amplified by head amplifiers 340a and 340b respectively, being subjected to demodulation by demodulators 341a and 341b and being subjected to error check by error check portions 342a and 342b to derive correct data. The correct data signals are fed to AND circuits 344a and 344b. Data separating portions execute the separation between addresses and data. Only data free from errors is transmitted to the buffer memory 34 via the AND circuits 344a and 344b, and respective pieces of the data are stored into respective addresses. The data is outputted from the memory 34 in response to a reading clock signal from the system controller 10. When the buffer memory 34 reaches given conditions close to overflow conditions, an overflow signal is transmitted to the system controller 10 and the system controller 10 outputs an instruction to the traverse controller to reduce the traverse feed width. Alternatively, the system controller 10 may lower the speed of the motor 17 to reduce the reproduction transmission rate. As a result, overflow is prevented.

In the case where the number of errors detected by the error check portion 342 is large, an error signal is transmitted to the system controller 10 and the system controller 10 outputs an instruction to a traverse control circuit 24a to reduce the track pitch. As a result, during the reproduction, the track pitch is reduced from the normal value Tp to 2/3Tp, 1/2Tp, and 1/3Tp so that the data of an equal address is reproduced 1.5 times, double,

and three times. Thus, the error rate is lowered.

In the case where all data in an (n+1)-th track gathers before all data in an n-th track gathers in the buffer memory 34, there is a chance that the data of the n-th track can not be reproduced. In this case, the system controller 10 outputs a reverse direction traverse instruction to the traverse controller to return the traverse inwardly. Then, the n-th track is subjected to the reproducing process. As a result, the data of the n-th track can be reproduced.

In this way, there is an advantage such that data can be surely reproduced without increasing the error rate.

A description will now be given of operation of reproducing information from a disk with non-tracking. As shown in Fig. 94, data is recorded on a disk, and the data includes data 345a, 345b, 345c, and 345d in an A track. In addition, data B1, B2, B3, and B4 in a B track are also recorded. When the reproduction is executed by the A head, the data in the B track can not be reproduced due to a discrepancy in azimuth angle.

For the simplicity of description, the data in the B track will be omitted. In the case where the recorded data 345 in the A track is reproduced by the A head 8a with a track pitch Tpo equal to that during the recording, the loci of the track extend as track loci 349a, 349b, 349c, and 349d since there is an offset in chucking with respect to the disk. The head width TH of the A head 8a is greater than the track pitch Tpo, and therefore halves of tracks on both sides are subjected to a reproduction process. The B track is not subjected to a reproduction process. Accordingly, reproduced

data free from errors, among signals reproduced from the respective track loci, have forms such as A head reproduced data 350a, 350b, 350c, 350d, and 350e. The data are sequentially transmitted to the buffer memory 34 of Fig. 93, and are recorded into given disk addresses. Thus, the data of the respective tracks are fully reproduced as memory data 351a and 351b. In this way, the data of the A track with non-tracking is reproduced. The data of the B track is similarly reproduced.

As previously described, in the eleventh embodiment, the recording and reproduction can be done with a small track pitch even in the absence of tracking servo control of the magnetic head. Thus, there is an advantage such that a memory of a large capacity can be realized by a simple structure. Since the traverse control is done by using the addresses on the optical surface, a low accuracy of feed of the traverse suffices and a linear sensor regarding a radial direction can be omitted. In the case of a non-tracking system, the accuracy of tracking basically depends on the accuracy of a bearing of a rotational motor. Generally, a high accuracy of the bearing of the rotational motor can be realized with a low cost. In the case of an MD ROM used in a cartridge, the recording wavelength can be equal to 1 μm or less so that a recording capacity of 2 to 5 MB can be obtained. In the case of a CD ROM, a print layer and a protective layer are formed on a magnetic layer as will be described later so that the recording wavelength is generally equal to 10 μm or more. Thus, a capacity of only several tens of KB can be obtained according to the normal system. On the other hand, a capacity of several tens

of KB to 1 MB can be obtained by using the non-tracking system. As previously described, the eleventh embodiment has an advantage such that a large memory capacity can be realized with a low cost while a conventional optical access mechanism for a CD, a CD ROM, an MD, or an MD ROM is used as it is.

DESCRIPTION OF THE TWELFTH PREFERRED EMBODIMENT

A recording and reproducing apparatus according to a twelfth embodiment of this invention is similar to the recording and reproducing apparatus of Fig. 87 except for design changes indicated later. The twelfth embodiment uses a recording medium in which a magnetic recording layer is formed on the back side of a ROM disk without a cartridge such as a CD ROM.

As shown in Fig. 101, the recording layer 2 includes a transparent layer 5, an optical recording layer 4, a magnetic recording layer 3, and a print layer 43 arranged sequentially with respect to an upward direction. The print layer 43 has a print area 44. A label of a CD title or letters 45 are printed on the print area 44. A protective layer 50 may be provided on the print area 44. The protective layer 50 is made of hard material having a Mohs scale of 5 or more. In the case of a recording medium such as a CD or a CD ROM which is not provided with a cartridge and which has a single optical recording surface, the print area 44 can be provided in approximately the whole of the opposite surface. As shown in Fig. 102, in the case of an LD, LD ROM, or others which have two optical recording surfaces, the print area 44 is provided at a central narrow region to prevent an adverse influence on the optical reproduction.

This embodiment will be further described with respect to the case where a CD ROM is used as the recording medium.

The recording medium is designed and fabricated as follows. As shown in Fig. 103, at a step number P=1, a substrate (a base plate) 47 is prepared which has a transparent portion 5 with pits 46. At a step number P=2, an optical reflecting film 48 made of suitable material such as aluminum is formed by vapor deposition or sputtering.

At a step number P3, suitable magnetic material such as barium ferrite having a magnetic coercive force Hc of 1, 750 or 2,750 is directly applied, and thereby a magnetic recording layer 3 is formed. It may be good that the magnetic material is applied to a base film and the base film with the magnetic material is transported together with a bonding layer to form a magnetic recording layer 3. The recording medium of this embodiment is not protected by a cartridge. Thus, it is necessary to use magnetic material having a high magnetic coercive force Hc to protect recorded data from an external magnetic field generated by, for example, a magnet. It has been experimentally confirmed through a field test that a damage to recorded data is absent when an exposed recording medium including a magnetic recording material having a magnetic coercive force Hc of 1,750 Oe to 2,750 Oe is used under normal industrial use conditions. As understood from Fig. 121, only a magnetic field of 1,000 to 1,200 Gauss is present in a normal home. Thus, it is good that the magnetic coercive force Hc of magnetic material for the magnetic recording layer 3 is set to 1,200

Oe or more. In this embodiment, by using the material having a magnetic coercive force of 1,200 Oe or more, a damage to data is prevented during normal use. Provided that the magnetic coercive force Hc of the magnetic material is increased to 2,500 Oe or more by using barium ferrite or others, the reliability during the data recording can be enhanced. The material of barium ferrite is inexpensive, and is formed by a cheap application step. In addition, the material of barium ferrite naturally exhibits random orientation so that a randomizing step is unnecessary. Thus, the material of barium ferrite is suited to a partial RAM disk of a CD ROM type which generally requires low-cost mass production. In this case, the magnetic material is processed into a disk. Since recording and reproduction are done along a circumferential direction, recording characteristics are lowered if the magnetic material has magnetic orientation in a given direction such as a magnetic card or a magnetic tape. To prevent the occurrence of such orientation in a given direction, a magnetic film is formed while a randomizer applies magnetic fields in various directions before applied magnetic material hardens. As previously described, in the case of barium ferrite, there is an advantage such that a randomizing step can be omitted. In the case of a CD or a CD ROM, the CD standards require that the title and the contents of a medium should be printed as a label to enable a consumer to visually identify and recognize the contents of the medium. In addition, it is preferable that a color photograph is printed to make the appearance beautiful to increase the product value. Generally, the magnetic material has

a brown color or a black color of a dark tone, and therefore direct printing thereon is difficult.

At a step number P=4, to enable color printing to conceal the dark color of the magnetic recording layer 3, a backing or preliminary layer 43 with a color such as a white color which has a high reflectivity is formed by, for example, application. The thickness of the preliminary layer 43 is equal to several hundreds of nm to several μm. From the standpoint of recording characteristics, a thin preliminary layer 43 is better. On the other hand, if the preliminary layer 43 is excessively thin, the color of the magnetic recording layer can not be concealed. Thus, the thickness d2 of the preliminary layer 43 is required to be a certain thickness. To block the transmission of light, a thickness equal to a half of the light wavelength or more is preferable. When the shortest wavelength λ of visible light is defined as λ=0.4 μm, a thickness of 0.2 μm ($=\lambda/2$) or more is preferable. Thus, the thickness d2 is preferably equal to 0.2 μm or more. When $d2 \geqq 0.2$ μm, it is possible to attain the effect of concealing the color of the magnetic material. From the standpoint of recording characteristics, it is preferable that $d2 \leqq 10$ μm. Thus, it is desirable that $0.2\ \mu m \leqq d2 \leqq 10\ \mu m$. In this case, there is an advantage such that both color concealing characteristics and magnetic recording characteristics can be adequately obtained. According to the results of experiments, it is discovered that a thickness d2 of about 1 μm is most preferable. In the case where magnetic material is mixed with and added to the preliminary layer 43, there is an advantage such that an effective space loss can be

decreased.

At a step number P=5, print ink 49 made of dyes is applied so that printed letters 45 such as a label of Fig. 101 are indicated. Full color printing is possible since the printing is done on the white-color preliminary layer 43. As shown in Fig. 103, the print ink 49 of the dyes is applied, and the ink soaks into the preliminary layer 43 by a depth d3 so that roughness is absent from the surface of the preliminary layer 43. Thus, there is an advantage such that, during the magnetic recording and reproduction, a magnetic head touch is good and the travel of the magnetic head is prevented from removing the printed letters. In this way, the recording medium is completed.

The magnetic recording layer 3 at the step number P=3 and the print ink 49 at the step number P=5 are formed by using a gravure application step such as shown in Fig. 105. Specifically, application material including magnetic material of barium ferrite is transferred onto an application material transfer roll 353 from an application material bowl 352, and the application material on the roll 353 is selectively etched into a CD-shaped etching portion 355 which remains on an intaglio drum. Unnecessary application material is removed by a scriber 356. A soft transfer roll 367 is covered with a soft resin portion 361. The CD-shaped application material is transferred onto the soft transfer roll 367 as a CD-shaped application portion 358. The application portion 358 is transferred and applied to the surface of a recording medium 2 such as a CD. Before the execution of a drying process, a random magnetic field

generator 362 applies a random magnetic field to the recording medium with the application material so that the application material has random magnetic orientation. Since the transfer roll 367 is soft, accurate application to a stiff object such as a CD can be done thereby. In this way, the applications at the step numbers P=3, P=4, and P=6 are executed. The printing step P=5 may be an offset printing step in consideration of a small film thickness.

As shown in Fig. 103, at a step number P=6, a protective layer 50 may be applied to the recording medium. The protective layer 50 is made of hard and transparent material having a Mohs scale of 5 or more. The protective layer 50 has a given thickness d4. The protective layer 50 prevents the removal of the print ink, and protects the magnetic recording layer 3 from wear by an external injury or the magnetic head. Thus, there is an advantage such that the reliability of data is enhanced.

As shown in Fig. 106, a protective layer 50, a print ink 49, a preliminary layer 43, and a magnetic recording layer 3 may be applied onto a removable film 359 by steps of P=6, 5, 4, and 3 in an order reverse to the order of the steps previously described with reference to Fig. 103. Random magnetic orientation is provided by the random magnetic field generator 362. The resultant application film is accurately located on the surface of a substrate 4 which is provided with pits 46, and transfer is executed and then fixing is executed by a thermal pressing process. Subsequently, the removable film 359 is removed. As a result, a recording medium is completed which has a structure equal to the structure at the step

P=6 regarding Fig. 103. In the ease of mass production, the transfer method increases the throughput but decreases the cost. Thus, in the case of mass production of CD's, there is an advantage such that the production efficiency is increased.

While the dyes are used during the printing in connection with Fig. 103, print ink 49 of a pigment may be used at a step number P=5 of Fig. 104. In this case, a given thickness d3 is provided. At a step number P=6, there is provided a protective layer 50 made of transparent material containing lubricant such as d4>d3. Thereby, there is an advantage such that roughness on the surface is decreased and a good head touch is enabled by the lubricant. The use of the pigment causes an advantage such that better color printing is enabled. In this case, after the step P=5, thermal pressing may be executed to remove roughness from the surface, and the resultant is used as a final product. In this case, since a step of making the protective layer 50 can be omitted, there is an advantage such that the number of manufacturing steps can be reduced by one.

Next, a description will now be given of a method of making a magnetic shield layer. The magnetic head is present at the side of the recording medium 2 near the magnetic recording layer 3, while the optical head is present at the side of the recording medium 2 near the transparent layer. Thus, there is a chance that electromagnetic noise leaks from the actuator for the optical head into the magnetic head and therefore the error rate increases during the magnetic signal reproduction. As shown in Fig. 116,

noise of a level close to 50 dB occurs. A magnetic shield is provided in the recording medium 2 as a countermeasure, and thereby adverse influence of the electromagnetic noise can be reduced. As shown in Fig. 107, at a step number P=2, a magnetic layer 69 made of permalloy which has a high μ (magnetic permeability) and a weak magnetic coercive force Hc is formed by a suitable process such as a sputtering process. The magnetic layer 69 provides a magnetic shielding effect. In the case where a magnetic layer 69 having a weak magnetic coercive force is required to be formed in a short time or a thick magnetic layer 69 is required to be formed during the manufacture, a permalloy foil having a thickness of several μm to several tens of μm may be used. A thick magnetic layer 69 can be formed by plating. A thicker magnetic layer 69 provides an enhanced magnetic shielding effect. While the optical reflecting layer 48 is made of aluminum at the step number P=2 of Fig. 103, a film of permalloy may be formed by sputtering. In this case, a single film provides both an optical reflecting effect and a magnetic shielding effect. A thick permalloy film can be formed by plating with a low cost. Thereby, there is an advantage such that the number of steps of forming a reflecting film and a shielding film can be halved. In addition to the transfer step of Fig. 106 with respect to the recording medium of Fig. 108, a bonding layer 60a and a magnetic layer 69 may be provided in a sandwiched manner. The magnetic layer 69 has a high-μ film such as a permalloy film having a thickness of several μm to several tens of μm. Thus, a recording medium having a magnetic field shielding effect can be fabricated

through the transfer step.

In a way such as previously mentioned, a recording medium is fabricated which includes an optical recording layer and a magnetic recording layer with a print surface such as shown in Fig. 101. Thus, there is an advantage such that a label similar to a label of a conventional CD which meets the CD standards is provided and simultaneously a magnetic recording surface is added. As previously described with reference to Fig. 121, most of normally used magnets are ferrite magnets. In general, such magnets are not exposed. Even if a magnet is exposed, only a magnetic field of about 1,000 Oe occurs therearound. Some of magnetic necklaces are made of rare-earth material, and such magnetic necklaces are small in size so that they hardly magnetizes the magnetic recording material of barium ferrite. In the case of use of a magnetic recording layer made of suitable material such as barium ferrite which has a magnetic coercive force Hc of 1,200 Oe, 1,500 Oe or more, there is an advantage such that data on the magnetic recording layer is prevented from being damaged by a normally used magnet. Furthermore, it is possible to add a magnetic shield layer made of high-μ magnetic material, electromagnetic noise from the optical head can be remarkably suppressed during the magnetic reproduction. The above-mentioned manufacturing method uses an inexpensive technique such as a gravure application technique and inexpensive materials. Thus, there is an advantage such that a RAM function and a print surface can be obtained without increasing the cost of a partial RAM disk such as a CD or CD ROM.

DESCRIPTION OF THE THIRTEENTH PREFERRED EMBODIMENT

A recording and reproducing apparatus according to a thirteenth embodiment of this invention is similar to the recording and reproducing apparatus of Fig. 87 except for design changes indicated later. The thirteenth embodiment uses a recording medium in which magnetic material having a magnetic coercive force Hc greater than that of a normal magnetic disk is used and a protective layer having a thickness of 1 μm or more is provided on an uppermost portion of a magnetic recording layer as previously described with reference to the twelfth embodiment. In addition, the thirteenth embodiment uses a magnetic head suited to the recording medium. Furthermore, the thirteenth embodiment is provided with a countermeasure to the introduction of noise from an optical head through a magnetic field.

First, the structure of the magnetic head will be described. Fig. 110 shows the recording and reproducing apparatus which uses a 3-head arrangement. Specifically, the magnetic head of Fig. 87 is divided into two portions and a magnetic head 8a and a reading magnetic head 8b are made into a single unit, and a noise cancelling magnetic head 8s is additionally provided. Reproduction can be done while recording is being executed. Thus, error check is executed simultaneously.

The magnetic heads 8a and 8b will now be described with reference to Fig. 111. An optical head 6 and the magnetic heads 8a and 8b are located at opposite sides of the recording medium 2, and are opposed to each other. The optical head 6 serves to access a

desired track on an optical recording layer 4 of the recording medium 2. The magnetic heads 8a and 8b move together with the optical head 6. Thus, the magnetic head 8a and 8b travel on a magnetic track at the opposite side of the optical track scanned by the optical head 6. The magnetic recording is executed by the magnetic head 8a designed for writing. The reproduction is executed by the magnetic head 8b.

Recording and reproducing conditions will now be described with reference to Fig. 113. The magnetic head 8a has a writing track width La and a head gap 70a with a length Lgap. Thus, a magnetic track 67a having a width equal to La is recorded on the magnetic recording layer 3. Above the magnetic track accessed by the magnetic head 8, there is a disk cleaning portion 376 including a circular plate made of soft material such as felt. The disk cleaning portion 376 removes dust from the disk, and thus there is an advantage such that the error rate can be reduced during the reproduction. The disk cleaning portion 376 is connected to a connection member 380 including a spring. In an OFF state of Fig. 111, both the magnetic head 8 and the disk cleaning portion 376 are out of contact with the recording medium 2. As shown in the part ON-A of Fig. 111, when the magnetic head 8 is moved downward, the disk cleaning portion 376 lands on the recording medium 2. The connection member 380 including the spring holds the magnetic head 8 out of contact with the recording medium 2 for a moment. Then, in an ON-B state, the magnetic head 8 softly lands on the recording medium 2. In this way, the magnetic head 8

makes a soft landing on the recording medium 2 through two steps. Thus, there is an advantage such that even if the magnetic head 8 is moved upward and downward during the rotation of the recording medium 2, a damage to the magnetic head 8 or the recording medium 2 is prevented. As shown in Fig. 113, a portion of a magnetic track 67a which precedes the magnetic head 8 is cleaned, and thus there is an advantage such that the error rate is reduced during the magnetic recording and reproduction. A magnetic head cleaning portion 377 is also provided which moves together with a magnetic head elevator 21. During the insertion of a disk into the apparatus or during the upward or downward movement of the magnetic head 8, a contact part of the magnetic head 8 is cleaned by the magnetic head cleaning portion 377 at least once. At this time, a circular plate of the disk cleaning portion 376 slightly rotates so that a new surface thereof comes operable. During the next insertion of a disk into the apparatus, the disk is cleaned by the new surface of the disk cleaning portion 377. Since the reproducing head gap 70b of the magnetic head 8a has a width Lb, only a part of the magnetic track 67a which corresponds to the width of the reproduced track 67b is subjected to a reproducing process.

In the thirteenth embodiment, the head gap length Lgap of the magnetic head 8a is important for the reason as follows. As previously described with reference to Fig. 103, the recording medium of the twelfth embodiment includes the preliminary layer 43, the print layer 49, and the protective layer 50 which extend

between the magnetic recording-layer 3 and the magnetic heads 8a and 8b, and which have the thicknesses d2, d3, and d4 respectively. Thus, a space loss corresponding to d=d2+d3+d4 is always present. The space loss S in unit of dB is given as:

$$S = 54.6(d/\lambda) \quad \cdots(1)$$

where λ denotes the recording wavelength. The head gap Lgap and the recording wavelength λ has the following relation.

$$\lambda = 3 \times Lgap \quad \cdots(2)$$

According to the results of experiments, the thickness of the preliminary layer 43 is preferably equal to 1 μm or more in view of light blocking characteristics. Generally, it is necessary that the sum of the thicknesses of the print layer 49 and the protective layer 50 is equal to at least 1 μm. Thus, the value d generally needs to be at least 2 μm, and the following relation is present.

$$d \geqq 2\ \mu m \quad \cdots(3)$$

By referring to the equations (1), (2), and (3), a minimum space loss S in unit of dB is given as:

$$S = 54.6 \times 2/3Lgap \quad \cdots(4)$$

The equation (4) determines the relation between the head gap and the space loss which is shown in Fig. 112.

Generally, to attain sufficient recording and reproducing characteristics, it is necessary to limit the space loss to 10 dB or less. Thus, it is found from Fig. 112 that the head gap Lgap needs to be set to 5 μm or more. In a conventional recording and reproducing apparatus for rotating a hard disk or a floppy disk to execute information recording and reproduction, a magnetic head

has a slider portion and is provided with a head gap of 0.5 μm or less. If information is recorded and reproduced into and from the recording medium of this invention by using such a conventional magnetic head, sufficient recording and reproducing characteristics can not be obtained due to the presence of the protective layer or the print layer. On the other hand, in the thirteenth embodiment, the magnetic head 8a has a slider portion 41 as shown in Fig. 111 and the head gap of the recording head 8a is equal to 5 μm or more so that the space loss is equal to 10 dB or less as understood from Fig. 112. Thus, there is an advantage such that sufficient recording and reproducing characteristics can be attained during the recording and reproduction.

In the thirteenth embodiment, it is possible to execute full color label printing on the surface of the recording medium. It is possible to adopt the recording medium having the same appearance as that of a conventional CD or CD ROM as shown in Fig. 101. Thus, there is an advantage such that when a CD having the magnetic recording layer of this invention is used, a consumer is prevented from being confused and the basic function of the CD standards is maintained. The magnetic recording layer uses barium ferrite which has a high magnetic coercive force Hc and which does not require the random orientation step. Thus, there is an advantage such that recorded data is not damaged under normal conditions and the recording medium can be manufactured at a low cost. The recording medium of this invention can be handled in the way same as the way of handling a conventional CD as previously

described, and thus there is an advantage such that a full compatibility between the recording medium of this invention and the conventional CD can be attained.

Next, a description will be given of countermeasures to magnetic field noise transmitted from the optical head to the magnetic head. Electromagnetic noise generated by an optical head actuator 18 tends to enter the reproducing magnetic head 8b so that the error rate may be increased. According to a first countermeasure, as shown in Fig. 114, a magnetic shield layer 69 previously described with reference to the twelfth embodiment is provided in the recording medium 2. Thereby, electromagnetic noise generated by the actuator of the optical head 6 is prevented from entering the magnetic head 8 so that an increase in the error rate can be prevented. In this case, when the optical head reaches an edge of the disk, electromagnetic noise tends to be transmitted from the optical head actuator to the magnetic head 8 since the magnetic shield is absent from an area outside the disk. Accordingly, as shown in Fig. 110, it is preferable that the recording and reproducing apparatus is provided with a magnetic shield 360 extending around the edge of the disk to block the electromagnetic noise. According to a second countermeasure, as shown in Fig. 111, the optical head actuator 18 is surrounded by a magnetic shield 360 made of high-μ material such as permalloy or iron. The magnetic shield 360 has an opening 362 for a lens. Thus, there is an advantage such that the transmission of electromagnetic noise from the optical head actuator to the magnetic head 8b is suppressed and

related noise in the output signal from the magnetic head is remarkably decreased.

Experiments were done under the following conditions. The optical head of the recording and reproducing apparatus was held fixed, and the optical recording portion was subjected to focusing control. On the other hand, the magnetic head was moved on the surface of the recording medium. During the experiments, a relative level of electromagnetic noise entering the magnetic head 8 from the optical head 6 was measured. Fig. 116 shows the relation between the measured relative level of the electromagnetic noise and the distance between the magnetic head and the optical head.

According to another countermeasure to noise, the noise is detected, and the detected noise is added to a reproduced signal at an opposite phase to reduce the noise component from the reproduced signal. As shown in Fig. 111, the magnetic recording and reproducing apparatus is provided with a noise cancel magnetic head 8s and a noise detector such as a magnetic sensor. In a noise canceler portion 378, a reproduced signal from the magnetic head 8b and the detected noise are added with opposite phases respectively and at a given addition ratio A so that the noise component of the reproduced signal can be canceled. By optimizing the addition ratio A, the noise component can be adequately canceled. The optimal addition ratio Ao is determined by scanning a magnetic track free from a recorded signal and varying the addition ratio so as to minimize the level of the reproduced signal. The optimal addition ratio Ao can be calibrated and updated. It is

good to execute the calibration when the noise level exceeds an acceptable range.

By utilizing the fact that the recording head 8a remains unused during the reproducing process in Fig. 110, the recording head 8a may be employed as a noise detector. In this case, a signal outputted from the recording head 8a is inputted into the noise canceler portion 378 to remove the noise component from the reproduced signal, and the noise cancel magnetic head 8s can be omitted.

A description will now be given of the structure which includes the noise cancel magnetic head 8s. As shown in Fig. 129, the noise cancel magnetic head 8s is connected to the magnetic heads 8a and 8b via an attachment portion 8t. When the magnetic head unit contacts the recording medium 2 as shown in Fig. 129(b), a space loss having a height do occurs with respect to the noise cancel magnetic head 8s.

In the case where λ=200 μm and the space loss height do is equal to 200 μm or more, the level of a reproduced signal from the magnetic recording layer is estimated as being equal to about -60 dB and the reproduction is almost difficult. When the magnetic head is moved upward by 0.2 mm, the level of noise is reduced by only -1 dB or less as shown in Fig. 116. In the case where λ=200 μm, provided that the distance between the noise cancel magnetic head 8s and the reproducing magnetic head 8b is set to at least $\lambda/5$ equal to 40 μm, the entrance of an original signal from the reproducing head can be prevented. Thus, there is an advantage such that the

transmission of electromagnetic noise from the optical head actuator to the reproducing magnetic head can be essentially completely suppressed.

It should be noted that the noise cancel magnetic head 8s may be replaced by a magnetic sensor such as a Hall element or an MR element. An example of the magnetic sensor is shown in Fig. 130. The drive magnetic noise of the optical head 6 is detected by the magnetic sensor, and a signal representative thereof is added in opposite phase to the magnetic reproduced signal. Thereby, the introduced noise can be greatly reduced. This design enables the apparatus to be further miniaturized in comparison with the magnetic head detection type.

Figs. 172(a) and 172(b) to Figs. 175(a) and 175(b) show examples of the details of the arrangement of Fig. 129. Fig. 172(a) shows an example using a head with one gap which serves as both the recording head 8a and the reproducing head 8b. In the case where heads of equal sizes are arranged as shown in Figs. 175(a) and 175(b), a high effect is attained although the size of the composite head is large. Figs. 175(a) and 175(b) show an example where the width of the noise cancel head 8s is set small to realize the miniaturization. Figs. 172(a) and 172(b) show an example using a noise cancel head 8s having a uniform width. In the arrangement of Fig. 172(c), a slider 41 is provided with a groove 41a which also forms the previously-mentioned groove having the gap do. The slider 41 is greater than the head 8a in the area of the surface contacting air, so that the magnetic head 8a receives a weaker air

pressure. Therefore, the contact between the head and the recording medium is made better. In this case, l2 > l1. Fig. 173 shows an arrangement in which the head gap is removed from the noise cancel head 8s of Fig. 171. Since a magnetic signal is not read out even when the noise cancel head 8s is brought into contact with the magnetic surface of the recording medium, there is an advantage such that only noise can be picked up.

Figs. 176(a) and 176(b) to Figs. 178(a) and 178(b) show arrangements each using a coil 499 as a noise cancel head. Fig. 176(a) shows an arrangement in which two coils 499a and 499b are located in a groove of a magnetic head 8. It is possible to detect a noise magnetic flux 85 as in Fig. 175(b). Fig. 177(a) shows an arrangement in which coils 499a and 499b are located in parallel with the gap of a head. It is possible to detect noise in the direction of the head magnetic field. Fig. 177(b) shows a noise cancel arrangement in which signals from the coils 499a and 499b are enlarged by amplifiers 500a and 500c respectively, and are combined by an amplifier 500b into a composite signal inputted to the noise canceler 378 of Fig. 134. Fig. 178(a) shows an arrangement in which vertical coils 499c and 499d are provided in addition to the coils 499a and 499b parallel to the head gap. The four coils enable higher noise detection ability. By adjusting and mixing the output signals of the parallel coils 499a and 499b and the vertical coils 499c and 499d as shown in Fig. 178(b), it is possible to obtain a noise detection signal optimal for noise cancel.

Fig. 179 shows a spectrum distribution having the results of

measurement of actual electromagnetic noise caused by the optical pickup portion in the apparatus equipped with the noise cancel head. As understood from the drawing, noise having frequencies of several KHz overlaps in frequency with the reproduction frequency band in the apparatus of this invention which uses a wavelength of 100 micrometers. Therefore, this noise significantly interferes with the reproduction. As shown in the drawing, the noise cancel head enables the reduction of the noise in the frequency band by about 38 dB. The noise reduction results in an improvement of the error rate during the reproduction.

According to another countermeasure to noise, the distance between the optical head and the magnetic head is set to 10 mm or more, and the noise is reduced by 15 dB or more as understood from Fig. 116. Thus, by setting the distance between the optical head and the magnetic head to 10 mm or more, there is provided an advantage such that the noise is remarkably reduced. In this case, it is important to maintain the accuracy of the positional relation between the optical head and the magnetic head.

A description will now be given of a method of maintaining the positional accuracy. As shown in Fig. 117, with respect to the optical head 6 and the magnetic head 8, traverse shafts 363a and 363b are rotated in equal directions in response to rotation of a common traverse actuator 23 via traverse gears 367a 367b, and 367c. The traverse shafts are provided with opposite screws respectively so that the optical head 6 is moved in a leftward direction 51a while the magnetic head 8 is moved in a rightward

direction 51b. The respective heads meet positional reference points 364a and 364b, and therefore positions thereof are adjusted. Thus, the optical head 6 is moved to a position above a reference optical track 65a while the magnetic head 8 is moved to a position above a reference magnetic track 67a. In this way, initial setting of the positions of the two heads is executed. Therefore, the accuracy of the positional relation between the two heads is maintained during the movements thereof. The positional setting is done at least once when a new recording medium 2 is inserted into the apparatus or when a power supply switch of the apparatus is turned on. Thereby, during later operation of the apparatus, the two heads are moved by equal distances. Thus, in the case where the optical head 8 accesses a given optical track 65, the magnetic head 6 accurately accesses a given magnetic track 67 on a radius equal to the radius of the currently-accessed optical track 65. In the case where the optical head 6 is moved thereafter, the magnetic head 8 is moved by the same distance. Thus, as shown in Fig. 118, an optical track 67b and a magnetic track 65b on the same radius are accurately accessed. In the case of access to an outermost part of the recording medium, the two heads are positioned above tracks on a circumference having a radius L2. In the case of access to an innermost part of the recording medium, the two heads are moved to positions above tracks on a circumference having a radius L1. In this case, the distance between the optical head 6 and the magnetic head 8 is equal to 2L1. Provided that this distance is set to 10 mm or more, the level of noise transmitted from the optical head to the

magnetic head is adequately small. In the case of a CD, L1=23 mm and thus the distance between the two heads is given as 2L1=46 mm, so that the level of noise is equal to 10 dB or less as understood from Fig. 116. Thus, there is an advantage such that an adverse influence of the noise hardly occurs.

As shown in Fig. 117, when a recording medium 2 is required to be inserted into the apparatus, the presence of the magnetic head 8 makes difficult the direct insertion of the recording medium 2. Accordingly, the elevator 21 for the magnetic head lifts the magnetic head 8 and the traverse by a significant distance, and then the recording medium is inserted into the apparatus. At this time, the previously-mentioned positional relation between the two heads tends to be out of order. On the other hand, at this time, as previously described, the magnetic head cleaning portion 377 cleans the contact surface of the magnetic head 8. Then, the magnetic head 8 and the traverse are returned to given positions. When the magnetic head 8 and the traverse are returned to the given positions, the positional relation between the optical head 6 and the magnetic head 8 is still out of order. Thus, if the magnetic head 8 is moved together with the optical head 6 without correcting the positional relation therebetween, the magnetic head 8 can not accurately access a given magnetic track 67 on a radius equal to the radius of a currently-accessed optical track 65. The previously-mentioned positional setting is done at least once when the recording medium is inserted into the apparatus. Thereby, there is provided an advantage such that a simple structure can increase the

positional accuracy of access to a given magnetic track 67 by the magnetic head 8. This is an important function in realizing a home-use low-cost apparatus.

Fig. 120 shows another design in which a traverse connecting portion 366 includes a flexible member such as a leaf spring. The traverse connecting portion 366 is guided by a connecting portion guide 375. An optical head 6 and a magnetic head 8 are connected by the traverse connecting portion 366 and the guide 375. Thus, the optical head 6 and the magnetic head 8 can move together in a direction 51. Thus, it is possible to obtain the advantage which results from the linkage between the movements of the two heads as previously described with reference to Fig. 117. Since the traverse connecting portion 366 is flexible, the magnetic head 8 can be easily lifted in a direction 51a. Thus, there is an additional advantage such that the magnetic head elevator can easily lift the magnetic head 8 during the insertion of the recording medium 2 into the apparatus.

The design of Fig. 117 may be modified into a design of Fig. 126 in which the distance between the optical head 6 and the magnetic head 8 is always equal to a given value Lo. In this case, the optical head 6 and the magnetic head 8 are moved in equal directions 51a and 51b. Since the distance between the magnetic head 8 and the optical head 6 can be set large, there is an advantage such that the transmission of noise from the optical head to the magnetic head can be suppressed. This design is effective in noise suppression especially for a small-diameter recording medium such

as an MD.

In the previous description of this embodiment, the magnetic head and the optical head are angularly separated by 180° with respect to the center of the disk as shown in Fig. 117. The angular separation between the two heads may be 45°, 60°, 90°, or 120°. In these cases, provided that the shortest distance between the two heads is 10 mm or more, it is possible to obtain an advantage such that the level of noise can be adequately decreased.

It is preferable to adopt one of the previously-mentioned countermeasures to noise or a combination of two or more of the previously-mentioned countermeasures to noise.

In the case where the electromagnetic shield with respect to the optical head 6 is adequately effective, the optical head 6 and the magnetic head 8 can be opposed to each other in a vertical direction as shown in Fig. 119. In this case, by providing positional references 364a and 364b, there is provided an advantage such that the accuracy of positional alignment between the two heads can be increased. The above-mentioned opposed configuration has an advantage such that the apparatus can be miniaturized since all the parts can be located at one side of the disk.

Next, a recording format will be described. With respect to an optical disk for data, a CAV (constant angular velocity) is provided and thus the rotational speed thereof remains the same even when the radius of the optical disk varies. In the application to a CD ROM, the rotation of a disk is controlled at a CLV (constant linear velocity) so that the linear speed remains constant although the rotational

speed depends on the radius of a track. In this case, it is difficult to adopt a recording format of a conventional floppy disk or a conventional hard disk. In the application to a CD ROM, to increase a recording capacity, this invention uses the following design. As shown at 370a, 370b, 370c, 370d, and 370e in Fig. 122, the data capacities of respective tracks are larger as they are closer to the outer edge of the disk. A head of data has a sync portion 369 and a track number portion 371 followed by a data portion 372 and a CRC portion 373. The capacity of the data portion 372 depends on the track. The CRC portion 373 is used for error check. A gap portion 374 having no signal is set after the CRC portion 373 so that a sync portion 369b in a next head or others can be prevented from being erroneously erased even when the linear velocity is different during the recording. This design has an advantage such that, in the case of a CD, the recording capacity is equal to about 1.5 times the recording capacity which occurs in the design where respective tracks are set to equal capacities as in a conventional floppy disk. In addition, since the magnetic head executes the magnetic recording and reproduction by directly using the CLV rotation control of the motor in response to the signal of the optical head for the CD, there is an advantage such that a motor control circuit exclusively for the magnetic recording can be omitted.

Next, physical formats on a disk will be described. The physical formats are of two types, a "normal mode" and a "variable track pitch mode". As shown in Fig. 123, magnetic tracks 67a, 67b, 67c, and 67d are located at opposite (back) sides of optical tracks

65a, 65b, 65c, and 65d, and the tracks are arranged at equal track pitches Tpo according to the "normal mode".

This invention adopts a "variable angle" system. As shown in Fig. 117 and Fig. 119, in this invention, the angular separation between the optical head 6 and the magnetic head 8 is equal to one of various values such as 0^{o}, 180^{o}, 45^{o}, and 90^{o}. Generally, in a conventional recording and reproducing apparatus of the rotational magnetic disk type, sync portions 369 of data, that is, indexes 455, are located at positions with a given angle as seen from the center of the disk. In the case of index of the variable angle system of this invention, as shown in Fig. 123, the angle of the location of the sync portion 369 at the data starting point can be arbitrarily chosen with a pitch of 17.3 mm in the circumferential direction by defining a given MSF optical block of the optical record portion as index. In this case, as shown in Fig. 214, provided that optical frame MSF information is recorded as index for every track, index information can be obtained simultaneously with tracking. In the case where "sync" following the MSF is used as index, recording can be started with an accuracy corresponding to 170.8 μm as shown in Fig. 213. In this case, although magnetic recording can be accurately started from the sync portion 369 in response to the index, the magnetic recording can not be always ended accurately. If the magnetic recording is not accurately ended, the last portion of the record signal is written over the sync portion 369. To prevent such a problem, it is necessary to know the number of optical pulses per round. Accordingly, rotation is designed to start from the optical

record portion of index. At a mid time point, the optical beam is returned to the original track by one track. Thus, the reproduction is again made on the optical address corresponding to the index. Accurate one revolution can be performed provided that the number of optical pulses which occurs during this interval is recorded. The data obtained through the measurement in this way is recorded on the magnetic record portion of the magnetic track-optical address correspondence table, that is, the track 0 or the track 1. Thereby, it is unnecessary to measure the pulse number again.

Since the physical frame number and the MSF block number corresponding to one revolution (round) are known, the magnetic recording can be ended with a high accuracy corresponding to 170 μm. Therefore, the sync portion 369 can be prevented from being damaged while the gap 374 can be minimized so that a greater recording capacity is enabled.

In this case, it is necessary to promptly get sub code data to establish synchronization. In Fig. 211, after an optical reproduced signal is subjected to EFM decoding, a sub code sync detector 456 obtains given MSF sub code. In more detail, with reference to Fig. 215, an index detector 457 receives the sub code from the sub code sync detector 456, and compares it with sub code in an optical address of a given magnetic track. When the two are equal, the index detector 457 controls a data buffer 9b to output data therefrom to start data recording from the sync of a block following the index address. Since this design uses the sub code information which can be obtained fastest, there is an advantage such that a

delay time is short and the reproduction is accurately started with the head of a desired tune.

In the case where data in the optical address which corresponds to index is damaged, magnetic recording on the track is difficult. To solve such a problem, as shown in Fig. 214, an error-free optical address following the wrong address is defined, and the optical address MSF information thereof is recorded on the magnetic track table of the magnetic record portion so that the track in question can be used again.

This design makes it possible to omit a detecting circuit or a detector for the absolute angle of the disk. The recording of a head portion can be started from a part of an arbitrary angle. Therefore, in the case of a CD, data recording can be started immediately after the reading of given optical address information in the optical record portion such as sub code which forms index. Thus, during reproduction, immediately after the optical information of the track is read out, the sync portion in the head of magnetic data starts to be reproduced. Accordingly, a loss time being a rotation waiting time is completely removed from the period of magnetic data recording and the period of reproduction, and a substantive data access time is shorter. This advantage is great especially in the case where recording and reproducing apparatus of equal types are used.

Next, the "variable track pitch mode" will be described. As in a game machine, a general ROM disk is inserted into the apparatus. At the start of a program, information is first read out from a track of a TOC region, and information is read out from a given track

recording the program and information is read out from a given track recording data. This sequence is the same at every starting.

In the case where a CAV optical disk is used, it is now assumed that, as shown in Fig. 124, access is made with respect to decided tracks such as a first track 65b, a 1004-th track 65c, a 2004-th track 65d, and a 3604-th track 65e. In the case where the hybrid disk of this invention is used, if magnetic information necessary for starting is present in a magnetic track out of alignment with the back side of an optical track accessed during the starting, wasteful access to the magnetic track is executed in addition to access to the optical track. Thus, the completion of the starting is delayed commensurately. In the case of the equal intervals of the "normal mode", there is a small possibility that the center of the magnetic track comes into alignment with the back side of the optical track. Therefore, it is necessary to access another magnetic track, and the speed of the starting is slow also in this case. The "variable track pitch mode" of this invention features that the magnetic tracks 67b, 67c, 67d, and 67e are defined at the back sides of the four optical tracks 65b, 65c, 65d, and 65e which are required to be read out at the starting. The track numbers and the address information of the optical recording portion which forms index and which corresponds to the track numbers are recorded on the TOC region of the optical recording portion or the TOC region of the magnetic recording portion. In the case of a CD, subcode information is recorded thereon. Data to be read out at the starting is set so as to be recorded on the magnetic track, and the

data represents a game gain item number, a progress degree, points, a personal name, and others. Thereby, at the starting, the magnetic track which records the information necessary for the starting is automatically accessed at the same time as access to optical data, and the information is read out from the magnetic track. Thus, a loss time is nullified, and there is an advantage such that the starting time is very short. In this case, as shown in Fig. 124, the track pitches between the tracks are equal to random values as Tp1, Tp2, Tp3, and Tp4. Therefore, although the recording capacity is slightly lowered, this design is effective to use which needs high-speed starting.

The "variable pitch mode" and the "variable angle mode" are effective to music use, for example, accompaniment use. In the case where this invention is applied to accompaniment use, personal environment setting data can be recorded and stored which represents musical intervals for respective music numbers desired by persons respectively, desired tempos of respective music numbers, desired amounts of echo, respective desired parameters of DSP, and others. Thereby, there is provided the following advantage. Provided that data setting is done once, only by inserting an accompaniment CD into an accompaniment machine, music is reproduced automatically with the musical intervals, the tempos, and the echoes desired by the respective persons. Thus, it is possible for the respective persons to enjoy the accompaniments under conditions well suited to the abilities and the tastes of the persons. In this case, magnetic tracks at the back sides of the

optical tracks 65b, 65c, 65d, and 65e for determining the heads of music numbers are defined, and personal accompaniment data regarding the music numbers are recorded on the magnetic tracks 67b, 67c, 67d, and 67e. In the case where the accompaniment on the optical track 65c is selected, the related personal accompaniment data is recorded on the magnetic track 57 at the back side thereof. During the start of reproduction of a given music number, the musical interval, the tempo, and the echo of the music number are set in a period of one revolution of the disk and the reproduced music starts to be outputted. Thus, also in music use, the "variable pitch mode" provides an advantage such that both optical data and magnetic data can be quickly accessed. In general music use, this design is effective when environment setting about, for example, DSP sound fields for respective music numbers, is used.

In the case where this invention is applied to a CD ROM, when the magnetic coercive force Hc is set to 1,750 Oe, a RAM capacity of about 32 kB can be attained. The optical recording surface of a CD ROM has a ROM capacity of 540 MB. Thus, there is a capacity difference by about one hundred thousand times. In most of actual products using a CD ROM, the 540-MB capacity thereof is not fully used. Generally, a CD ROM has an unused or free capacity of at least several tens of MB. This invention uses the free area of the ROM and records data compressing and expanding programs and various data compressing reference tables into the ROM to execute the compression of data recorded into the RAM.

The data compressing design will now be described with reference to Fig. 125. In the case of a game machine, the optical recording portion 4 is previously loaded with information closely related to game contents possibly required during the execution of a game program, for example, data compressing reference tables such as a place name reference table 368a and a person's name reference table 368b. The free area in the ROM is large, and various reference tables can be prepared which are of information having a high possible use frequency among words such as person's names, place names, and numeral sequences. If the word "Washington" is directly recorded on the magnetic recording layer 3 forming the RAM, an area of 80 bits is consumed. On the other hand, in this invention, the data compressing reference table 368a defines "Washington" as a binary code "10", and thus the 80-bit data is compressed into the 2-bit data "10". The compressed data is recorded on the magnetic recording layer 3, and thereby the information is recorded while the used capacity is reduced by a factor of 1/40. It is known that general data compression techniques provide data compression corresponding to double or three times. Provided that use is limited, data compression by a factor of 10 or more can be done according to this data compressing design. Thus, the 32-kB magnetic recording capacity of a CD ROM is substantially equivalent to the 320-kB magnetic recording capacity of a magnetic disk. As previously described, in the hybrid disk of this invention, the ROM area of the optical recording portion is used in compressing data to be stored into the RAM, and thus there is an advantage such that the

logical RAM capacity is virtually-increased although the physical ROM capacity decreases. In Fig. 125, since the data compressing and expanding programs are stored in the ROM of the optical record portion, the substantive capacity of the RAM is prevented from decreasing. The data compressing and expanding programs may be stored in the magnetic record portion. The data compressing design may use a Huffman optimal coding method or a Ziv-Lempel method. In the case of the Ziv-Lempel method, previously-prepared reference tables and Hash functions are recorded in the optical record portion, and thereby record data in the magnetic record portion can be compressed.

The overall operation of the recording and reproducing apparatus will be described hereinafter with reference to Fig. 127 and Fig. 128. The system controller 10 operates in accordance with a program, the flowchart of which is shown in Fig. 127 and Fig. 128.

Under conditions where the magnetic head is lifted, a step 410 places a disk into a correct position. Then, a step 411 returns the magnetic head to the normal position. A step 412 moves the optical head to a TOC track, and a step 413 reads out optical data from the TOC track. A first way uses control bits, that is, Q1-Q4 bits of the sub code in Fig. 213. The magnetic layer can be recognized provided that a recording medium is defined as being with the magnetic recording layer when Q3=1. In Fig. 213, there are already used conditions of Q1, Q2, Q3, Q4=0, 0, 0, 0, conditions of Q1, Q2, Q3, Q4=1, 0, 0, 0, conditions of Q1, Q2, Q3, Q4=0, 0, 0, 1, conditions of Q1, Q2, Q3, Q4=1, 0, 0, 1, and conditions of Q1, Q2,

Q3, Q4=0, 1, 0, 0. Thus, conditions of Q1, Q2, Q3, Q4=0, 1, 1, 0 are defined as a magnetic data track. In this case, the magnetic track format information can be recorded in the TOC. Specifically, as shown in Fig. 214, there are recorded physical positions in a CD optical record portion which form indexes corresponding to starting points of recording and reproduction of respective magnetic tracks. For example, in the case of the first track, when the optical head accesses the MSF or the block of 3-minute 15-second 55-frame, the magnetic head accesses the first track. As shown in Fig. 213, the index indicating the record starting position enables an accuracy corresponding to 17.3 mm with the MSF information only. The use of a given frame in a given MSF enables an index signal to be obtained at a higher accuracy, for example, an accuracy of 176 μm. Thus, in the case where index is made from the sync signal in a block following the given MSF block and the recording is started, the reproduction can be started from a head of a desired tune at an accuracy of 176 μm. In this case, as described with reference to Fig. 123, CLV is adopted so that indexes of the respective tracks are different. The different indexes do not adversely affect actual recording and reproduction. Since the use of the MSF information obtains the index in this way, it is unnecessary to provide special index. The readout data contains a flag representing whether or not the optical disk has a magnetic recording portion, address information such as CD subcode numbers corresponding to the positions of magnetic tracks for defaults of magnetic data, and information representing whether or not the

variable pitch mode is present. - A step 414 checks the presence of the flag of the magnetic recording layer. When the result of the check is Yes, an advance to a step 418 is done. When the result of the check is No, a step 415 reads out an optical mark representing whether or not the magnetic recording layer on the magnetic recording surface or others is present. When a step 416 detects the absence of the optical mark, a jump to a step 417 is done so that magnetic recording and reproduction regarding the present disk are not executed.

The program enters a magnetic recording and reproducing mode at the step 418, and advances to a block 402 which executes initial setting of the magnetic track. A step 419 in the block 402 moves the magnetic head downward onto the surface of the recording medium, and a step 420 reads out magnetic data from the TOC area. Then, a step 421 lifts the magnetic head to prevent wear thereof. A step 422 checks whether or not an error flag representing error conditions of the magnetic data is present. When a step 423a detects the presence of the error flag, an advance to a step 427a is done. The step 427a ejects the optical disk, and a step 427b indicates "clean optical disk" on a display of the apparatus. Then, a step 427c stops the program.

On the other hand, a step 424 checks whether or not the default value recorded on the optical recording surface is good with the optical address correspondence table of the respective magnetic tracks. When the result of the check is No, a step 426 updates the contents of a part of the magnetic track-optical address

correspondence table in response to the magnetic data information of the TOC track. The updated table is stored into an internal memory of the apparatus. When the result of the check is Yes, an advance to a step 428 is done.

When the step 428 detects the presence of a reading instruction regarding the magnetic track, an advance to a step 440 is done. Otherwise, an advance to a step 429 is done. In cases other than the variable track pitch mode, an advance to the step 440 is done. In the case of the variable track pitch mode, a step 430 sets an optical track group number n to 0. A step 431 increments n by 1. When a step 432 detects that n is equal to a final value, a jump to a step 438 is done. Otherwise, a step 433 accesses a heading optical track in the n-th optical track group. When a step 434 detects that the default magnetic track is good, a step 436 moves the magnetic head downward onto the surface of the recording medium. Then, a step 437 reads out magnetic data and stores the readout data into the internal memory of the apparatus, and a return to the step 431 is done. On the other hand, when the optical address corresponding to the magnetic head is the default value so that bad conditions are detected, a step 435 accesses an optical address other than the default value. Then, steps 436 and 437 read out magnetic data, and a return to the step 431 is done. The step 431 increments n by 1. When n reaches the final value at the step 432, reading out the optical data and the magnetic data is completed at the step 438. Therefore, in the case of a game machine, a game program is started, and the game scene

which occurs at the previous end is retrieved on the basis of the data recorded on the magnetic recording portion. A step 439 lifts the magnetic head, and an advance to a step 446 is done.

When the step 429 detects the absence of the variable track pitch mode, a jump to a step 440 is done. When the step 440 detects the absence of the normal track pitch mode, a jump to a step 446 is done. Otherwise, a step 441 receives an instruction of accessing the n-th magnetic track. A step 442 derives the optical address corresponding to the n-th magnetic track by referring to the information in the internal memory of the system controller 10, and a step 443 accesses the optical address. Then, a step 444 reads out magnetic data, and a step 445 stores the readout data into the internal memory and a jump to the step 446 is done.

The step 446 checks whether or not a rewriting instruction is present. When the result of the check is No, a jump to a step 455 is done. When the result of the check is Yes, a step 447 is executed. The step 447 checks whether or not a final storing instruction is present. When the result of the check is Yes, an advance to the step 427a (or the step 455) is done. When the result of the check is No, an advance to a step 448 is done. The step 448 checks whether or not data desired to be rewritten is present in the internal memory of the apparatus. When the result of the check is Yes, a jump to a step 454 is done so that the magnetic recording is not executed but only rewriting of the internal memory is executed. When the result of the check is No, a step 449 refers to the magnetic track-optical address correspondence table and accesses the given optical track.

Then, a step 450 moves the magnetic head downward, and steps 451, 452, and 453 execute reading out the magnetic data, storing the readout data into the internal memory, and lifting the magnetic head. A step 454 rewrites or updates the information transferred into the internal memory, and then an advance to the step 455 is done.

The step 455 checks whether or not a final storing instruction is present. When the result of the check is No, an advance to a step 458 is done. The step 458 detects whether or not the work has been completed. When the work has been completed, an advance to a step 476 is done. Otherwise, a return to the step 428 is done. When the result of the check at the step 455 is Yes, an advance to a step 456 is done. The step 456 extracts only updated data from the magnetic data in the internal memory, and a step 457 detects whether or not updating is present. In the absence of updating, an advance to a step 458 is done. In the presence of updating, a step 459 accesses the optical address of the corresponding magnetic track. Steps 460, 470, and 471 execute moving the magnetic head downward, recording magnetic data immediately after the detection of the optical address, and checking the recorded data. When a step 472 detects that the error rate is large, a jump to a step 481 is done. The step 481 lifts the magnetic head, and a step 482 cleans the magnetic head with the head cleaning portion. A step 483 executes the recording again and checks the error rate. When the error rate is good, an advance to the step 428 is done. When the error rate is bad, a jump to the step

427a is done.

When the step 472 detects that the error rate is small, an advance to a step 473 is done. The step 473 checks whether or not the recording has been completed. When the result of the check is No, a return to the step 470 is done. When the result of the check is Yes, a step 474 lifts the magnetic head. A step 475 checks whether or not all the work has been completed. When all the work has been completed, an advance to a step 476 is done. Otherwise, a return to the step 428 is done.

The step 476 lifts the magnetic head, and a step 477 cleans the magnetic head with the head cleaning portion. Then, a step 478 detects whether or not an ejecting instruction is present. In the presence of the ejecting instruction, a step 479 ejects the optical disk. In the absence of the ejecting instruction, a step 480 stops the program.

A band pass filter tuned to a frequency band equal to a frequency distribution of a reproduced signal from the magnetic head may be provided in the drive circuit for the actuator 18 to remove noise. Electromagnetic noise may be reduced by the following design. After access to a magnetic head, a drive current to the actuator for the optical head 6 is turned off. Then, reproduction is executed by the magnetic head. When the reproduction is completed, driving the actuator is restarted.

In most of conventional CD's, a thick films of print ink are applied to the back sides thereof by screen printing or others, so that there is a roughness of several tens of μm. When the magnetic

head is brought into contact with such a CD, print ink is removed or damaged. As shown in the ON state of Fig. 115, the recording medium 2 having a magnetic shield layer 69 is inserted into the apparatus. In this case, the transmission of electromagnetic noise from the actuator for the optical head 6 is remarkably suppressed as compared with the OFF state of Fig. 115 in which the recording medium 2 having no magnetic shield layer 69 is inserted into the apparatus. The noise is outputted from the magnetic head reproducing circuit 30, and can be easily detected. Accordingly, even when the magnetic head 8 is not brought into contact with the magnetic recording layer 3, the recording medium of this invention can be discriminated from a conventional recording medium such as a CD. Only when the recording medium of this invention which has the magnetic recording layer is inserted into the apparatus, the magnetic head 8 is brought into contact with the surface of the recording medium. Thus, the magnetic head is prevented from contacting the back side of a recording medium such as a CD or an LD which has no magnetic recording layer. Therefore, there is an advantage such that the magnetic head is prevented from damaging the optical recording surface of the recording medium and printed matters on the back side of the recording medium.

According to another design, in Fig. 111, a discrimination code signal denoting the presence of a magnetic recording layer in a recording medium is previously recorded on a TOC area of the optical recording portion of a CD or on an optical track portion near the TOC area. First, optical TOC information is read out from a

recording medium while the magnetic head is held out of contact with the recording medium. Only when the discrimination code signal for the presence of the magnetic layer is detected, the magnetic head 8 is moved into contact with the recording medium. In this design, when a conventional CD is inserted into the apparatus, the magnetic head 8 does not contact the optical recording side and the label side of the recording medium. Thus, there is an advantage such that a damage to the conventional CD can be prevented. It may be good that a given optical mark is provided on the print surface of an optical disk, and a magnetic recording layer is decided to be present only when the optical mark is detected.

DESCRIPTION OF THE FOURTEENTH PREFERRED EMBODIMENT

Fig. 134 shows a recording and reproducing apparatus according to an eighteenth embodiment of this invention which is similar to the embodiment of Fig. 110 except for design changes which will be described later. Information recording and reproduction into and from a magnetic recording portion 3 of a recording medium 2 are executed through modulation and demodulation responsive to an optical-system clock signal 382 which is extracted from a reproduced signal related to an optical recording surface of the recording medium 2.

In Fig. 134, an optical reproducing circuit 38 includes a clock reproducing circuit 38a which recovers the optical-system clock signal 382 from the optically reproduced signal. A clock circuit 29a contained in a magnetic recording circuit 29 subjects the optical-

system clock signal 382 to frequency division, generating a magnetic-system clock signal 383. The magnetic-system clock signal 383 is used as a reference in modulation executed by a modulating circuit 334 in the magnetic recording circuit 29. These conditions are shown in Fig. 216. The optical-system clock signal from the clock reproducing circuit 38a has a frequency of 4.3 MHz. The optical-system clock signal is down-converted to the modulation clock signal for the MFM modulator 334 of this invention which has a frequency of 15-30 KHz, and magnetic recording is done. Starting with a head of a tune is performed through the detection of an optical address by an index detector 457 as previously described. In this case, the control of rotation of a motor is performed in response to the optical signal. As shown in Fig. 218, the magnetic recording is started by a periodical signal after the optical index.

During the reproduction of information from the magnetic recording portion of the recording medium 2, a clock circuit 30a in a magnetic reproducing circuit 30 recovers a magnetic-system clock signal 383, and the magnetic-system clock signal 383 is used as a reference in demodulation executed by a demodulating section 30b in the magnetic reproducing circuit 30.

With reference to Fig. 217, a detailed description will now be given of operation which occurs during the magnetic reproduction. After the reproduction is made on the optical address for the index, a power supply to an actuator of an optical pickup portion 6 is turned off to prevent the occurrence of electromagnetic noise as

shown in Fig. 218(d). Then, the magnetic reproduction is turned on, and the control of the rotation of the motor and the demodulation of data are done in response to the magnetic record signal. The reproduced signal from a magnetic head 8 is shaped by a wave shaper 466, and a clock reproducing section 467 reproduces a clock signal therefrom. The reproduced clock signal is fed to a pseudo magnetic sync signal generator 462. A magnetic sync signal detector 459 reproduces a magnetic sync clock signal, and an MFM demodulator 30b executes demodulation into a digital signal. The demodulated signal is subjected by an error correcting section 36 to error correction before being outputted as magnetic reproduced data.

The magnetic reproduced signal corresponds to frequency division of the optical reproduced signal by a given factor. Immediately before a change from "optical" to "magnetic", the signal resulting from the frequency division of the optical reproduced clock signal continues to be fed to a PLL 459a of the magnetic sync signal detector 459 as reference information. The central frequency of the PLL locking is set close thereto. Accordingly, upon a change from "optical" to "magnetic", the frequency lockup is executed in a short time according to the magnetic reproduced clock PLL. In this way, the magnetic recording clock signal is generated by the frequency division of the optical reproduced clock signal, and the magnetic recording is done in response to the magnetic recording clock signal. This design is advantageous in that the optical reproduced clock signal can be replaced by the

magnetic reproduced clock signal in a short time upon a change of the optical head 6 into an off state during the reproduction of the magnetic signal. In the case where the optical head 6 and the magnetic head 8 fixedly travel on the same circumference or different circumferences, a constant division ratio is good. In the case where the heads travel on different circumferences without being fixed, the radiuses rM and ro of the circumferences are derived and the division ratio is corrected in accordance with the derived radiuses.

A description will now be given of the way of the rotation control. With respect to the rotation control during the optical reproduction, a pseudo optical sync signal generator 461 and a shortest/longest pulse detector 460 in a motor rotation controller 26 of Fig. 217 generate an optical sync signal. A motor controller 261a controls the rotational speed of a motor 17 at a prescribed rotational speed in response to the optical sync signal. At this time, a change switch 465 is in a position "B". When an optical sync signal detector 465 establishes synchronization, it feeds a changing command to the change switch 465 so that the switch 465 changes from the position "B" to a position "A". Thus, the motor 17 rotates at the synchronized rotational speed.

With reference to Fig. 218, at t=t2, the optical reproduction is turned off and is replaced by the magnetic reproduction. Immediately thereafter, the MFM period T of the magnetic reproduced signal is measured by the wave shaper 466, and thereby the magnetic sync signal having a frequency of 15 KHz or 30 KHz

can be obtained. The obtained magnetic sync signal is processed by the pseudo magnetic sync signal generator 462 and a frequency divider/multiplier 464 into a clock signal matching in frequency to the optical rotation sync signal and being fed to the change switch 465. Immediately after a change from "optical" to "magnetic", the change switch 465 moves from the position "A" to a position "C" so that rough rotation control is executed. During a later period, when the locking is established through the PLL 459a in the magnetic sync signal detector 459, the change switch 465 moves from the position "C" to a position "D" so that accurate rotation control responsive to the magnetic sync signal will be started. With reference to Fig. 218, at a moment of t=t3, the magnetic reproduced signal is synchronous with the reproduced clock signal so that the magnetic data will be continuously demodulated.

It is now assumed that an error is caused by a scratch on the recording medium surface at t=t4, and the error continues for a certain time tE. In this case, at t=t5, the magnetic reproduction is turned off while the optical reproduction is turned on. During a period tR, the rotation control responsive to the optical reproduced signal is done to stabilize the rotation of the motor.

At t=t7, the period tR terminates, and the optical reproduction is turned off while the magnetic reproduction is turned on. Since the error has ended, the change of the rotation control from "optical" to "magnetic" is completed in a short time. At t=t8, the magnetic record sync signal is reproduced so that data 5 is surely reproduced. In this way, the error is compensated. As

previously described, the magnetic reproduction is executed while the rotation control responsive to the optical reproduced signal and the rotation control responsive to the magnetic reproduced signal are changed in a time division manner. This design is advantageous in that the reproduction of the magnetic signal is prevented from being adversely affected by the electromagnetic noise caused by the optical pickup portion during the optical reproduction. Also in the case where the magnetic head 8 and the optical head 6 are separated by 1 cm or more, the magnetic reproduction is enabled by using the system of Fig. 217 and Fig. 218. In this case, the optical reproduction and the magnetic reproduction can be simultaneously executed.

As shown in Fig. 135, the velocity ω of rotation of the recording medium 2 tends to fluctuate due to a variation in rotation of a drive motor which is generally referred to as "a wow flutter". In a conceivable design where the frequency of a magnetic recording clock signal is fixed, the recording wavelength λ of a magnetically recorded signal on a recording medium 2 tends to vary even in one track according to the wow flutter. On the other hand, in the recording and reproducing apparatus of Fig. 135, since the magnetic-system clock signal 383 is generated on the basis of the optically reproduced signal through frequency division and the magnetic recording is executed in response to the magnetic-system clock signal 383, the affection of the wow flutter is canceled so that the magnetically recorded signal on the recording medium 2 has an accurate constant period. Therefore, there is an advantage such

that accurate recording can be realized even at a short recording wavelength. In addition, since a given time part of the recorded signal can be accurately located in one round of a track, a gap portion 374 (see Fig. 123) for preventing overlapped record can be set as small as possible. During the reproduction of a magnetically recorded signal, the optical-system clock signal is subjected to frequency division so that the magnetic-system clock signal for demodulation can be accurately recovered as shown in Fig. 132. Thus, a decision or discrimination window time 385 (Twin) for the demodulation in the reproduction can be set short, and the data discrimination performance can be enhanced and also the error rate can be improved.

As denoted by "data 1" in Fig. 132, according to conventional two-value (bi-value) recording, only one bit can be recorded per symbol. On the other hand, in this embodiment, two bits or more can be recorded per symbol as will be described hereinafter. Specifically, as shown in "reproduce 2" in Fig. 132, a signal 384 to be magnetically recorded can be subjected to pulsewidth modulation (PWM) by using an accurate time Top determined by the optical-system clock signal 382. Four digital values "00", "01", "10", and "11" are assigned to four different recorded signals 384a, 384b, 384c, and 384d respectively which can result from pulsewidth modulation of a 1-symbol waveform. Thus, two bits can be recorded per symbol so that an increased amount of recorded data can be realized.

If recording is executed at uniform periods To, the value of

$\lambda/2$ is equal to t3'-t3=To-dT and is thus smaller than the shortest record period Tmin so that the accuracy of recorded information can not be maintained regarding the signal 384d of Fig. 150. Accordingly, in the case of the signal 384d, a new starting point is set to the moment t3 and the magnetic-system clock signal is shifted by the time dT. Thus, a discrimination (decision) window 384 for detecting "00" of "data 2" is defined by a moment t4=t3'+dT. In addition, pulses which occur moments t5, t6, and t7 are decided to be "01", "10", and "11" respectively. In this way, the 2-bit data is demodulated.

When the pulsewidth modulation is designed so that eight different modulated signals can be generated, three bits can be recorded per symbol. When the pulsewidth modulation is designed so that sixteen different modulated signals can be generated, four bits can be recorded per symbol. In these cases, a more increased amount of recorded data can be realized.

The optical recording wavelength is 1 μm or less while the magnetic recording wavelength equals a larger value of, for example, 10 μm to 100 μm, due to a great space loss. Thus, when a pulse interval (pulsewidth) is measured by using the optical-system clock signal as a reference, a higher resolution in the measurement is attained. The combination of PWM and the optical-system clock signal provides a recording capacity remarkably greater than the recording capacity realized by conventional two-value recording.

In this embodiment, a region in the magnetic recording portion of the recording medium 2 is designed according to a use.

In the case of a CD ROM for a game machine or a CD ROM for a personal computer, a large recording capacity is required, and thus recording regions for tracks are set over an entire surface of the recording medium 2. Music CD's generally require only several hundreds of bytes for recording information of music names, a music order, copy guard (protection) code, and others. Thus, in the case of music CD's, recording regions of one track to several tracks are set, and a remaining area except a magnetic track portion can be used for other purposes such as a screen print area with unevenness.

One magnetic track may be provided on an outer area or an inner area of the optical recording surface side of a recording medium. In the case of one track, as shown in Figs. 84(a) and 84(b), recording material can be added to an exclusive playback disk by additionally providing the elevating motor 21, the elevating circuit 22, the magnetic recording and reproducing block 9, and the magnetic head 8. This design is advantageous in that the apparatus structure is simple and the apparatus cost is low. When one track is provided on an inner area of the recording medium, the recording capacity of that one track is relatively small. When one track is provided on an outermost area of the recording medium such as a magnetic track 67f of Fig. 124, the recording capacity of that one track is 2 KB at a wavelength of 40 μm. In this case, since a mechanism for accessing the track is unnecessary, there is an advantage such that the apparatus structure can be simple and small.

In this case, when a CD is inserted into the apparatus, the

TOC of the optical track 64a in Fig. 124 is read out by the optical head 6 and simultaneously the rotational motor 17 is subjected to CLV drive in response to the clock signal of the TOC. Since the TOC radius of the CD is constant, rotation at a constant velocity is enabled. Under these conditions, the magnetic recording and reproduction are executed. The sync signal and the index signal for the magnetic recording are read out from the optical track 65. It is now assumed that, as shown in Fig. 84, information indicating the presence of the magnetic recording layer 3 is in an optical track 65 at or near the TOC area. The optical recording block 7 detects this information, driving the head elevating motor 21 and bringing the magnetic head 8 into contact with the magnetic recording layer 3 as shown in Fig. 84(b) to execute the reproduction of the magnetic record signal.

The reproduced data is temporarily stored into the memory 34 of the recording and reproducing apparatus 1, and updating is executed in response to the stored data to reduce the number of times of actual magnetic recording and reproduction and to reduce a wear.

The optical track 65a at the TOC and the outermost magnetic track 67f are simultaneously subjected to recording and reproduction, and are thus separated by a physical distance close to 3 cm as shown in Fig. 84. Therefore, as shown in Fig. 116, the degree of the entrance of electromagnetic noise caused by the optical head 6 into the magnetic head 8 is reduced by 34 dB.

In the one-track system, the magnetic recording layer 3 uses

an outer portion of the recording medium, and may be provided on the optical recording side of the recording medium. In the case where this design is applied to a CD player having an upper lid 38a as shown in Fig. 131, since the magnetic head 8a is accommodated under the CD, the CD player can be small in size and simple in structure.

In the case where the magnetic recording layer 3a of Fig. 131 is formed on the side of the transparent substrate 5 of the recording medium by a thick film fabrication technology such as a screen printing technology, there occurs an additional thickness or height of several tens of μm to several hundreds of μm. This additional height causes the magnetic head 8a to contact only the magnetic recording layer 3a but not contact the transparent substrate 5. Thus, the magnetic head 8a is prevented from damaging the transparent substrate 5. The provision of the magnetic recording portion reduces the capacity of the optical recording portion. In the case where the magnetic head 8a is fixed with being separated from the CD 2 by a distance ho of 0.22 mm or more, and where an elevating member 21b supported on the upper lid 38a forces a rubber roller 21d in a direction 51, the CD is deformed thereby so that the magnetic recording portion 3b contacts the magnetic head 8a. The pressure applied via the rubber roller 21d enables reliable contact between the magnetic recording portion 3b and the magnetic head 8a, and thus enables good magnetic recording characteristics.

In this case, as shown in Fig. 98, the magnetic track 67f is

provided by applying magnetic recording material to an outermost area of the side of the transparent substrate 5 of the CD recording medium through a screen printing technique. In fact, printing is done under conditions where a conventional CD is reversed to cause a back side thereof to face upward at a screen printing step. Such a recording medium can be made by a conventional CD manufacturing line.

If the magnetic head contacts the uneven screen print area or the transparent substrate on the optical recording side, the magnetic head and the print area or the transparent substrate tend to be damaged. In this embodiment, such a problem is resolved as follows. As shown in Fig. 131, the magnetic recording surface of the recording medium 2 is formed with an optical mark 387. The optical mark 387 may be provided on the opposite side of the recording medium 2. The optical mark 387 has printed data, such as a bar code, which represents the size of the magnetic recording region. An optical sensor 386 provided at a side of the magnetic head 8 serves to read out data or information represented by the optical mark 387 on the recording medium 2 in a known way. Specifically, an optical detector 386 having a combination of an LED and an optical sensor reproduces the bar code data. The optical mark 387 is generally located on or inward of a TOC portion of a CD. The optical mark 387 is used in preventing a damage from being caused by the magnetic head 8.

Specifically, as shown in Fig. 131(b) and Fig. 145(a), the bar code information read out from the optical mark 387 represents a

region of the magnetic recording layer of the CD in the radial direction, the value of the magnetic coercive force Hc of the magnetic recording material, a secret code for a copy guard, or the identification number of the CD. A mechanism or a circuit for moving the magnetic head 8 is activated in response to the readout information so that the magnetic head 8 can be prevented from contacting an area of the recording medium 2 except the region of the magnetic recording layer. Thus, a damage by the magnetic head 8 can be prevented.

This embodiment may be modified as follows. In the case of a CD, an area inward of a TOC region is not provided with an optical recording portion. As shown in Fig. 131(a), this area is formed with a transparent portion 388 extending below the optical mark 387. The optical head 6 serves to read out information from the back side of the optical mark 387 through the transparent portion 388. In this case, the optical sensor 386 can be omitted.

It should be noted that the optical sensor 386 may be provided at a side of the optical head 6. In this case, the optical sensor 386 is located at a fixed part of the recording and reproducing apparatus or the upper-lid type CD player of Fig. 131, and hence wiring to the optical sensor 386 can be simplified.

In addition, the optical sensor 386 may be designed so as to detect light which has passed through the optical mark 387. Furthermore, the optical sensor 386 may be common to an optical sensor for detecting the presence and the absence of a CD in the recording and reproducing apparatus.

According to one example, optical recording layers are formed at intervals through vapor deposition of aluminum or other substances so that a circumferential bar code or a concentric-circle bar code is provided as an optical mark. In this case, the optical mark can be formed during the fabrication of the optical recording film.

As shown in Fig. 131(b), Fig. 144(a), and Fig. 145(a), three films of a magnetic recording region 398, printed letters 45, and an optical mark 387 can be formed in a step of applying screen printed material 399 to a CD twice during the formation of a magnetic recording layer 3. The resultant print surface of the CD has a state such as shown in Fig. 145(a). When black material having a high magnetic coercive force Hc is used, a good contrast of the printed title letters 45 is attained. Provided that print ink is replaced by ink of magnetic material having a high magnetic coercive force Hc in a conventional CD manufacturing line, the recording medium 2 of this invention can be made through screen printing. Thus, the recording medium 2 of this invention, that is, a CD with a RAM, can be made at a cost similar to the cost of manufacture of a conventional CD.

As shown in Fig. 145(a), data "204312001" is read out from the bar code 387a. A screen printing machine 399 prints data of different ID numbers on CD's respectively. In the case where the screen printing machine 399 is inhibited from changing the printed contents from a CD to a CD having a copy protecting function, a circular bar code printer 400 prints a bar code 387a or numerals

387b representative of a disk ID number as shown in Fig. 144(a) and Fig. 144(b). In this case, normal ink may be used, and the resultant print surface has a state such as shown in Fig. 145(b). This design is advantageous in that the user can visually read the disk ID number. In the case where OCR numerals 387b representing a disk ID number are printed on a bar code area 387a, it is possible to confirm the disk ID number by either visual observation or use of an optical detector.

As shown in Fig. 144(a), a second printer 399a provides a magnetic recording region 401 of material having a high Hc of, for example, 4000 Oe, which is greater than that of a magnetic recording region 398. The magnetic recording region 401 can be subjected to reproduction by a normal recording and reproducing apparatus, but can not be subjected to record thereby. In a factory, a disk ID number or a secret code is recorded thereinto. This design is advantageous in that illegal copy of the disk is more difficult.

As shown in Fig. 146(a), an optical disk 2 is provided with a space portion 402a filled with magnetic powder 402 such as iron powder, and a magnetic portion 403 is provided at a top thereof. the magnetic portion 403 has a magnetic coercive force Hc comparable with that of iron. When the magnetic portion 403 is not magnetized, the magnetic powder 402 is not attracted by the magnetic portion 403 so that letters will not appear as shown in Fig. 145(a). After the magnetic portion 403 is magnetized by a multi-channel magnetic head, the magnetic powder 402 is attracted thereby so that the letters appear as shown in Fig. 146(b). In the

case where OCR letters are recorded as shown in Fig. 145(c), the user can visually read the OCR letters along a direction 51a. On the other hand, the magnetic head 8 can read out magnetic recorded information of a disk ID number or others from the magnetic recording portion 403. According to this design, it is sufficient that data of a disk ID number or others is magnetically recorded in an OCR configuration disk by disk in a factory. Thus, this design is advantageous in that conventional disk manufacturing steps can be used.

According to another design, a magnetic recording layer 3 is provided at an outer portion of the side of a transparent substrate 5 of a recording medium as shown in Fig. 98, and a copy guard signal is recorded thereon in a factory. This design enables the use of a conventional caddy. Therefore, this design is advantageous in that the compatibility between caddies is attained.

In the case of an exclusive playback MD-type disk, only one side has a shutter. By providing a magnetic layer on a side of a transparent substrate of the disk, this invention can be applied thereto.

Copy protection and key unlocking will now be described. It is now assumed that a CD contains 100 programs locked by logical keys. The user informs the program maker (the software maker) of a disk ID number and pays a given fee. The program maker replies key numbers, corresponding to the disk ID number, to the user. For example, the key number corresponding to the tenth program is recorded into the TOC area of the magnetic recording region of

the CD. When the tenth program is reproduced, the key information in the magnetic recording layer and the disk ID number in the optical mark are inputted into a use allowing program. If the key information is right, use of the program is permitted according to the use allowing program. In this way, during a later period, the program can be used without any additional operation. Thus, this design is advantageous in that the program can be used without inputting the key information after the key information has been inputted once. Since a disk ID number varies from disk to disk and can not be changed, a key can not be unlocked even if key information of a personal disk is inputted into another personal disk. Thus, this design is advantageous in that use of a program without paying a given fee can be inhibited.

As shown in Fig. 131, a portable CD player has a movable upper lid or door 389. When a CD is moved into and from the player, the upper lid 389 is open. In this embodiment, the magnetic head 8 and a magnetic head traverse shaft 363b move together with the upper lid 389. When the upper lid 389 assumes an open position, the magnetic head 8 and the upper lid 389 are separate from the recording medium 2 so that the movement of the recording medium 2 into and from the player can be easily performed. When the upper lid 389 assumes a closed position, the magnetic head 8 and the magnetic head traverse shaft 363b are close to the recording medium 2. Only when the execution of magnetic recording or reproduction is required, the magnetic head 8 is brought into contact with the recording medium 2 by a head

actuator 22.

The optical head 6 is subjected to tracking operation by a traverse actuator 23, a traverse gear 367b, and a traverse shaft 363a. The traverse gear 367b and traverse gears 367a and 367c are in mesh with each other. The drive force of the traverse actuator 23 is transmitted to the traverse gear 367c via the traverse gears 367a and 367b. In Fig. 151, as the traverse gear 367b is rotated clockwise by the traverse actuator 23, the magnetic head traverse shaft 367b is moved in the direction denoted by the arrow. In this way, the magnetic head 8 and the optical head 6 are moved together by equal distances in equal radial directions of the recording disk 2. Thus, provided that positional adjustment of the optical head 6 and the magnetic head 8 is previously executed, the optical head 6 and the magnetic head 8 are automatically enabled to access an optical track and a magnetic track at opposite positions on the surfaces of the recording medium 2 respectively when the upper lid 389 is closed. In this way, the mechanism for moving the magnetic head 8 and the magnetic head traverse 363b together with the upper lid 389 makes it possible to apply this embodiment to a CD player, and the recording and reproducing apparatus can be compact.

With reference to Fig. 133, a CD ROM cartridge has a lid 390 which can rotate between a closed position and an open position about a shaft 393 in a direction 51c. When the lid 390 is rotated to the open position, a CD ROM or a recording medium 2 can be moved into and from the cartridge. The CD ROM cartridge has a window and a movable shutter 301 for optical recording.

In this embodiment, the CD ROM cartridge has a movable shutter 391 which blocks and unblocks a window for magnetic recording. The magnetic-recording window is formed in the lid 390. The magnetic-recording shutter 391 is movably supported on the lid 390. The magnetic-recording shutter 391 and the optical-recording shutter 301 engage each other via a connecting portion 392. As the optical-recording shutter 301 is opened in the direction 51b, the magnetic-recording shutter 391 is moved in the direction 51a so that the magnetic-recording window is unblocked. In this way, the magnetic-recording window and the optical-recording window are simultaneously opened to enable the movement of a CD into and from the cartridge. The CD ROM cartridge of this embodiment is compatible with a conventional CD ROM cartridge.

DESCRIPTION OF THE FIFTEENTH PREFERRED EMBODIMENT

According to a fifteen embodiment of this invention, a magnetic recording layer 3 is provided on an outer surface of a cartridge 42 for a disk 2. Fig. 136 shows a recording and reproducing apparatus in the fifteenth embodiment. Figs. 137(a), 137(b), 137(c), and Figs. 138(a), 138(b), and 138(c) show conditions of recording and reproduction which occur when the cartridge is inserted into, fixed, or ejected from the apparatus. Figs. 139(a), 139(b), and 139(c) show sections of the conditions of Figs. 137(a), 137(b), 137(c).

An optical recording and reproducing section, and a magnetic recording and reproducing section of the apparatus of Fig. 136 are

basically similar to those of the apparatus of Fig. 87 and Fig. 110 except that the noise canceler is omitted from the magnetic recording and reproducing section.

The recording and reproducing apparatus 1 of Fig. 136 has an opening 394 for inserting the disk cartridge thereinto. Fig. 136 shows conditions where the cartridge 42 has been inserted in a direction 51.

In the case where the cartridge 42 is inserted into the recording and reproducing apparatus 1 as shown in Fig. 137(a), an optical sensor 386 reads out an optical mark 387 such as a bar code provided on a part of a label portion 396 of the cartridge. An optical reproducing circuit 38 in Fig. 136 reproduces data, and a clock reproducing circuit 389 reproduces a sync clock signal. The reproduced data is fed to a system controller 10. If a magnetic recording layer 3 is decided to be present, a head moving command is fed to a head actuator 21 so that a head elevating section 20 moves magnetic heads 8a and 8b toward the magnetic recording layer 3. Data in the magnetic recording layer 3 is read out by the magnetic heads 8a and 8b, being demodulated into original data by demodulators 341a and 341b of magnetic reproducing circuits 30a and 30b. At this time, a clock reproducing circuit 38a reproduces a sync clock signal on the basis of a signal in the optical mark 387. The use of the sync clock signal enables reliable demodulation even if a running velocity fluctuates. Therefore, this design is advantageous in that the data in the magnetic recording layer 3 can be surely read out even if the running velocity fluctuates due to a

shock upon the insertion of the cartridge 42 into the apparatus. In the case where identification information of a cartridge ID number, a software title, or others is recorded in the optical mark 387, data management can be done cartridge by cartridge.

Generally, only a single magnetic head 8 suffices. As shown in Fig. 136, two magnetic heads may be provided to execute the recording and reproduction of same data twice. This design improves a reliability in the readout of the data. A combining circuit 397 combines error-free portions of data 1 and data 2 into error-free complete data, thereby reproducing data containing index information such as TOC data information which is stored into an IC memory 34. The TOC data contains information of the results and the processes of the recording and reproduction, and the previous directory of the cartridge 42. Therefore, the progress of use and the contents of the optical disk can be detected upon the insertion of the cartridge 42 into the apparatus.

While the cartridge 42 remains in the apparatus as shown in Fig. 137(b), magnetic recording and reproduction are arbitrarily done to add new information or to delete the recorded information. In this case, the contents of the TOC needs to be changed. In this invention, the TOC data in the IC memory 34 is updated without rewriting the data in the magnetic recording layer 3. Thus, the new TOC data in the IC memory 34 is different in contents from the old TOC data in the magnetic recording layer 3. When the cartridge 42 is ejected from the apparatus as shown in Fig. 137(c), the data in the magnetic recording layer 3 is updated. The new data is

immediately reproduced by the magnetic head 8b, being checked and confirmed.

In the presence of multiple tracks such as three tracks, data updating is executed only on one, for example, a second one, of the tracks which requires a TOC data change, and thereby the number of errors is reduced during the recording. In this case, when the cartridge 42 is ejected from the apparatus as shown in Fig. 137(c), only third one of the tracks is subjected to recording by the magnetic head 8b.

In the presence of two heads as shown in Fig. 137, a recorded signal 68 is simultaneously read out by the magnetic head 8a, and error check is executed thereon. As shown in Fig. 139(c), a magnetic signal 68a which has been recorded by the magnetic head 8b can be checked by using the magnetic head 8a. If an error is present, an error message is indicated on a display section 16 of the recording and reproducing apparatus 1. An indication may also be given which represents "please insert the cartridge into the body again". In addition, a warning sound may be generated by a buzzer 397. Therefore, the user is forced to insert the cartridge 42 into the insertion portion 394 of the apparatus again. In the case where the cartridge 42 has been inserted into the apparatus again, TOC data is recorded once again when the cartridge 42 is ejected from the apparatus. The second recording has no error at a high probability. If such a process is repeated a given number of times, the magnetic recording layer 3 of the cartridge 42 is decided to be damaged while the ID number of the optical mark 387 is recorded.

During a later period, when the cartridge 42 having this recorded ID number, a command of lowering the magnetic head 8 is not issued to unexecute the readout of the data. The data of the ID number is stored in the IC memory 34 with being backed up. In this way, TOC data can be reliably recorded and reproduced into and from each cartridge 42. This design is advantageous in that the addition of a simple arrangement enables the detection of a table of contents of a recording disk upon the insertion of a related cartridge into the apparatus. For a recording medium side, the attachment of a magnetic label to a conventional cartridge 42 suffices.

DESCRIPTION OF THE SIXTEENTH PREFERRED EMBODIMENT

A sixteenth embodiment of this invention is similar to the fifteenth embodiment except that a disk cartridge is replaced by a tape cartridge. Specifically, a magnetic layer 3 provided with a protective layer 50 which has been described with reference to Fig. 103 is attached to an upper portion of a tape cartridge 42 for a recording and reproducing apparatus 1.

Fig. 140 shows a whole arrangement which is similar to the arrangement of Fig. 136 except for design changes indicated hereinafter. The recording and reproducing apparatus 1 of Fig. 140 has an insertion opening 394 for a VTR cassette or cartridge 42 Fig. 140 shows conditions where the cassette 42 is being inserted into the apparatus along a direction 51. Figs. 141 and 142 shows conditions where the cassette is placed in and out of the apparatus. Fig. 143 shows a transverse section of a magnetic head portion with

the cassette being placed in the apparatus.

In the case where the cartridge 42 is inserted into the recording and reproducing apparatus (VTR) 1 as shown in Fig. 142(a), an optical sensor 386 reads out an optical mark 387 provided on a part of a label portion 396 of the cartridge. Bar code information and a sync signal are recorded on the optical mark 387. An optical reproducing circuit 38 in Fig. 140 reproduces data, and a clock reproducing circuit 389 reproduces a sync clock signal. The reproduced data is fed to a system controller 10. If a magnetic recording layer 3 is decided to be present, a head moving command is fed to a head actuator 21 so that a head elevating section 20 brings magnetic heads 8a and 8b into contact with the magnetic recording layer 3. Data in the magnetic recording layer 3 is read out by the magnetic heads 8a and 8b, being demodulated into original data by demodulators 341a and 341b of magnetic reproducing circuits 30a and 30b. At this time, a clock reproducing circuit 38a reproduces a sync clock signal on the basis of a signal in the optical mark 387. The use of the sync clock signal enables reliable demodulation even if a running velocity fluctuates. Therefore, this design is advantageous in that the data in the magnetic recording layer 3 can be surely read out even if the running velocity fluctuates due to a shock upon the insertion of the cartridge 42 into the apparatus. In the case where index information such as a cartridge ID number or a software title is recorded in the optical mark 387, data management can be done cartridge by cartridge (cassette by cassette).

Generally, only a single magnetic head 8 suffices. Two magnetic heads may be provided to execute the recording and reproduction of same data twice. This design improves a reliability in the readout of the data. A combining circuit 397 combines error-free portions of data 1 and data 2 into error-free complete data, thereby reproducing data containing TOC data and others which is stored into an IC memory 34. The TOC data contains the absolute address which occurs at the moment of the end of the preceding operation of the cartridge 42, and the absolute addresses of the start and the end of respective segments and respective tunes. Accordingly, when the magnetic data is reproduced, the current tape absolute address is known which occurs at the moments of the insertion of the cartridge 42 into the apparatus. The contents of an absolute address counter 398 in the system controller 10 are updated in response to the information of the absolute address.

It is now assumed that the tape stores tunes. For example, it is known that the current address corresponds to 1-minute 32-second of an eighth tune while the current absolute address corresponds to 62-minute 12-second. In the case where a point at an absolute address of 42-minute and 26-second in a sixth tune is desired to be accessed, the tape is rewound by an amount corresponding to an absolute address of 19-minute 46-second while referring to the data from an absolute address detecting head 399 so that the current tape position can be quickly accorded with the head of the sixth tune. The interval between the current tape position and the desired tape position is previously known, so that

the access speed can be high by accelerating, moving, and decelerating the tape at optimal rates. In addition, the list of the TOC information can be immediately indicated upon the insertion of the tape cassette into the apparatus.

While the cartridge 42 remains in the apparatus as shown in Fig. 141(b), magnetic recording and reproduction are arbitrarily done to add a new tune or to delete a recorded tune. In this case, the contents of the TOC needs to be changed. In this invention, the TOC data in the IC memory 34 is updated without rewriting the data in the magnetic recording layer 3. Thus, the new TOC data in the IC memory 34 is different in contents from the old TOC data in the magnetic recording layer 3.

In the presence of multiple tracks such as three tracks, data updating is executed only on one, for example, a second one, of the tracks which requires a TOC data change, and thereby the number of errors is reduced during the recording. In this case, when the cartridge 42 is ejected from the apparatus as shown in Fig. 137(c), only third one of the tracks is subjected to recording by the magnetic head 8b.

In the presence of two heads as shown in Fig. 137, a recorded signal 68 is simultaneously read out by the magnetic head 8a, and error check is executed thereon. As shown in Fig. 139(c), a magnetic signal 68a which has been recorded by the magnetic head 8b can be checked by using the magnetic head 8a. If an error is present, an error message is indicated on a display section 16 of the recording and reproducing apparatus 1. An indication may also be

given which represents "please insert the cartridge into the body again". In addition, a warning sound may be generated by a buzzer 397. Therefore, the user is forced to insert the cartridge 42 into the insertion portion 394 of the apparatus again. In the case where the cartridge 42 has been inserted into the apparatus again, TOC data is recorded once again when the cartridge 42 is ejected from the apparatus. The second recording has no error at a high probability. If such a process is repeated a given number of times, the magnetic recording layer 3 of the cartridge 42 is decided to be damaged while the ID number of the optical mark 387 is recorded. During a later period, when the cartridge 42 having this recorded ID number, a command of lowering the magnetic head 8 is not issued to unexecute the readout of the data. The data of the ID number is stored in the IC memory 34 with being backed up. In this way, TOC data can be reliably recorded and reproduced into and from each VTR tape cartridge 42. This design is advantageous in that the addition of a simple arrangement enables the TOC function which does not need any additional access time. For a recording medium side, the attachment of a magnetic label to a conventional cartridge 42 suffices.

DESCRIPTION OF THE SEVENTEENTH PREFERRED EMBODIMENT

A seventeenth embodiment of this invention relates to a method of unlocking a key of a given program in an optical disk such as a CD ROM. As shown in Fig. 147, an ID number which varies from disk to disk is recorded on an optical mark portion 387 of a

CD. The data representing, for example, "204312001" is read out from the optical mark portion 387 by an optical sensor 386 having a combination of a light emitting section 386a and a light receiving section 386b. The readout data is put into a disk ID number area (OPT) of a key management table 404 in a CPU.

To enhance the copy guard function, there is provided a high Hc portion 401 of barium ferrite having a magnetic coercive force Hc of 4000 Oe. In a factory, ID number data (Mag) of, for example, "205162", is magnetically recorded on the high Hc portion 401. The ID number data is read out from the high Hc portion 401 by a normal magnetic head. The readout data is put into a disk ID number area (Mag) of the key management table 404.

A specific operation sequence will be described with reference to Fig. 148. In the case where a command of starting a program having a number N comes at a step 405, a reading process is done to check whether key information of the program is recorded on a magnetic track at a step 405a. At this time, a recording current is driven in the magnetic head to erase data from the magnetic track. In the case of a formal disk, key information is not erased because of a high Hc. In the case of an illegal disk, key information is erased. Next, at a step 405b, a check is made as to whether key data or a password is present. If it is no, the user is informed of a key inputting command as shown in Fig. 170 at a step 405c. Then, at a step 405d, the user inputs, for example, "123456". At a step 405e, a check is made as to the input data is correct. If it is no, the operation stops at a step 405f and an indication of "a copy

disk and a wrong key" is given on a display screen. If it is yes, an advance to a step 405g so that the key data for opening the program having the number N is recorded on the magnetic track of the recording medium 2. Then, a jump to a step 405i is done.

Returning to the step 405b, if it is yes, an advance to a step 405h is done. At the step 405h, the key data of the program having the number N is read out. At a step 405i, a disk ID number (OPT) is read out from the optical recording layer. At a step 405j, a disk ID number (Mag) is read out from the magnetic recording layer. At a step 405k, a check is made as to the ID numbers are correct. If it is no, an indication of "a copy disk" is given on the display screen at a step 405m and the operation stops. If it is yes, secret code unlocking calculation is executed among the key data, the disk ID number (OPT), and the disk ID number (Mag) to check whether the data is correct. A step 405p executes a check. If it is no, an error indication is executed at a step 405q. If it is yes, a step 405s starts the program having the number N to be used.

According to this invention, for example, 120 tunes are recorded into a CD while being compressed by a factor of 1/5. For example, 12 tunes among the 120 tunes have no keys and thus can be reproduced freely while the other tunes are locked by keys. Such a CD is sold at a price corresponding to a copyright fee of the 12 tunes. The user is informed of data of the keys by paying an additional fee. Then, the user can enjoy the other tunes as shown in Fig. 147.

According to this invention, for example, a plurality of game

programs are recorded into a CD. For example, only one game program thereamong has no key and thus can be reproduced freely while the other game programs are locked by keys. Such a CD is sold at a price corresponding to a copyright fee of one game program. The user is informed of data of the keys by paying an additional fee. Then, the user can enjoy the other game programs as shown in Fig. 147.

The use of an audio expansion block 407 enables a CD to contain a 370-minute length of music. A desired tune can be selected by unlocking the related key. When a key is unlocked once, key data is recorded. Accordingly, during a later period, it is unnecessary to input the key data. This invention can also be applied to a CD forming an electronic dictionary, a CD containing video information, or a CD containing general application programs. It should be noted that the ID number in the high Hc portion 401 may be omitted to lower the cost.

DESCRIPTION OF THE EIGHTEENTH PREFERRED EMBODIMENT

An eighteenth embodiment of this invention realizes a copy guard function which can be applied to the case where a software such as an OS is installed into a given number of machines or personal computers. Fig. 149 shows an arrangement of the eighteenth embodiment which is similar to the arrangement of Fig. 147 except for design changes indicated hereinafter.

An optical mark portion 387 or a high Hc portion 401 of a disk stores data of the maximum number of personal computers into which information is permitted to be installed from the disk. The

data is formed as data of a disk ID number (OPT) or a disk ID number (Mag) for a key management table. For example, the data represents "ID=204312001, N1=5, N2=3". This means that the disk ID number is "204312001". Additionally, this means that the maximum number of personal computers into which a first program is permitted to be installed is equal to 5, and that the maximum number of personal computers into which a second program is permitted to be installed is equal to 3. As shown in the drawing, in the case where a program 1 is installed into a first personal computer 408 identified as "xxxx11", a key unlocking decoder 406 outputs data since five tables of the program 1 remain. The output data enables a program such as an OS to be installed into a hard disk 409 of the first personal computer 408 via an external interface 14. At this time, the data of the ID number "xxxx11" of the personal computer 408 is fed to a CD ROM drive 1a. The ID data is stored into an "n=1" position of the program 1 in the key management table 404, and is then recorded on a magnetic track 67 of the CD ROM.

In the case where the program such as the OS is intended to be installed from the CD ROM 2a into a second personal computer 408a identified as "xxxx23", a check is made on the key management table 404. As a result of the check, it is known that four machines remain into which the program is permitted to be installed. Thus, the installing process is started and executed. The data of the ID number "xxxx23" of the personal computer 408a is stored into an "n=2" column in the program 1 in the key

management table 404. In such a way, the program such as the OS can be installed into at most five personal computers. In the case where the program such as the OS is intended to be installed into a sixth personal computer, there is no unoccupied column in the program 1 so that an ID number of the sixth personal computer can not be recorded. Thus, the program such as the OS is inhibited from being installed into the sixth personal computer. In this way, illegal copy of the program such as the OS is prevented. If the program such as the OS in one of the first personal computer to the fifth personal computer breaks, the program such as the OS can be freely installed thereinto since the ID number of that personal computer has been already registered. As previously described, the disk ID number is recorded into the high Hc portion 401 and the optical mark 387 as two types of data. This design causes more work and cost to be necessary in copying a disk, and thus enhances the copy guard function.

A programmed operation sequence for executing the method of this invention will now be described with reference to Fig. 150. At a step 410a, a command of installing a program having a number N is issued. At a step 410b, an ID number of a personal computer is read out. For example, the ID number is "xxxx11". Then, a CD ROM 2a is set in a CD ROM drive 1a. At a step 410c, magnetic data is fed to a memory of the personal computer 408 and a key management table 404 is made. At a step 410e, a machine ID number registered in a column of the program having the number N in the table 404 is read out. At a step 410f, a check is made as to whether the readout

ID number is equal to the ID number of the personal computer into which the program is intended to be installed. If it is yes, an advance to a step 410q is done. If it is no, a check is made at a step 410g as to whether an unoccupied column (area) for registering the machine ID number is present. Specifically, a check is made as to how many personal computers remain into which the program is permitted to be installed. If it is no, an advance to a step 410n so that the program is prevented from being installed. Then, operation stops at a step 410p. On the other hand, if it is yes, the ID number of the personal computer into which the program is intended to be installed is registered in the table 404. As a result, a reduction occurs in the number of remaining personal computers into which the program is permitted to be installed. At a step 410i, the machine ID number is recorded into the magnetic track 67 by the magnetic head. At a step 410j, an installing process is started. If the installing process succeeds at a step 410k, the operation stops at the step 410p. If the installing process fails, the ID number of the personal computer into which the program is intended to be installed is deleted from the magnetic track. Then, the operation stops at the step 410p.

DESCRIPTION OF THE NINETEENTH PREFERRED EMBODIMENT

A ninth embodiment of this invention relates to an interface between a personal computer and a CD ROM drive. As shown in Fig. 151, a personal computer 408 has a software portion 411 containing an application program 412 such as a word processing software. A Cornell portion 414 manages a system. The application

transmits and receives information to and from the Cornell portion 414 via a shell portion 413. The Cornell portion 414 has an operating system (OS) 415 in a narrow sense, and an input/output control system 416. The input/output control system 416 includes a device driver 417 for the inputting and outputting of signals from and to devices such as a hard disk. As shown in the drawing, A, B, C, and D drivers 418a, 418b, 418c, and 418d are logically defined as external storage units. The personal computer is physically connected to interfaces 14 and 424 of external storage units such as an HDD 409, a CD ROM 2a, and an FDD 426 via an interface 420 such as an SCSI and a BIOS 419 composed of a hardware including a software such as information in a ROM IC. The personal computer transmits and receives data to and from the interfaces 14 and 424.

In the case of a drive 1a for a CD ROM which has a magnetic recording portion of this invention, two drivers, that is, the A driver 418a and the B driver 418b are defined in the input/output control system 416. The A driver functions to reproduce data of a logically defined optical record file 421 via the interface 14 in the CD ROM drive 1a. The A driver does not operate for recording. Specifically, an optical reproducing portion 7 reads out exclusive playback data from an optical recording layer 4 in the optical disk, and the readout data is transmitted to the personal computer 408 via the A driver. The B driver functions to record and reproduce data into and from a logically defined magnetic record file 422. Specifically, a magnetic recording and reproducing portion 9 records and reproduces data into and from the magnetic recording layer 3 of the

optical disk 2. The magnetic recording and reproducing portion 9 transmits and receives data to and from the personal computer 408 via the B driver 418b in the device driver 417.

In this embodiment, the two drivers 418a and 418b are defined with respect to the single drive 1a for a CD ROM having a RAM. According to this design, provided that the OS 415 executes multiple tasks, the recording and reproduction of the magnetic file 422 can be executed while the personal computer 408 reproduces the optical record file 421. Thus, a process of inputting and outputting the files can be performed at a higher speed than the speed in the case where only a single drive 418 is present. This advantage is remarkable when a virtual file is used.

Methods of executing the above-mentioned simultaneous processing will be described. A first method is designed as follows. Fig. 152 shows an optical address table 433 and a magnetic data table 434 of a CD ROM 2a having a RAM. In the case of a CD ROM, a write inhibiting flag is active for all the data in the optical address table 440. As long as special designation is absent, all the data in the magnetic address table 441 can be rewritten. A CD ROM drive 1a previously transfers data, which is high in use frequency, to a drive memory 34a upon the insertion of the CD ROM 2a. Accordingly, the addresses of necessary data in the magnetic address table 441 are arranged according to the order of the use frequencies thereof as magnetic data having a physical address of, for example, "00". When the disk is inserted into the device, the magnetic data at the address "00" is read out and is transferred to

the drive memory 34a in an arrangement according to the order of necessity. The drive memory 34a includes an IC memory. This design makes it sufficient that, during the recording and reproduction of magnetic data into and from the CD ROM, the recording and reproduction are executed only by accessing the data in the IC memory 34a. Thus, in the case where the simultaneous processing is executed by time-division processing in a CPU of a system controller 10, data reading and writing from and into the magnetic file 422 in the drive memory 34a can be performed while an optical reproducing section 7 reproduces optical data. Since it is sufficient that the recording and reproduction is executed only once on the magnetic recording layer 3 of the CD ROM 2a, the recording surface thereof is less injured. Even when a power supply to the CD ROM drive 1a is turned off, the contents of the drive memory 34a is backed up by a memory backup portion 433. Only when the CD ROM 2a is ejected from the device, changed magnetic record data in the drive memory 34a is selected and is recorded into the magnetic recording layer 3 regardless of whether the power supply is on or off. Thus, recording into the magnetic recording layer 3 is done only once during the interval between the insertion of the disk to the ejection of the disk. Therefore, a long life of the disk is enabled. The files are processed simultaneously or in parallel in this way, so that a higher data transfer speed is attained. The data in the drive memory 34a is backed up by the memory backup portion 433 even when the power supply to the CD ROM drive 1a is turned off. Thus, in the case where the power supply is turned on again, it is

unnecessary to read out the magnetic data from the CD ROM as long as the CD ROM has not been replaced.

A data compressing/expanding portion 435 of Fig. 125 may be provided in the system controller 10 of the CD ROM drive 1a. This design increases the substantive capacity of the magnetic file 422.

Next, a description will be given of the case where the CD ROM drive of this invention is handled as a single drive. The operation in this case is similar to that in the case of two drives except for the following points.

As shown in Fig. 153, a CD ROM having a RAM according to this invention can be handled as one drive such as an A drive 418 in an input/output control system 416 of a personal computer 408. In this case, even a single-task OS can read and write data from and into a drive 1a for the CD ROM having the RAM. According to a file design, as shown in Fig. 154, successive addresses are assigned to an optical file 421 and a magnetic file 422. In addition, an optical data table 440 and a magnetic data table 441 are handled as a single file. For example, as shown in the drawing, addresses up to a logic address "01251" are assigned to data of the CD ROM, and active write inhibiting flags are applied to all of them. Addresses starting from the logic address "01252" are assigned to magnetic data, and active write enabling flags are applied thereto.

The personal computer is enabled to handle the CD ROM having the RAM as a single memory disk. The optical data can be reproduced. The magnetic data can be recorded and reproduced. The address of magnetic data which is high in use frequency is

recorded as the logic address "01252". Thus, by transferring the data in the magnetic recording layer 3, which corresponds to this address, to the magnetic file 422 of the drive memory 34a via the magnetic recording and reproducing section 9 and the data compressing/expanding section 435 after the insertion of the CD ROM 2a into the device as shown in the drawing, it is hardly necessary to physically read out the data from the magnetic recording layer 3 in a later period. The recording and reproduction of the magnetic data are virtually performed by rewriting the data in the drive memory 34a composed of the IC memory. The amount of the magnetic data is equal to a small value, for example, 32 KB, so that all the magnetic data can be stored in a small-capacity IC memory. This design enables a longer life of the disk and higher speeds of access, and data inputting and outputting processes. As previously described, the magnetic data is physically recorded only when the disk is ejected from the device. The one-drive system can be simple in structure.

A method of effectively executing the reproduction of data from the magnetic recording layer 3 and the reproduction of data from the optical recording layer 4. To prevent a reduction in data transmission rate of a CD ROM, it is desirable that the reproduction on the magnetic recording layer is done while the reproduction on the optical recording layer is being executed. In addition, it is important to shorten a start-up time upon the insertion of a CD ROM into a drive. A file arrangement according to this embodiment is designed as follows. As shown in Fig. 154, a CD ROM 2a having a

magnetic recording layer has an optical file 421 and a small-capacity magnetic file 422 provided with physical optical addresses and magnetic addresses other than an optical address table 440 respectively. As shown in Fig. 155, magnetic drives 67a, 67b, 67c, 67d, 67e, and 67f are located at back sides of the optical addresses A, B, C, D, E, and F which correspond to the magnetic addresses a, b, c, d, e, and f respectively. This correspondence relation is recorded in a magnetic TOC area at a magnetic address of 00 together with frequency management data. The system controller 10 of Fig. 153 has a 1-address link table 443 which informs the drive memory 34a of the physical positions of the optical address and the magnetic address. As shown in Fig. 154(b), the contents thereof have two address link recorded information.

A specific method of simultaneously performing the reproduction of the magnetic data and the reproduction of the optical data will now be explained. In the case where a CD ROM is inserted into the drive to start up only a necessary program, the reproduction of only necessary optical data is executed. It is good that only magnetic data necessary for starting the program is recorded in the magnetic track on the back side of the optical track storing the necessarily reproduced data. The necessary magnetic data is, for example, personal point data and personal progress data related to a game software.

The operation according to this method will now be described with reference to Fig. 156. At a step 444a, an initial value "m=0" is set. At a step 444b, an incrementing process is done by referring to

a statement "m=m+1". At a step 444c, a check is made as to whether the number m is equal to a final value. If it is yes, a jump to a step 444m is done. If it is no, an advance to a step 444d is done so that optical data in an m-th optical address A(m) is reproduced. Then, at a step 444e, an entrance into a subroutine is done which serves to find an optical address, among optical addresses in the optical track corresponding to the magnetic track, which is close to the optical address A(m). In the subroutine, at a step 444f, setting "n=0" is done. At a step 444g, an incrementing process is executed by referring to a statement "n=n+1". At a step 444w, a check is made as to whether the number n is equal to a final value. If it is yes, a jump to the step 444m is done. If it is yes, an optical address M(n) at the back side of the n-th magnetic address is read out from the address link table 443 at a step 444h. At a step 444i, a checking process of, for example, "M(n)+10" is done to check whether the optical address is close thereto. If it is no, a return to the step 444g is done to check a next optical address. If it is yes, the magnetic head is lowered onto the magnetic recording layer 3 at a step 444j so that the data in the magnetic address n is reproduced and the optical traverse is fixed. At a step 444k, a check is made as to whether the reproduction of the magnetic data has been completed. If it is no, the step 444j is executed again. If it is yes, a return to the step 444b is done so that the number m is incremented by one. The above-mentioned processes are repeated. Here, if the number m reaches an end value (a completed value), a jump to a step 444m is done to check whether the reproduction on

the magnetic track containing the data necessary for starting the program has been completed in conjunction with a step 444n. If it has been completed, a jump to a step 444v is done. If it has not yet been completed, the entrance into a subroutine 444p for the reproduction on n0 magnetic tracks is performed to reproduce the remaining magnetic data. In this subroutine, setting "n=0" is done at a step 444q, and setting "n=n+1" is done at a step 444r. At a step 444s, a check is made as to whether the number n reaches a completed value. If it is yes, a jump to the step 444v is done. If it is no, the optical address corresponding to the n-th magnetic address is accessed. The magnetic data is reproduced at a step 444u, and a return to the step 444r is done to execute the setting "n=n+1". As long as the completion has not yet been reached, the similar processes are repeated. If the completion has been attained, a jump to the step 444v is done so that the work of reproducing the data for starting the program is completed.

According to this design, the magnetic data necessary for starting the program is recorded on the magnetic track at the back side of the optical track of the optical data. Thereby, there is an advantage such that a time for starting the program can be shorted. In this case, as shown in Fig. 154, the selection of the magnetic tracks on the back sides of the optical tracks means that the magnetic tracks are not always arranged at equal intervals. The use of the variable pitch magnetic tracks of this invention realizes the shortening of the time for starting the program.

As shown in Fig. 154, the optical addresses of the optical

tracks at the back sides of the magnetic tracks 01, 02, ··· into the magnetic TOC area, and magnetic tracks at a free pitch can be realized. The magnetic tracks are arranged according to the use frequency, and thereby frequency management data can be omitted and the substantive capacity can be larger.

DESCRIPTION OF THE TWENTIETH PREFERRED EMBODIMENT

A twentieth embodiment of this invention relates to a method of correcting bugs in a program in a CD ROM software by using a CD ROM 1a. As shown in Fig. 157(b), a bug correcting program 455 is recorded in an optical file 421 in the CD ROM 1a having a capacity of 540 MB. A program such as an OS is also stored in the remaining part thereof as ROM data. A magnetic file 422 has a capacity of about 32 KB, which contains only bug correcting data. As shown in Fig. 157(b), correction data, correction contents, and optical addresses of optical ROM data to be corrected are contained therein. As shown in Fig. 157(c), only a given file such as an OS which has bugs is transferred to a memory 34, and correction-resultant data 448 is generated in response to the bug correcting program 447 and the bug correcting data 446.

An operation sequence will now be described with reference to Fig. 157(a). When the given file having the bugs is read out at a step 445a, the whole of the given file is transferred to the memory 34. At a step 445b, setting "N=0" is done. At a step 445c, the number N is incremented. At a step 445d, N-th bug correcting data in the given file is read out. At a step 445e, a check is made as to whether the correction is of the type without changing the address.

If it is yes, the data is corrected at a step 445f. If it is no, the line is deleted at a step 445h. At a step 445j, the logic address of the optical file is changed. Then, an advance to a step 445k is done. At the step 445k, a check is made as to whether a line is added. If it is no, an advance to a step 445p is done. If it is yes, the addition of the line is executed at steps 445m and 445n so that the logic address of the optical file is changed. Then, an advance to a step 445p is done. At the step 445p, a check is made as to whether other processing is present. If it is no, an advance to a step 445r is done. If it is yes, the other processing is executed at a step 445q. At the step 445r, a check is made as to whether the number N reaches M, that is, whether the correction has been completed. At a step 445s, the correction is completed. The given file which has been corrected is outputted.

In this embodiment, the correcting program is previously recorded into the optical ROM portion, and the correcting data is recorded into the magnetic file upon the shipment of the recording medium (the optical disk). This design is advantageous in that the correction of bugs in the OS or others can be executed after the manufacture of the optical disk. The correcting program is recorded into the optical ROM portion while only the correcting data is recorded into the magnetic file 422. This design enables the recording of a relatively large amount of the correcting data.

DESCRIPTION OF THE TWENTY-FIRST PREFERRED EMBODIMENT

A twenty-first embodiment of this invention relates to a

method of correcting data bugs in a CD ROM in real time during the readout of a file such as a dictionary. As shown in Fig. 158(b), an optical ROM data correcting table 446 is recorded in a magnetic file 422, and correction-resultant data corresponding to an optical address is recorded therein. As shown in Fig. 158(c), data of an optical file 421 is corrected in real time in response to a correcting program in the optical file 421 and the corrrecting data in the magnetic file 422. The correction-resultant data is outputted as data 448.

An operation sequence will now be described with reference to Fig. 158(a). With respect to the file data correcting program 447, a command of reading out given optical data is received at a step 447a. At a step 447b, a number N is set to a starting number of an optical address of data to be read out. At a step 447c, the number N is incremented by one. At a step 447d, data at the optical address N is read out. At a step 447e, a check is made as to whether the optical address is k1-kM of the correcting table 446. If it is no, an advance to a step 447g is done. If it is yes, the data at the optical address N is corrected in response to the correcting table 447f. Then, at the step 447g, a check is made as to all necessary optical data is read out. If it is no, a return to the step 447c is done. If it is yes, an advance to a step 447h is done to output the correction-resultant optical data. Since the data is corrected and outputted in unit of optical address, this design is advantageous in that the data can be outputted in real time. In the case of a dictionary, the magnetic recording layer 3 can be used for recording data having a

high use frequency and marking important data.

DESCRIPTION OF THE TWENTY-SECOND PREFERRED EMBODIMENT

A twenty-second embodiment of this invention relates to a method of logically increasing the capacity of a magnetic file using a virtual memory in which a physical large-capacity file in a hard disk 425 is logically present in the magnetic file 422. The arrangement of this embodiment is similar to the arrangement of Fig. 153 except for design changes indicated hereinafter.

As shown in Fig. 159, a personal computer 408 corresponding to a machine ID=Ap, a CD ROM drive 1a, an HDD 425 corresponding to a disk ID=AH, a disk drive DD corresponding to a disk ID=BH, a replaceable optical disk 428 are physically connected via interfaces. A magnetic file 422 can be connected to a personal computer 408a corresponding to a machine ID=Bp via a LAN network such as TOPIP, a communication port 432, a network BIOS 436, a network OS 431, and an application program 412, and also can be connected to a hard disk 405a corresponding to a disk ID=CD which is directly coupled with the personal computer 408a. In this embodiment, virtual large-capacity disks in the magnetic file 422 can be set in the hard disk 425 of the personal computer 408, the replaceable disk 428, and a hard disk 425a of another personal computer 403a respectively. The virtual disks are denoted by 450, 450a, and 450b respectively. The use of the virtual disk 450 virtually increases the capacity of the magnetic file 422 to, for example, 100 MB or 10 GB.

A specific data structure will be described with reference to

Fig. 160. The CD ROM 1a has the physically-existing optical file 421, the physically-existing magnetic file 422, and the logically-defined virtual file 450. Actual data in the virtual file 450 is stored in the HDD 425, the replaceable disk 428, or the physical file 451 in the HDD 425a. The magnetic file portion 422 of the CD ROM 1a contains a virtual directory entry 452 holding directory information such as characters and names of respective virtual files, and link information of the physical file 451 and the virtual file 450. The virtual directory entry has characteristic data related to 11 items, that is, 1) an address 438 in the magnetic file, 2) a connection program number 453 which contains a number of a communication program including a command of connection with another personal computer via the LAN, 3) a machine ID number 454 which contains a machine ID number of a drive or a personal computer provided with the disk storing a physical file 451 containing the actual data, 4) the disk ID number 455 of the disk containing the physical file 451, 5) the name 456 of the virtual file, 6) an expanding item 457, 7) a characteristic 458 indicating the type of the virtual file, 8) a reservation region 459, 9) the time and the date of change of the file, 10) a start cluster number 461 indicating the cluster number at which the file is started, and 11) a file size 462. The fifth item to the eleventh item are equal to those in directory used by an OS such as MSDOS, and are usually composed of 32 bytes. All the items occupy 48 to 64 bytes.

As shown in the magnetic file table 422a, the magnetic file 422 contains a number of virtual directory entries 452 which is

equal to the number of virtual files. Fig. 160 shows only the items 1, 2, 3, 4, 5, and 10.

With respect to the first virtual directory entry 452a, "AN" is in the connection program number corresponding to the item 2). It is known from the sub machine ID number 454 corresponding to the item 3) that the ID number of the machine containing the physical address 451 is Ap. Since the CD ROM 1a is connected to the CD ROM drive of the personal computer corresponding to the machine ID=Ap, it is unnecessary that the connection program AN for connecting the LAN is started to access the disk of another personal computer. In the case where the main machine ID number 454 corresponds to another personal computer, the connection program AN is started and the connection to the personal computer of the LAN address corresponding to the main machine ID number 454 is provided so that the disk 425a thereof is accessed. Since substantially all the directory information is in the link data 452, it is unnecessary to access the physical file 451 when the personal computer looks at the directory. It is sufficient to access the physical file only when data is read and written from and into the virtual file 450.

In this way, access to the physical file is executed. As shown in the directory range table 465, the directory 463 of the physical file contains sub virtual directory entry 467 of a normal format. This data stores items 5)-11) among the items 1)-11) in the main virtual directory entry 452. Data of the main disk ID number at the original CD ROM side having the virtual file 450, data of the user ID number

470 corresponding to the setting of the virtual file 450, data of a secret number 471 for each file, and data of the main machine ID number 472 corresponding to the final main personal computer making the virtual file are added to a sub reservation region 468 corresponding to the item 8) in comparison with that in the virtual directory entry 452. The added data is used for checking and confirming the relation between the virtual file 450 and the physical file 451 from the physical file side. If the relation is decided to be in a low degree as a result of the check, a permission of writing an OS is not issued. To inhibit normal writing which does not relate to the virtual file 450, reproduction exclusive code as "01H" is stored in the characteristic 458 corresponding to the item 7) in the case of MSDOS. Thus, in general, the recording can not be executed. In the case where data is recorded into the virtual file 450, information such as the change information 460 and the CD ROM ID number 469 associated with the virtual file 450 is fed to the input/output control system of the personal computer. A check is made as to whether this data agrees with the sub file link data 467. If the result of the check is good, the IOSYS in the Cornell portion permits the writing into the physical file 451 so that the recording is executed. In the case where data is added to "File A", the directory 463 of the physical file 451 is examined and the contents of FAT 466 are additionally written as FAT 466a so that the additional data in the "File A" is physically recorded into the new data region. In this case, the file size is expanded, and the data of the file size 462 of each of the virtual directory entry and the

directory entry 467 in the virtual file and the physical file is written into, for example, "5600 KB".

In this way, the data of the physical file 451 corresponding to the virtual file 450 can be recorded and reproduced. Since all the work related to the virtual file 450 is performed by the OS, the input/output OS, and the network OS, the user can handle the apparatus as if the physical file having a capacity of, for example, 5600 KB, is present in the magnetic recording layer 3 of the CD ROM 1a.

Physical recording and reproduction of data is enabled by linking the physical file 451 and the virtual file 450 in response to the data from the virtual directory entry 452. Although the capacity of the magnetic file 422 is equal to a small value, that is, 32 KB, in connection with the CD ROM 1a, 500 to 1000 virtual directories 452 can be provided and thus virtual recording and reproduction on 500 to 1000 virtual files 450 can be performed.

A description will now be given of a method of reproducing a virtual file with reference to Fig. 161. It is now assumed that a command for calling a file "X" is received at a step 481a. At a next step 481b, a check is made as to whether only the contents of the directory information suffice. If it is yes, the virtual directory entry in the magnetic file 422 is read out. At a step 481d, only the directory contents such as the file name, the directory name, the file size, and the making date and time are indicated on the display of the personal computer as shown by the characters 496a on the screen 495 of Fig. 164(a).

Here, screen indication is described. In Fig. 164(a), the indicated characters 495b and 495c represent that a virtual file 450 is logically present in the drive A, that is, the CD ROM 1a with the RAM. A 10-MB still picture file and a 1-GB moving picture file can be recorded into the virtual file 450. A 540-MB CD ROM file is also denoted by indicated characters 496d. There are also indicated characters 496e denoting "four files". In this embodiment, the personal computer is provided with a 20 GB hard disk. As shown in Fig. 160, the virtual disk setting capacity VMAX of the virtual disk with respect to one CD ROM 1a is recorded in the sub disk ID column of the main machine ID number 474. One of the physical file capacity of the sub disk ID number or the virtual disk setting capacity corresponds to the maximum recording capacity of the virtual disk. The remaining recording capacity is equal to the maximum recording capacity minus the currently-used capacity in the virtual file. In the case shown by Fig. 164(a), a virtual file having a total capacity of 10 GB is set, and a capacity of 1020 MB is used in the virtual file. It is shown on the screen that a capacity of 8980 MB remains in the virtual file 450. The virtual file is denoted as the indicated characters 496g. The addition of the character "V" means a virtual file. Thus, the virtual file can be discriminated from other files by referring to the character "V".

As shown in Fig. 165 and Fig. 151, when the driver of the CD ROM 1a with the RAM is separated into an A drive and a B drive, the ROM portion of the CD ROM is indicated as indicated characters 496h while the RAM portion of the CD ROM is indicated as

indicated characters 496i and 496j. Since the ROM and the RAM are separately indicated in this way, this design is advantageous in that easy handle by the operator is enabled. In the case of multiple-task processing, simultaneous reading and writing on the ROM portion and the RAM portion can be executed so that a high processing speed can be attained.

Returning to Fig. 161, if it is no at the step 481b, an advance to a step 481e is done so that a check is made as to whether the ID number of the currently-used machine agrees with the main machine ID number 454 in the virtual directory entry 452. If it is no, that is, if no physical file is present in the personal computer, a jump to a step 482a is done. If it is yes, that is, if a physical file 451 is present in the personal computer, an advance to a step 451f is done so that the drive number of the physical file is read out from the sub disk ID number 455. Then, a check is made as to whether the drive is active. If it is no, an indication of commanding "turn on a drive corresponding to the drive ID number" on the display screen is performed at a step 481g. At a step 481h, a check is made as to whether the drive has been activated. If it is no, stopping is done at a step 481i. If it is yes, an advance to a step 481j is done. At the step 481j, a check is made as to whether a disk corresponding to the sub disk ID number 455 is present. If it is no, an advance to a step 481k is done so that a check is done as to whether the disk is a replaceable recording medium such as an optical disk and a floppy disk by referring to the replaceable disk identifier in the sub disk ID number. If it is no, an indication "error" is given on the display

screen at a step 481n. Then, stopping is done. If it is yes, an indication "insert the disk" of the sub disk number ID 455 is given on the display screen at a step 481m. Then, a return to the step 481j is done. If it is yes at the step 481j, an advance to a step 481q is done so that the corresponding file name 456 is searched for by referring the directory region 465 of the disk corresponding the sub disk ID number. If it is decided to be absent at a step 481r, an error indication is made at a step 481p. If it is decided to be present at the step 481r, an advance to a step 481s is done and therefore collation of the information is executed to confirm that the physical file actually corresponds to the virtual file. Specifically, collation is made between the data in the virtual directory entry 452 and the directory entry 467. In addition, collation is made between the disk ID number of the CD ROM and the main disk ID number 469 of the CD ROM side in the directory entry 467. Furthermore, collation is made as to the change time and the file size. No check is given of the characteristic. At a step 481t, a check is made as to whether all the collated items are equal. If it is no, error indication is given at a step 481u. If it is yes, the readout of the physical data of the corresponding file "X" in the directory region 465 starts to be executed at a step 481v. A FAT start cluster number "YYY" is waited. At a step 481w, the cluster number continuous to the FAT "YYY" is read out. A step 481x reads out necessary data among the data of the cluster number of the data region. At a next step 481y, the readout of the file "X" is completed. Therefore, the virtual file 450 is provided with an arbitrary capacity within the capacity of the hard

disk of the personal computer 408.

If the physical file corresponding to the virtual file is decided to be absent from the hard disk of the present personal computer at the step 481e, a jump to a step 482a is done so that the connection with the personal computer of the main ID number which contains the physical file is started. In this case, the connecting routine 482 is in the network OS. First, the LAN address of the main machine ID number is read out from the item of the main machine ID number in the virtual directory entry. At a step 482b, the number of the connecting program is read out. The given network connecting program is executed, and the previously-mentioned LAN address is inputted to try the connection. A step 482c checks the connection. If the connection fails, error indication is made at a step 482d. If the connection succeeds, a command of reading the file is transmitted to the sub personal computer 408a via the network such as the LAN.

From a step 482g, OS work by the sub personal computer 408a is started. Data is read out from the physical file in response to a command of reading the file "X" from the main personal computer. This work is same as the previously-mentioned subroutine 483 for reading out the physical file data. Accordingly, the subroutine 483a uses the previously-mentioned subroutine. At a step 482h, a check is made as to whether the readout of the file has been completed. If it is yes, an advance to a step 482j is done so that the data of the file is transmitted to the main personal computer 408. Then, an advance to a step 482k is done. If it is no,

an advance to a step 482l is done so that an error message is transmitted to the main personal computer. Then, an advance to the step 482k is done.

The step 482k is in the connecting routine 482 by the network OS in the personal computer 480 which is executed via the LAN. The step 482k receives the data of the file or the error message from the sub personal computer 408a. At a step 482m, a check is made as to whether the error message is present. If it is yes, error indication is made at a step 482p. If it is no, an advance to a step 482y is done to complete the work of reading the file.

With reference to Fig. 162, a description will now be given of a routine 485a for rewriting the virtual file. If the user gives a command of rewriting the data in the given file "X" at a step 485a as shown by the indicated characters 496 of Fig. 166(a), the virtual directory entry 452 of the given file "X" is read out at a step 485b. At a step 485c, a check is made as to whether a secret number is present in the file. If it is yes, indication "password?" on the display screen is made as the indicated characters 496p of Fig. 166(a) at a step 486d. The user inputs "123456" via the keyboard as denoted by the characters 496q. A check is made as to whether this number agrees with the secret number. If it is no, error indication on the display screen is made at a step 485e. If it is yes, an advance to a step 485g is done so that a check is made as to whether the physical file 451 is present in the personal computer. A check is made as to whether the current machine ID number agrees with the main machine ID number. If it is yes, an advance to a step 485 is

done. If it is no, an advance to a step 486a is done which is in a routine 488 for the connection with another personal computer via the network. The step 485h in a subroutine 487 for rewriting the physical file data extracts the drive name of the sub machine ID number from the virtual directory entry 452, and a check is made as to whether the drive having the drive name is present in the personal computer. If it is no, characters 496r representing "turn on the drive power supply" are indicated on the display screen at a step 485i as shown in Fig. 166(b). At the step 485i, a check is made as to whether the drive is present. If it is no, an advance to a step 485j is done so that characters 456s representing "an error" is indicated on the display screen. If it is yes, an advance to the step 485j is done. The step 485k checks whether the disk having the ID number same as the sub disk ID number 455 in the driver is present. If it is no, a jump to a step 485m is done so that the replaceable recording medium characteristic is checked. If it is yes, indication "insert the replaceable medium disk xx" is made on the display screen at a step 485n as shown in Fig. 166(d). Then, a return to the step 485k is done. If it is no, a jump to the step 485j is done to execute the indication of "error".

If it is yes at the step 485k, the directory region 465 in the disk having the sub disk ID number is read out and then the corresponding file name 456 is searched for and checked. If it is no, a jump to the step 485j is done to execute the indication of "error". If it is yes, an advance to a step 485r is done so that a collation or check is made as to whether the physical file is the

actual physical file in the virtual file. Specifically, a check is made as to whether the contents of the virtual directory entry 452 is equal to the data in the directory entry 467 except the characteristic data. In addition, a check is made as to whether the disk ID number of the client-side CD ROM is equal to the main disk ID number 469 of the CD ROM in the server side disk entry.

At a step 485s, a check is done. If it is no, a jump to the step 485j is done to execute the indication of "error". If it is yes, an advance to a step 485t is done so that the system such as the OS temporarily erases the write inhibiting flag such as the characteristic data "01H" or "02H" in the directory entry of the file "X". In this case, the recording is enabled. This file can not be seen from files other than the virtual file of the CD ROM because of the presence of "invisible code", and can not be corrected also.

In this way, the virtual file can be seen from and corrected by only the corresponding CD ROM so that the virtual file is protected. At a step 485u, a check is made as to whether the disk having the physical file has a free capacity. If it is no, the error indication is executed by the step 485j. If it is yes, an advance to a step 485v is done so that the data in the corresponding file of the directory is read out and the start cluster number is obtained. At a step 485w, the cluster number which follows the start cluster number is obtained from the FAT region 466. With respect to the data region 473, at a step 485x, the data in the data region of the cluster number is rewritten. In the case where the amount of the new data is greater than the amount of the old data, the data is also recorded

in the new cluster. In this way, the data is actually recorded into the physical file 451. At a step 485y, a check is made as to whether the completion has been reached. If it is no, a return to the step 485x is done. If it is yes, an advance to a step 485z is done so that the FAT and the directory of the physical file 451 are rewritten. At this time, the data "02H" corresponding to "invisible" is recorded again into the characteristic of the directory entry 467. Thus, as shown in Figs. 167(a) and 167(b), the substance of the physical file is made invisible to the user. Accordingly, it is generally difficult to execute rewriting other than rewriting of the virtual file 450 in the CD ROM 1a by the OS. This design is advantageous in that the data can be prevented from being improperly rewritten. In the case where the previously-mentioned secret number is set for each virtual file, the data is protected further.

An advance to a step 486n is done, so that the data in the directory entry 467 except the characteristic data is transferred to the virtual directory entry 452 of the magnetic file. As a result, the contents of the two are the same in the items including the date and the time. Thus, during a later period, writing into the physical file 451 is permitted by the collating work upon rewriting. The operation work ends at a step 486p.

If it is no at the step 485g, a jump to a step 486a is done so that the routine 488 for the connection with the LAN is started. First, the LAN address of the main machine ID number corresponding to the presence of the physical file is read out from the virtual directory entry 452. At a step 486b, a plurality of the

numbers of programs are read out which are designed to provide the connection via the network such as the LAN from the LAN address "B" of the main personal computer 408 currently provided with the CD ROM 1a to the sub personal computer 408a of the LAN address "A" of the main machine ID number as shown in Fig. 168. In addition, the LAN addresses are inputted, and the connecting programs are successively executed. At a step 486c, a check is made as to the connection. If the connection has been realized by one of the programs, an advance to a step 486e corresponding to "yes" is done. If it is no, an advance to a step 486d is done so that error indication is performed. At the step 486e, new data and a command of rewriting the physical file 451 are transmitted to the sub personal computer 408a.

Then, an advance to a step 486f is done. Here, the OS of the main personal computer is replaced with the work by the input/output control OS and the network OS of the sub personal computer 408a. The file rewriting command and the new data are received. At a next step, the subroutine 487 for rewriting the data in the physical file is executed. At a step 486g, a check is made as to whether the file data rewriting has succeeded. If it is yes, an advance to a step 486h is done so that the information of the completion of the rewriting and the newest data in the directory entry 467 of the physical file are transmitted to the main personal computer 408 via the network. Then, a jump to a step 486j is done which corresponds to the work by the network OS of the main personal computer 408. If it is no at the step 486g, a jump to a step

486i is done so that the error message is transmitted to the main personal computer 408 via the network. Then, a jump to the step 486j is done which corresponds to the work by the network OS of the main personal computer 408.

At the step 486j which corresponds to the work by the network OS of the main personal computer 408, the error message or the data of the directory entry 467 of the physical file 451 is received from the sub personal computer 408a. If the error message is decided to be absent by a step 486k, a step 486n rewrites the virtual directory entry 452 of the virtual file 450 of the magnetic file of the CD ROM in response to the data of the directory entry 467 which represents the items such as the date. At a step 486p, the rewriting work ends. If the error message is decided to be present at the step 486k, an advance to a step 486m is done so that "error" is indicated on the display screen.

As shown in Fig. 168, the virtual file 450 having a capacity of, for example, 10 GB can be logically realized in connection with the CD ROM 2a having the RAM although the magnetic recording layer 3 of the disk has only a capacity of 32 KB. The physical file may be defined in the HDD of the main personal computer or in the HDD of the sub personal computer 408a.

A description will now be given of a method of making a new virtual file with reference to Fig. 163. It is assumed that, as shown in Fig. 169(a), at a step 491a, the user inputs the user ID number or a command of saving a new data file having a name "X". The OS checks whether the magnetic file 422 has a free capacity. If it is no,

stopping is executed at a step 491c. If it is yes, the sub disk ID number and the main machine ID number 474 of the default of the user ID number are read out at a step 491d. At a step 491e, screen indication is executed as shown in Fig. 169(a) to check whether the default is good. If it is no, the user is forced to input a changed default value at a step 491f and then a check is executed again. If it is yes, an advance to a step 491g is done so that a check is made as to whether the ID number of the main machine of the default which links with the virtual file is equal to the ID number of the machine currently provided with the CD ROM. If it is no, an advance to a step 492a is done which lies in a network connecting subroutine. If it is yes, an advance to a step 491h is done which lies in a new file registering subroutine 493. At the step 491h, a check is made as to whether a disk having the ID number of the default is present. If it is no, a step 491i checks whether the disk is of the replaceable type by referring to the data. If it is yes, "insert disk xx" is indicated as shown in Fig. 169(a). At a step 491k, a check is made as to whether the disk has a physical capacity for providing a physical file. If it is no, "error" is indicated at a step 491u. If it is yes, an advance to a next step 491m is done so that the data is stored into a free part of the data region 473 of the physical file from the cluster start number xx. At a step 491n, a check is made as to whether the data storing has been completed. If it is no, the error indication is executed by the step 491u. If it is yes, the directory region 465 and the FAT region 466 of the physical file are rewritten in response to the record file. At a step 491q, the OS stores invisible

characteristic data such as "02H" into the characteristic 458 of the directory entry 467 of the physical file (see Fig. 160). Write inhibiting data "01H" may be stored. The input control OS handles only the virtual file in a special way, and the recording and reproduction on the file are performed while the file links with the virtual file. According to other operation sequences, neither the recording nor the reproduction can be performed. At a step 491r, a secret number and the main machine ID number are stored into the directory entry 467. At a next step 491s, unique information such as the file name and the registration date and time which is equal in contents with the directory entry 467 of the physical file 451 is stored into the virtual directory entry 452 of the recording medium 2. Thereby, the collation with the physical file 451 can be reliably executed when the virtual file is rewritten during a later period. In addition, a physical file 451 in another personal computer on the network can be prevented from being erroneously rewritten. The new file making routine ends at a step 491t.

If it is no at the step 491g in the connecting subroutine 488, an advance to a step 492a is done so that the LAN address of the main machine is read out from the virtual directory entry 452, and the connection with the main personal computer is executed via the network. In addition, the physical file 451 for the virtual file 450 in the disk of the sub personal computer 408 is registered by using the new file registering subroutine 493, and the result is transmitted to the main personal computer. The flow portion from the step 492a to a step 492j is equal to that in Fig. 162, and a description thereof

will be omitted. At a step 492i, the new registration is checked. Then, an advance to a step 491s is done so that the data in the directory entry 467 of the physical file 451 is stored into the virtual directory entry 452 of the recording medium 2. At a step 491t, the new file registration is completed.

The recording medium 2 will now be described. In the case where the directory information is recorded into the magnetic recording layer, the virtual file is damaged if the information is damaged. Thus, in the case where this design is applied to a CD ROM, equal virtual directory entries are recorded into two or three physically separated places as shown in Fig. 171. To protect the directory information from a circumferential scratch on the disk, the recording into separate tracks 67x, 67y, and 67z is executed. To protect the directory information from a radial scratch on the disk, the directory entries 452x, 452y, and 452z are located at different positions of angles θx, θy, and θz respectively.

According to this invention, the system provides a physical file and logically defines a large-capacity virtual file in the RAM portion of an optical disk 2 by using a capacity of an HDD as previously described. Thus, the optical disk having a small-capacity RAM can be handled as a ROM disk with a large-capacity RAM. Even in the case where the main personal computer 408 into which the optical disk 2 is inserted lacks the server side physical file 451 corresponding to the virtual file 450, the data is recorded and reproduced by automatically accessing the physical file 451a of the sub personal computer 408a via the network as shown in Fig. 168.

This design is advantageous in that the physical file corresponding to the virtual file can be accessed when the optical recording medium 2 of this invention is inserted into any personal computer. This design can be realized by an application program.

As previously described, the recording medium 2 has an optical recording surface. The back side of the recording medium 2 is provided with the magnetic recording layer 3. In the recording and reproducing apparatus which executes the RAM type recording and reproduction such as the magneto-optical recording and reproduction, the magnetic head is used in common for the two purposes. Thus, without substantially increasing the number of parts and the cost, it is possible to magnetically record information of independent channels provided on the recording medium. In this case, the slider tracking mechanism for the magnetic head is originally provided so that an increase in the cost of the recording and reproducing apparatus hardly occurs. Thus, there is an advantage such that the magnetic recording and reproducing function which is independent of the optical recording can be added at essentially the same cost.

The recording medium containing the recorded information is applied to a music CD, an HD, a game CD ROM, and an MD ROM, and the back side thereof is provided with the magnetic recording track. This recording medium is subjected to the reproducing process by the ROM type recording and reproducing apparatus of Fig. 17. Thereby, there is provided an advantage such that the conditions which have been previously used can be retrieved upon

the reproduction. As described with respect to the first embodiment, in the case where the recording is limited to only one track of the TOC area, information of several hundreds of bits can be recorded when the gap width is set to 200 μm. This capacity meets the requirements for use of a game IC ROM with a nonvolatile memory. In the case of limitation to the TOC, a device for accessing the magnetic track can be omitted so that the structure of the system can be simple.

In the recording and reproducing apparatus which is exclusive for the reproduction regarding the optical recorded information, it is necessary to provide the magnetic head and others at the opposite side of the optical head with respect to the recording medium. The related parts can be common to the magnetic field modulating head for the magneto-optical recording, so that the cost of the apparatus can be lowered by mass production. The parts are originally very cheaper than optical recording parts and magnetic recording parts for a low density, and thus an increase in the cost is small. Since the optical head is mechanically linked with the magnetic head located at the opposite side thereof, it is unnecessary to add a related tracking mechanism. Thus, in this regard, an increase in the cost is small.

The time information or the address information is recorded on the optical recording layer at the surface of the recording medium of the RAM type or the ROM type. The tracking with respect to the optical head is executed in response to the time information or the address information. Thereby, the tracking

control is done so that the magnetic head can move to an arbitrary position on the disk. Thus, there is an advantage such that it is unnecessary to use expensive parts such as a linear sensor and a linear actuator.

The protective layer on the back side of a conventional magneto-optic recording medium of the magnetic field modulation type is formed from binder and lubricant by spin coat. In this invention, it is sufficient that the magnetic material is added to the combination of the binder and the lubricant, and the spin coat is executed at the same step. Thus, the number of manufacture steps does not increase. A related increase in the cost is in a negligible order relative to the entire cost. Therefore, the new value being the magnetic recording function is added without significantly increasing the cost.

As previously described, in this invention, the magnetic channel can be added without significantly increasing the cost. In addition, the RAM function can be added to a conventional disk of the ROM type and a player exclusively for a ROM.

The high Hc magnetic sheet of this invention is attached to the label portion of a video tape cassette or an audio tape cassette. Upon the loading of the cassette, data is read out from the magnetic sheet by the magnetic head 8. The readout data is stored into the IC memory in the microcomputer. In the case where the data on the magnetic sheet is required to be updated, only the contents of the IC memory are updated during the insertion of the cassette. When the cassette is ejected from the apparatus, only the updated

data in the IC memory is recorded into the magnetic recording layer by the magnetic head fixed near the cassette insertion opening. Thereby, the index information such as the TOC and the address of the cassette tape can be recorded on the cassette separately from the tape. This design is advantageous in that the search for the information in the cassette tape can be quickly executed.

This invention can be applied to a video game machine connected to a display 44a and a key pad 450A as shown in Fig. 180. The reproduction can not be performed if an illegal copy identifying signal is not recorded on the magnetic recording layer 3. This design is advantageous in that a CD made by illegal copy can be excluded. Data such as environment setting data, the name of the user, the point, and the result at a mid part of the game is recorded into the magnetic recording layer 3. Thus, the game can be restarted from the conditions which occur at the end of the preceding play of the game. As shown in Fig. 180, the magnetic recording layer 3 is provided at the print surface side of the CD. As previously described, the magnetic recording layer 3 may be provided at the transparent substrate side. This design enables a small size of the cassette.

DESCRIPTION OF THE TWENTY-THIRD PREFERRED EMBODIMENT

Fig. 181 shows a recording and reproducing apparatus according to a twenty-third embodiment of this invention. As shown in Figs. 182(a) and 182(b) and Figs. 183(a)-183(e), a

magnetic head is moved onto a CD only when an upper lid 389 is closed. In Fig. 182(a), the upper lid 389 is in an open state. When the upper lid assumes the open state, the magnetic head 8 is retracted to a position below a magnetic head protective portion 501 extending outside the CD 2. The retraction of the magnetic head permits the CD to be inserted into the apparatus.

The CD 2 is inserted into the apparatus, and the upper lid is moved to a closed state. During the movement of the upper lid to the closed state, the magnetic head 8 and its suspension move in a direction 51 to a place above the CD 2 according to the movement of the upper lid.

The operation sequence will now be described with reference to Figs. 183(a), 183(b), 183(c), 183(d), and 183(e). In Fig. 183(a), when the upper lid 389 is closed in a direction 51a, lid rotation shafts 393 and 393a rotate so that a head retracting device 502 moves in a direction 51b and the magnetic head 8 connected thereto moves in a direction 51c. In this way, as shown in Fig. 183(b), the magnetic head 8, a slider 41, and a suspension 41a move to a place above the recording medium 2 such as the CD.

Upward and downward movement of the magnetic head 8 will now be described with reference to Figs. 183(c), 183(d), and 183(e). As shown in Fig. 183(c), an optical head 6 executes the reproduction on an innermost track 65a of the TOC and others. As shown in Figs. 184(a), 184(b), and 184(c), a medium identifier 504 is read out, and a check is made as to whether the medium has a magnetic track 67 by referring to the medium identifier 504. If the

medium actually has a magnetic track 67, the optical head 6 is moved to a place inward of the innermost track as shown in Fig. 183(d). A head elevator 505 is forced by a head elevating link 503, bringing the magnetic head 8 into contact with an outermost magnetic track 67a and enabling the recording or reproduction of a magnetic record signal via the magnetic head 8.

As shown in Fig. 185(a), a servo signal region 505 is provided. During the manufacture of a recording medium, a high Hc portion is applied thereto as shown in Fig. 185(b). As shown in Fig. 185(c), the recording medium is formatted in a factory or others. A servo signal, selector information, and a medium identification number are recorded on a sync signal region 507 medium by medium. This recording is executed by using a magnetic head capable of recording information into a magnetic region having an Hc of 2750-4000 Oe. Next, as shown in Fig. 185(d), a low Hc magnetic portion 402 is applied. The low Hc magnetic portion 402 is made of material having an Hc of 1600-1750 Oe. As shown in Fig. 185(e), a protective layer 50 is applied thereon.

The magnetic portion 402 and the protective layer 50 make it more difficult to rewrite the information in the high Hc magnetic portion. Thus, the medium identification number 506 recorded in the sync signal region 507 can be more reliably prevented from being rewritten. This design is advantageous in that the previously-mentioned illegal copy guard function is hardly removed.

The servo signal 505 and the address signal can not be erased by a conventional recording and reproducing apparatus. Thus, after

the shipment of the medium from the factory, the data in the sync signal region can be maintained and protected so that stable data recording can be realized in response to the data in the sync signal region.

Rotation servo will be further described with reference to Fig. 183(d). In the presence of an optical recording portion at an innermost part of the CD 2, the rotational speed of a motor is made constant by CLV motor rotation control in response to the sync signal in the optical track. In this case, the magnetic recording and reproduction are enabled.

In the absence of an optical recording portion from an innermost part of the CD 2, the magnetic head 8 reproduces the servo signal 505 from the sync signal region 507 of Fig. 185(a). A rotation servo signal is thus reproduced by a rotation servo signal reproducing section 30c of Fig. 181. The rotation servo signal is transmitted to a motor drive circuit 26 so that the motor is controlled at a constant rotational speed. Therefore, data can be recorded and reproduced into and from desired sectors in data recording regions 508 and 508a of the magnetic track 67a of Figs. 185(a), 185(b), 185(c), 185(d), and 185(e).

After the recording or reproduction has been completed, the optical head 6 moves toward a disk outer portion as shown in Fig. 183(e). Thereby, the head elevating link 503 returns to the original position, and the magnetic head 8 moves in a direction 51e and separates from the magnetic track 67a. The separation of the magnetic head 8 from the magnetic track 67a prevents a wear

problem. In this way, the magnetic head 8 can be moved upward and downward by a traverse motor 23. This design is advantageous in that it is unnecessary to provide another head elevating actuator.

As shown in Figs. 186(c), 186(d), 186(e), the optical head 6 is forced to an outermost portion of the disk by the traverse motor 23, and the head elevating link 503 is moved in the direction 51a. The magnetic head 8 is lowered along the direction 51b into contact with the magnetic track 67a so that the recording and reproduction of the magnetic signal are enabled. In the case where magnetic noise from the optical head 6 causes a problem, the operation of an optical head actuator 18 is suspended. When the operation is suspended or when the reproduction of a signal from the optical track can not be executed, a drive current to the optical head is cut off. In addition, the servo signal 505 in the magnetic track of Fig. 185(a) is reproduced via the rotation servo signal reproducing portion 30c of Fig. 181, and rotation servo control is executed in response to the reproduced servo signal. Thereby, it is possible to temporary separate the optical reproduction and the magnetic reproduction. Since the noise from the optical head is thus prevented from interfering with the magnetic reproduction, an error rate can be small in the magnetic reproduction.

The arrangement of this embodiment can be applied to the plural magnetic track type or the one magnetic track type. In the case of a one track system, access to the head is unnecessary so that the apparatus can be simple in structure. In the case of one track at a disk outermost part, the capacity is large. As shown in Figs.

187(a), 187(b), 187(c), 187(d), and 187(e), the recording medium has sectors provided with the sync signal region 507, into which the magnetic servo signal 505 is stored in a factory or others. Upon the magnetic reproduction, the servo control responsive to the optical signal is replaced by the servo control responsive to the magnetic signal so that the drive current to the optical head 6 can be cut off. Thus, the noise from the optical head can be prevented from occurring.

A method of the rotation servo control responsive to the optical servo signal will now be described with reference to Figs. 188(a)-188(f). Fig. 188(a) show conditions which occur at t=0. The optical head 6 is in a position corresponding to an outer track or a TOC track 65a. In Fig. 188(b), at t=t1, the optical head 6 reads out information from the TOC track 65a. A medium identifier 504 is found out from the subcode of the TOC, the subcode portion of an audio track, or the first track of a CD ROM as shown in Fig. 184(c), Fig. 184(b), and Fig. 184(a). At this time, since the head elevating link 503 moves from a position A to a position B according to the movement of the optical head 6, a switch 511 of a mechanical delay device 509 is moved to an on position. Until a delay time tD elapses, the head elevating link 503a remains inactive. In Fig. 184(c), at t=t2, the reproduction of the TOC data is completed. In the case where the delay time tD is set as tD>t2, the magnetic head 8 is not moved downward. In the absence of a medium identifier, that is, in an off state, tD>t3. In Fig. 188(d), at t=t3, the optical head 6 moves in the direction 51d, and the head elevating link 503

suspends pressing the switch 511 so that the head is not moved downward.

In the presence of a medium identifier, there is always a magnetic track 67a. In an on state, at t=t4 (t4>tD), the switch 511 remains pressed for the delay time tD or longer as shown in Fig. 188(e). Therefore, the output of the mechanical delay device 509 becomes effective, and the head elevating link 503a moves downward a support portion including the suspension of the magnetic head 8 in the direction 51e. As a result, the magnetic head 8 contacts the magnetic track 67a. At this time, since the optical track 6 executes the reproduction on the optical track 65a of the TOC or others, the optical servo signal is reproduced. The motor 17 is rotated at a constant rotational speed by the CLV control responsive to the optical servo signal. Accordingly, the magnetic signal is reproduced in synchronism with the sync signal of the optical reproduced signal. Since the rotation servo control can be executed simultaneously in response to the magnetic reproduction and the optical reproduced signal, it is unnecessary to provide another mechanism for rotation servo control. Thus, this design is advantageous in that the medium and the apparatus can be simple in structure. In this case, the rotation servo signal reproducing portion 30c may be omitted from the arrangement of Fig. 181.

When the reproduction or recording of the magnetic signal has been completed, the system controller 10 of Fig. 181 transmits a given signal to the traverse moving circuit 24a so that the optical

head 6 is moved in a direction 51f and the switch 511 of the mechanical delay device 509 is released. At t=t5 after a delay time tDS shorter than the delay time tD elapses, the head elevating link 503a moves upward along a direction 51g as shown in Fig. 188(f) so that the magnetic head 8 is elevated out of contact with the magnetic track 67a. In this way, a simpler arrangement enables the upward and downward movement of the magnetic head, and the optical reproduction and the magnetic reproduction can be simultaneously executed.

As shown in Figs. 185(a), 185(b), 185(c), 185(d), and 185(e), a plurality of magnetic tracks 67 may be used. In this case, as shown in Fig. 189(a), the track width TWH of the magnetic track 8 is set greater than the width TW of the magnetic track 67a by a quantity corresponding to an eccentricity amount (an off-center amount). This design is advantageous in that a single head can be used in common for recording and reproduction. When the widths are set as TWH>>TW, the recording into all the magnetic track 67a can be executed so that the previously-recorded portion will not be left at all. In the case where magnetic layers corresponding to a plurality of tracks are separately provided, a single head can be used as both a recording head and a reproducing head.

In the case of the multiple track system, setting of the track pitch Tp is important. The CD standards allow an error Δr of ± 0.2 mm between the position of an optical track 65 and the center of the CD circle in the radial direction. Under ideal conditions, as shown in Fig. 189(a), a magnetic track 67a is located at the back

side of a given optical track 65a; and access to the magnetic track by referring to the optical address can be accurately executed. Under actual bad conditions, as shown in Fig. 189(b), the optical track 65a and the magnetic track 67a are offset by $+\Delta r$. Under opposite actual bad conditions, as shown in Fig. 189(c), the optical track 65a and the magnetic track 67a are offset by $-\Delta r$. To prevent the magnetic track 8 from accessing a magnetic track 67b neighboring the desired magnetic track, it is necessary to satisfy the following conditions.

$$r - \Delta r - TWH/2 > r + \Delta r + TWH/2 - Tp$$

Accordingly, the following relation is obtained.

$$Tp > 2\Delta r + TWH$$

In the case of a CD, Δr=0.2 mm so that the track pitch Tp is determined by the following relation.

$$Tp > 0.4 \text{ mm}$$

Thus, it is necessary to set the track pitch Tp to 0.4 mm or greater.

As shown in Fig. 187(a) and Fig. 189(a), the separate magnetic recording layers are provided, and the magnetic servo signal is recorded thereinto by a single magnetic head. In this case, as shown in Fig. 190, the structure of the arrangement can be simple.

As shown in Figs. 183(c), 183(d), and 183(e), the magnetic head 8 is moved upward and downward by using the traverse motor 23. This method of moving the magnetic head 8 can be applied to an arrangement where an optical head 6 and a magnetic head 8 are located on a common side of a recording medium as shown in Figs. 191(a), 191(b), 191(c), 191(d), and 191(e). In the case where an

identifier is detected under conditions of a TOC track 67a in Fig. 191(c), the optical head 6 moves to a state of Fig. 191(d) along a direction 51a. Therefore, a head elevating link 503 moves in the same direction, raising the magnetic head along a direction 51b into contact with the magnetic track 67a provided on an outer area of the optical recording surface side of the medium. Then, the magnetic recording or reproduction via the magnetic head 8 is performed. At this time, the optical head reproduces an optical servo signal from an optical track provided on an inner area of the medium, and rotation servo control for rotation at a constant speed is executed in response to the reproduced optical servo signal. The rotation servo control may be performed in response to the magnetic servo signal reproduced from the magnetic track 67a. After the magnetic recording or reproduction has been completed, the optical head 6 moves outward as shown in Fig. 191(e) and the magnetic head 8 moves downward out of contact with the medium.

Figs. 192(c) and 192(d) show another design in which an optical head 6 moves along a direction 51a to a region outside an outer edge of a recording medium, and thereby a magnetic head 8 is raised along a direction 51b into contact with a magnetic track 67a. Operation according to this design is approximately similar to the operation of the design of Figs. 186(a), 186(b), 186(c), 186(d), and 186(e).

As previously described, the magnetic recording track 67a is provided on an outer area of the optical recording surface side of the recording medium. Even in the case where the magnetic head

8 and the optical head 6 are located on the same side of the recording medium, the magnetic head 8 is moved upward and downward by the traverse motor 23 so that the number of parts can be reduced.

According to a CD player of Fig. 193(a), when an upper lid 389 is open but a CD is not inserted into the player, a magnetic head 8 and a suspension 41a are exposed. The magnetic head 8 and the suspension 41a tend to be damaged by a touch thereto.

To prevent such a problem, a magnetic head shutter 512 covers the magnetic head 8 when the upper lid 389 is open. As a CD 2 is inserted into the player and the upper lid 389 is closed, the magnetic head shutter 512 moves in a direction 51a to uncover the magnetic head 8. This process will be further described. With reference to Fig. 191(a), as the upper lid 389 is closed in a direction 51, a lid rotation shaft rotates in a direction 51d and the magnetic head shutter 512 moves in a direction 51e. Therefore, as shown in Fig. 191(b), a magnetic head window 513 is unblocked so that the magnetic head 8 is permitted to move upward and downward. In this regard, the arrangement of Figs. 192(a) and 192(b) is similar. This design is advantageous in that the magnetic head 8 and the suspension 41a can be protected by the magnetic head shutter 512.

There is no problem in an arrangement where a magnetic head 8 and a traverse of an optical head 6 are adequately separate as shown in Figs. 193(a) and 193(b). On the other hand, in the case where a magnetic head 8 is located in a range of movement of a

traverse, the magnetic head 8 is provided with a spring 514 as shown in Fig. 194(e). In this case, only when an optical head 6 executes the reproduction on an outermost optical track 65a, the magnetic head 8 is forced in a direction 51a by the optical head 6 so that the magnetic head 8 is retracted outward. This design is advantageous in that an adequate access range of the optical head 6 can be maintained. This design is effective in the case of a recording medium such as a CD having a magnetic recording track 67a which is not provided on the optical recording surface side thereof.

In some of cases where an optical head 6 and a magnetic head 8 are located on opposite sides of a recording medium respectively, a magnet generates a strong magnetic field depending on the designing of the optical head 6. Fig. 195 shows experimentally measured data of a magnetic filed on an optical recording portion of a CD which is caused by a CD ROM optical pickup made by "SANYO". The magnetic field is equal to 400 gauss in the absence of a magnetic head, and is equal to 800 gauss in the presence of a magnetic head 8 opposing the optical head. Thus, in this case, when the magnetic coercive force Hc of the magnetic recording portion of the recording medium is low, magnetically recorded data tends to be erased. According to this invention, such a problem is solved by setting the magnetic coercive force Hc to 1500 Oe or more. In addition, according to this invention, the magnetic head 8 is prevented from opposing the optical head when the optical head is used. Specifically, as shown in Fig. 196(c), a magnetic head

retracting link 515 is moved while being linked with a traverse. When the optical head 6 accesses an outer optical track 65a, the magnetic head 8 is forced by the retracting link 515 to a region outward of the recording medium 2. As a result, the concentration of magnetic fluxes by the magnetic head 8 is prevented so that the recorded magnetic data can be prevented from being damaged.

As shown in Fig. 116, the optical head 6 also causes ac magnetic noise in addition to the previously-mentioned dc magnetic field noise. As shown in Fig. 197, the magnetic head 8 is separated by a given distance LH or more from the optical head 6 containing an optical head actuator. This design is advantageous in that dc and ac noises from the optical head 6 are prevented from entering the magnetic head 8. It is understood from Fig. 116 that the noise level can be reduced by 15 dB when the given distance LH is equal to 10 mm. Thus, it is preferable that the two heads are separated by 10 mm or more.

According to an arrangement using a multiple track head 8 for providing a magnetic track 67a divided into three as shown in Fig. 198(a), an increased capacity of magnetic recording is attained. In the case where a magnetic head 8 corresponds to three azimuth heads 8a, 8b, and 8c of different azimuth angles, the track density can be increased by three times. In the case of a non-azimuth head, a required track pitch Tp is equal to 0.4 mm in track width. In the case of an azimuth head of this type, the required track pitch Tp is equal to 0.13 mm in track pitch. In the case of azimuth heads 8a and 8b of different azimuth angles as shown in Figs. 198(c) and

198(d), a double recording capacity is attained.

A description will now be given of a method of recording a medium identifier into a TOC area. Optical tracks 65a, 65b, 65c, and 65d are wove and wobbled as shown in Figs. 199(b), and thereby an additional signal (a wobbling signal) is recorded into the TOC area of Fig. 199(a). As shown in Fig. 200, an optical reproducing section is provided with a wobbling signal demodulator 38c which functions to reproduce the wobbling signal. According to this design, information of a medium identifier and others can be recorded into the TOC area. This design is advantageous in that the medium can be identified only by executing the reproduction on the TOC area, and that tune names and title names can be recorded into the TOC area.

In the case of a CD player of the tray type such as shown in Figs. 201(a), 201(b), 201(c), and 201(d), upward and downward movement of a head are executed by a loading motor 516. In Fig. 201(a), the loading motor 516 rotates and a tray moving gear 518 moves in a direction 51a, so that loading of a tray 520 starts. In Fig. 201(b), as the tray 520 is placed in the player, a micro-switch 521 is actuated and therefore the motor is deactivated. Then, the reproduction of a CD starts. In the presence of a medium identifier, the motor 516 further rotates in a direction 51g so that the tray moving gear 518 further advances in a direction 51b. Therefore, as shown in Fig. 201(c), a head moving link 503 is rotated, and a head elevator 519 is raised in a direction 51c. As a result, a magnetic head 8 is brought into contact with a magnetic track 67a so that the

magnetic recording or reproduction is enabled. After the magnetic recording or reproduction has been completed, the motor 516 rotates in the opposite direction so that the tray moving gear 518 moves in a direction 51d. Therefore, the head elevator 519 is raised in a direction 51e, and the magnetic head 8 is moved out of contact with the magnetic track 67a. Then, the normal optical reproduction is started. As previously described, the reproduced magnetic data is stored into a memory 34 composed of an IC memory, and a data updating process is executed in response to the data in the memory 34. Immediately before the tray is ejected from the player, only the updated data (the new data) is subjected to magnetic recording or reproduction to update the magnetically recorded data.

DESCRIPTION OF THE TWENTY-FOURTH PREFERRED EMBODIMENT

Fig. 221 shows an information recording medium according to a twenty-fourth embodiment of this invention. With reference to Fig. 221, an information recording medium 1111 includes a substrate 1108, a reflecting film 1107, a protective layer 1106 for the reflecting film 1107, and a magnetic recording layer 1112 which are laminated in that order. The magnetic recording layer 1112 has a magnetic layer 1105, a concealing layer 1103, a print layer 1102, and a protective layer 1101 for the print layer 1102 which are laminated in that order.

A description will now be given of the case where an optical recording portion of the information recording medium 1111

agrees with a CD ROM. The information recording medium 1111 was fabricated as follows. The substrate 1108 was formed by a molding process. The substrate 1108 was made of polycarbonate. The substrate 1108 had an optical recording surface 1114, and a pit formation surface opposite the optical recording surface 1114. After the reflecting film 1107 was vapor-deposited on the pit formation surface of the substrate 1108, the protective layer 1106 was provided on the reflecting film 1107. The protective layer 1106 was made of photo-curing or photo-setting resin (resin hardened by light), being formed by spin coat. The magnetic layer 1105 and the concealing layer 1103 extended on the protective layer 1106. A print region 1110 extended on the concealing layer 1103. The print region 1110 was used for printing characters 1109 on a label representing, for example, the title of the CD. The protective layer 1101 extended on the print region 1110, protecting the printed characters 1109. The protective layer 1101 was made of transparent material. According to this design, essentially the entire area of one surface of the CD could be used as a print region 1110.

A magnetic head contacts the protective layer 1101 and records a magnetic signal into the magnetic layer via the protective layer 1101, the print layer 1102, and the concealing layer 1103.

The substrate 1108 made of polycarbonate was formed by injection molding which used a die assembly. The reflecting film 1107 made of an aluminum alloy was formed on the pit formation surface of the substrate 1108 by a vapor deposition process or a

sputtering process. The protective layer 1106 made of photo-setting resin was formed on the reflecting film 1107 by, for example, spin coat, to complete a CD ROM portion. These processes were similar to corresponding processes in the fabrication of a prior art CD ROM.

With reference to Fig. 222(a), magnetic powder was dispersed in resin, and the resin with the magnetic powder was applied to the protective layer 1106 to form the magnetic layer 1105. The magnetic powder was iron-based acicular powder having a coercive force of 1950 Oe, a saturation magnetization of 143 emu/g, and a BET specific surface area of 56 m^2/g. The resin for the magnetic layer 1105 was a mixture of vinyl chloride-based resin and polyurethane-based resin. The resin for the magnetic layer 1105 might be of other types. The hardening of the resin might be of the thermo-setting type. The resin might be of the type not hardened provided that the resultant magnetic layer 1105 did not flow and move at normal temperatures. The resin and the magnetic powder were mixed by a sand mill for 3 hours before being applied to the protective layer 1106.

Specifically, the material for the magnetic layer 1105 was a mixture having the following composition:

acicular metal magnetic powder:	100 (parts by weight)
carbon black:	6 (parts by weight)
alumina:	15 (parts by weight)
MR-110:	15 (parts by weight)
polyurethane resin:	15 (parts by weight)

oleyl oleate:	-	5 (parts by weight)
MEK (methylethylketone):		270 (parts by weight)
toluene:		270 (parts by weight)
cyclohexanone:		90 (parts by weight)

where MR-110 was produced by Japanese company "Nippon Zeon". The mixture material was applied to the protective layer 1106 by an airless spray, and was dried and made into the magnetic layer 1105 having a uniform thickness of 2.5 μm. In the airless spray, the mixture material was pressurized by a pump 1119 and was passed through a nozzle 1120 to be made into particles moving toward the protective layer 1106.

With reference to Fig. 222(b), the concealing layer 1103 was an under layer for concealing the color of the magnetic layer 1105 and enabling clear indication of the print layer 1102. The concealing layer 1103 had superposition of an aluminum alloy film 1104 and a paint film 1113. The aluminum alloy film 1104 served to reflect light at the surface of the magnetic layer 1105 and to decrease light absorbed by the magnetic layer 1105. The aluminum alloy film 1104 was formed as follows. In a vacuum chamber 1121, an aluminum alloy within a crucible was heated by a heater 1123 powered by an electric power source 1124 so that a vapor of the aluminum alloy was generated. The aluminum alloy vapor was applied to the magnetic layer 1105, and consequently the aluminum alloy film 1104 was deposited on the magnetic layer 1105. The aluminum alloy film 1104 had a thickness of 0.2 μm.

With reference to Fig. 222(c), the paint film 1113 used a

white pigment in the case where full color print was provided thereon. The paint film 1113 might use a colored pigment. A paint for the paint film 1113 used titanium oxide powder having a particle diameter of about 0.28 μm. The paint for the paint film 1113 was a mixture having the following composition:

titanium oxide powder	100 (parts by weight)
alumina	8 (parts by weight)
polyurethane resin:	15 (parts by weight)
oleic acid:	2 (parts by weight)
stearic acid:	2 (parts by weight)
MEK:	120 (parts by weight)
toluene:	120 (parts by weight)
cyclohexanone:	40 (parts by weight)

The components were mixed by a ball mill for 70 hours, and 3 parts by weight of curing agent were added to the resultant mixture before the mixture containing the curing agent was applied to the aluminum alloy film 1104. The curing agent was, for example, desmodule L produced by "Dupont". The mixture containing the curing agent, that is, the paint for the paint film 1113, was applied to the aluminum alloy film 1104 by an airless spray to form the paint film 1113 having a thickness of 2 μm.

A label representing, for example, the title of the CD was printed on the concealing layer 1103. The used printing was of the offset type employing 4 colors in the case of full color. Screen printing might be used. With reference to Fig. 222(d), the printed characters 1109 had a thickness equal to or less than 4 μm.

With reference to Fig. 222(e), the protective layer 1101 served to protect the print layer 1102 and the concealing layer 1103 from the magnetic head and to prevent dust from being affixed to the surface of the magnetic recording layer 1112. It was preferable that the protective layer 1101 was water-repellent. The hardness of the protective layer 1101 was preferably equal to 5 H or more according to the pencil hardness test standards. The material for the protective layer 1101 used ultraviolet-curing resin. Silicone oil was added to the ultraviolet-curing resin to provide water-repellent characteristics. The mixture of the ultraviolet-curing resin and the silicone oil was transparent. The mixture of the ultraviolet-curing resin and the silicone oil was applied to the print layer 1102 by an offset printing process, an airless spray, or a screen printing process. The mixture of the ultraviolet-curing resin and the silicone oil on the print layer 1102 was exposed to ultraviolet rays to form the protective layer 1101. The protective layer 1105 had a thickness of 1.5 μm or more.

DESCRIPTION OF THE TWENTY-FIFTH PREFERRED EMBODIMENT

An information recording medium according to a twenty-fifth embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated hereinafter. The method of fabricating the information recording medium of the twenty-fifth embodiment is similar to the method of fabricating the information recording medium of the twenty-fourth embodiment except for

design changes indicated hereinafter.

A magnetic recording layer 1112 was formed on a CD ROM as follows. With reference to Fig. 223(a), magnetic material 1128 for a magnetic layer 1105 was applied to a protective layer 1106 by screen printing in which the magnetic material 1128 was passed through meshes in a screen plate 1126 by a squeegee 1127. The magnetic material 1128 on the protective layer 1106 formed the magnetic layer 1105 which had a thickness of 3.5 μm. A concealing layer 1103 and a print layer 1102 were formed as in the twenty-fourth embodiment.

Material for a protective layer 1101 was applied to the print layer 1102 by screen printing. The material for the protective layer 1101 formed a layer having a thickness of 5 μm. The material for the protective layer 1101 on the print layer 1102 was exposed to ultraviolet rays. The distance between the surfaces of the magnetic layer 1105 and the magnetic recording layer 1112 caused a spacing loss affecting an output signal of a reproducing head which represented information recorded on the magnetic recording layer 1112. The spacing loss (dB) was given by 54.6 (d/λ), where d denotes a spacing (μm) and λ denotes a recording wavelength (μm). Printed characters 1109 caused a variation in the distance between the surfaces of the magnetic layer 1105 and the magnetic recording layer 1112. The distance variation caused a variation in the output signal which was equal to 2.2 dB at a wavelength of 100 μm and 4.4 dB at a wavelength of 50 μm. The output signal variation affected recording and reproducing characteristics as modulation. To

suppress such modulation, it was preferable to reduce the distance between the surfaces of the magnetic layer 1105 and the magnetic recording layer 1112. With reference to Figs. 223(c) and 223(d), an excessive amount of the material for the protective layer 1101 was applied to the print layer 1102. The material on the print layer 1102 was ground and polished into the protective layer 1101 by a grinding tape 1125 while the information recording medium 1111 was rotated. As a result, the variation in the distance with respect to the magnetic layer 1105 was equal to 18% or less. The surface of the protective layer 1101 was formed with roughness having Rmax of 0.8. The roughness reduced the area of the contact between the protective layer 1101 and the magnetic head, and also reduced the coefficient of the friction between the protective layer 1101 and the magnetic head. This design was advantageous in the life and the durability of the information recording medium 1111.

DESCRIPTION OF THE TWENTY-SIXTH PREFERRED EMBODIMENT

An information recording medium according to a twenty-sixth embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated hereinafter. The method of fabricating the information recording medium of the twenty-sixth embodiment is similar to the method of fabricating the information recording medium of the twenty-fourth embodiment except for design changes indicated hereinafter.

Material for a magnetic layer 1105 used ferromagnetic powder

of pure metal iron which had a coercive force of 1510 Oe, a saturation magnetization of 130 emu/g, and a BET specific surface area of 49 m^2/g. The magnetic powder and resin were mixed by a sand mill for 3 hours. The material for the magnetic layer 1105 was a mixture having the following composition:

pure metal iron:	100 (parts by weight)
carbon black:	6 (parts by weight)
alumina:	15 (parts by weight)
MR-110:	15 (parts by weight)
polyurethane resin:	15 (parts by weight)
oleyl oleate:	5 (parts by weight)
MEK:	120 (parts by weight)
toluene:	120 (parts by weight)
cyclohexanone:	40 (parts by weight)

where MR-110 was produced by Japanese company "Nippon Zeon". Immediately before an application process, 6 parts by weight of curing agent were added to the mixture. The curing agent was, for example, desmodule L produced by "Dupont".

The resultant material for the magnetic layer 1105 was applied to a film of polyethylene terephthalate (PET) which had a thickness of 62 μm. The applied material formed a layer having a thickness of 2 μm. Magnetic orientation was removed from the magnetic material by using an ac magnetic field, and the magnetic material on the PET film was dried and calendered. Then, the magnetic material on the PET film was subjected to a curing process or a hardening process in an atmosphere having a

temperature of 60°C for 24 hours. After the hardening process, acrylic-based thermoplastic resin was applied to the surface of the PET film which was remote from the magnetic layer. The applied thermoplastic resin formed a layer having a thickness of 4 μm. The PET film with the magnetic layer and the thermoplastic resin layer was made by a die assembly into an annulus having an outside diameter of 117 mm and an inside diameter of 40 mm. The resultant annulus was thermally fused and bonded to a CD ROM. Then, ultraviolet-curing ink was printed on the magnetic layer on the CD ROM by screen printing. The printed ink formed layers having a thickness of 100 μm. The printed ink was cured or hardened by using ultraviolet rays. As a result, the information recording medium of this embodiment was completed.

An information recording medium being a first reference was fabricated. The information recording medium of the first reference is similar in structure to the information recording medium of this embodiment except that the ultraviolet-curing ink was not used. The method of fabricating the information recording medium of the first reference is basically similar to the method of fabricating the information recording medium of this embodiment.

An information recording medium being a second reference was fabricated. The information recording medium of the second reference is similar in structure to the information recording medium of this embodiment except for design changes indicated hereinafter. The method of fabricating the information recording medium of the second reference is similar to the method of

fabricating the information recording medium of this embodiment except for design changes indicated hereinafter. With respect to the information recording medium of the second reference, a paint for a paint film 1113 in a concealing layer 1103 used titanium oxide powder having a particle diameter of about 0.28 μm. The paint for the paint film 1113 was a mixture having the following composition:

titanium oxide powder	100 (parts by weight)
alumina	8 (parts by weight)
polyurethane resin:	15 (parts by weight)
oleic acid:	2 (parts by weight)
stearic acid:	2 (parts by weight)
MEK:	120 (parts by weight)
toluene:	120 (parts by weight)
cyclohexanone:	40 (parts by weight)

The components were mixed by a ball mill for 70 hours, and 3 parts by weight of curing agent were added to the resultant mixture. The curing agent was, for example, desmodule L produced by "Dupont". Magnetic material equal to the magnetic material in this embodiment, and the mixture containing the curing agent (that is, the paint for the paint film 1113) were applied to a PET film having a thickness of 62 μm. The applied magnetic material and the applied paint material formed layers having thicknesses of 2 μm and 3 μm respectively. Magnetic orientation was removed from the magnetic material by using an ac magnetic field, and the magnetic material and the paint material on the PET film were dried and calendered. Then, the magnetic material and the paint material on

the PET film were subjected to a curing process or a hardening process in an atmosphere having a temperature of 60°C for 24 hours. After the hardening process, acrylic-based thermoplastic resin was applied to the surface of the PET film which was remote from the magnetic layer. The applied thermoplastic resin formed a layer having a thickness of 4 μm. The PET film with the magnetic layer, the paint layer, and the thermoplastic resin layer was made by a die assembly into an annulus having an outside diameter of 117 mm and an inside diameter of 40 mm. The resultant annulus was thermally fused and bonded to a CD ROM.

Experiments were performed on samples of the disk-shaped information recording media of this embodiment, the first reference, and the second reference to compare the characteristics thereof. A first type of the experiments related to scratches on the samples. During the first type of the experiments, a square glass plate of 30 cm by 30 cm was paved with Kanto loam dust of 1 g, and each of the disk samples was placed on the Kanto loam dust in a manner such that the magnetic layer on the disk sample downwardly faced the Kanto loam dust. The disk sample was rotated by 300 turns while a load of 500 g was applied thereto. Scratches caused on the magnetic layer were visually observed. A second type of the experiments related to recording frequency characteristics. During the second type of the experiments, rectangular wave signals of different frequencies were recorded into each of the disk samples by a Sendust bulk head while a recording current was varied. Output signals representative of the recorded

signals were generated by a reproducing process, and frequency characteristics were determined on the basis of the generated output signals while a maximum value of the output signals was used as a reference. A linear recording density D80 was defined as corresponding to 80% of the maximum output value.

It was found from the results of the experiments that the information recording medium having the recessed magnetic recording portion due to the presence of the print layer was less subjected to scratches than the information recording medium having the non-recessed magnetic recording portion. Also, it was found that the information recording medium having the recessed magnetic recording portion due to the presence of the print layer had the extended linear recording density D80 in comparison with the information recording density having the concealing layer.

While the PET film with the magnetic recording layer was attached to the disk member by the bonding layer in this embodiment, the magnetic layer might be transferred onto the disk member via the bonding layer. The magnetic powder used in the magnetic layer might be different from the powder of pure metal iron. For example, the magnetic powder used in the magnetic layer might be powder of Co-γ iron oxide, powder of γ iron oxide, powder of barium ferrite, powder of hexagonal ferrite, powder of iron nitride, or powder of iron carbide. The resin for bonding the magnetic layer and the disk member might use thermoplastic resin, thermo-setting resin, vinyl chloride-based resin, polyurethane-based resin, or epoxy-based resin. The bonding layer might be previously

bonded to the non-magnetic substrate. The bonding layer might use a sheet of resin.

DESCRIPTION OF THE TWENTY-SEVENTH PREFERRED EMBODIMENT

An information recording medium according to a twenty-seventh embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated later. The method of fabricating the information recording medium of the twenty-seventh embodiment is similar to the method of fabricating the information recording medium of the twenty-fourth embodiment except for design changes indicated later.

First preliminary experiments were performed as follows. Used magnetic powder was metal magnetic powder "MAP2000" having a BET specific surface area of 55 m^2/g which was produced by Japanese company "Kanto Denka Kogyo". Used binder resin was polyurethane resin solution "UR-8530" containing sulfonic group which was produced by Japanese company "Toyobo". The polyurethane resin solution contained 30 wt% solid components and solvent being a mixture of MEK/toluene with a mixing ratio of 1/1. The polyurethane resin solution had a molecular weight of 50000. Used dispersing agent was p-toluenesulfonic acid being 1 hydrate and having a molecular weight of 190.21 which was produced by Japanese company "Nakaraitesuku". Measurement was made as to the monomolecular absorption amount of the p-toluenesulfonic acid with respect to the metal magnetic powder.

Specifically, materials described later and dispersing beads were placed into a 500-ml polyethylene container, and a dispersing process was done for 1 hour by shaking the container. The resultant mixture was filtered by a Nutsche, being dried with air blow. Then, the resultant substance was subjected to thermo-gravimetric analysis. The absorption amount of the dispersing agent was estimated and measured from the thermo-gravimetric analysis curve. The materials placed into the container were 100 g of the metal magnetic powder, 300 g of MEK being solvent, 10 g of p-toluenesulfonic acid, and 300 g of dispersing zircon beads having a diameter of 1 mm. The result of the measurement was 2.88 parts by weight with respect to 100 parts by weight of the magnetic powder. This value approximately agreed with the theoretical monomolecular absorption amount calculated from parameters including the molecular cross-sectional area of sulfonic group, the molecular weight of p-toluenesulfonic acid, the BET specific surface area of the metal magnetic powder, and the Avogadro number. Accordingly, with respect to the metal magnetic powder, a value of 2.88 wt% was thought to be an absorption saturation value. In fact, hydrogen gas occurred when p-toluenesulfonic acid was applied to the metal magnetic powder. Thus, it was confirmed that the dispersing agent was absorbed by the metal magnetic powder.

Second preliminary experiments were performed. Second preliminary experiments were similar to the first preliminary experiments except for the points indicated hereinafter. Materials described later and dispersing beads were placed into a 500-ml

polyethylene container, and a dispersing process was done for 3 hours by shaking the container. The resultant mixture was filtered by a Nutsche, being dried with air blow. Then, the resultant substance was subjected to thermo-gravimetric analysis. The absorption amount of binder resin was estimated and measured from the thermo-gravimetric analysis curve. The materials placed into the container were 100 g of the metal magnetic powder, binder resin solution containing 50 g of polyurethane resin solution and 137.5 g of mixture solvent of MEK/toluene with a mixing weight ratio of 1.1, and 300 g of dispersing zircon beads having a diameter of 1 mm. The result of the measurement was 10.44 parts by weight with respect to 100 parts by weight of the magnetic powder. This value was thought to be reasonable.

Experiments were performed on adjustment of ink for a magnetic layer in an information recording medium as follows. Used magnetic powder was metal magnetic powder "MAP2000" produced by Japanese company "Kanto Denka Kogyo". Used dispersing agent was p-toluenesulfonic acid being 1 hydrate. Used organic solvent was MEK. The metal magnetic powder being 500 g in weight, the dispersing agent being p-toluenesulfonic acid (1 hydrate), and the organic solvent being 1500 g in weight were agitated and mixed at a high speed by a dispersing machine. The resultant mixture was filtered by a Nutsche and a suction filter so that the metal magnetic powder which occurred after the dispersing process was extracted therefrom. Surplus MEK was removed from the metal magnetic powder by air blow, and the

metal magnetic powder was adequately dried. Then, polyurethane resin solution having 30 wt% solid components was added to the metal magnetic powder. The polyurethane resin solution was "UR-8530" produced by Japanese company "Toyobo". The polyurethane resin solution and the metal magnetic powder were mixed and kneaded by three rolls, being diluted and being subjected to a dispersing process by a sand mill. In addition, organic solvent was added to the resultant mixture to form magnetic paint. The organic solvent contained MEK/toluene/cyclohexanone with a weight ratio of 3/3/1. The magnetic paint was adjusted to have 30.0 wt% nonvolatile components. As shown in Fig. 228, seven samples of the magnetic paint which were identified by sample numbers "1"-"7" were prepared while the amount ratio between polyurethane and p-toluenesulfonic acid (the dispersing agent) was varied. Each of the samples of the magnetic paint was applied to a CD by a 400 mesh produced by Japanese company "Mesh Kogyo", and ultraviolet-curing resin was similarly applied to the magnetic paint. The ultraviolet-curing resin was "SSD White" produced by Japanese company "Dai Nippon Inki Kagaku Kogyo". The resultant CD was subjected to an ultraviolet curing process to complete an information recording medium having a 4-μm thick magnetic layer and an 8-μm thick concealing layer.

Measurement was made as to output signals from information recording media related to the samples of the magnetic paint respectively. The conditions of the measurement were that the relative speed between each information recording medium and a

magnetic head was 1.3 m/s and the linear recording density was 600 BPI, and the read/write track widths were 200 μm. The decibel notation values of the measured output signals are indicated in Fig. 228.

It was assumed that all the dispersing agent was absorbed by the magnetic powder as the prepared and added amount thereof increased to a value of 2.88 wt%. The absorption rate A was defined as "A=the prepared and added amount in parts by weight × 100/2.88 (%)". The absorption rates A related to the samples of the magnetic paint are indicated in Fig. 228. As shown in Fig. 228, the output signal was maximized at a small added amount of the dispersing agent. The absorption rate A varied linearly with the BET specific surface area of the magnetic powder.

DESCRIPTION OF THE TWENTY-EIGHTH PREFERRED EMBODIMENT

An information recording medium according to a twenty-eighth embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated later. The method of fabricating the information recording medium of the twenty-eighth embodiment is similar to the method of fabricating the information recording medium of the twenty-fourth embodiment except for design changes indicated later.

Experiments were performed on adjustment of ink for a concealing layer in an information recording medium as follows. Used powder for the concealing layer was 500 g of titanium oxide

powder "R-580" produced by Japanese company "Ishihara Sangyo". The titanium oxide powder had a particle diameter of about 0.28 μm and a BET specific surface area of 7 m^2/g. As shown in Fig. 228, seven samples of the paint film (the concealing layer) which were identified by sample numbers "8"-"14" were prepared while the amount ratio between dispersing agent and resin was varied.

The brilliances of the samples of the paint film were measured by a glossmeter "VG-1D" produced by Japanese company "Nippon Denshoku" and having incident and reflection angles of 45 degrees. The measured brilliances are indicated in Fig. 229. As shown in Fig. 229, the brilliance was maximized at a small added amount of the dispersing agent.

With respect to dispersing adjustment of magnetic paint, to enable dispersing agent to be uniformly absorbed by metal magnetic powder having a great BET specific surface area, pretreatment is preferably of the wet type using organic solvent for an adequate wet absorption process. In this case, the organic solvent is preferably MEK.

DESCRIPTION OF THE TWENTY-NINTH PREFERRED EMBODIMENT

An information recording medium according to a twenty-ninth embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated later. The method of fabricating the information recording medium of the twenty-ninth embodiment is similar to the method of fabricating the information

recording medium of the twenty-fourth embodiment except for design changes indicated later. The twenty-ninth embodiment uses ultraviolet-curing resin as photo-curing resin.

Experiments were performed on adjustment of ink for a magnetic layer in the information recording medium as follows. Used magnetic powder was metal magnetic powder "MAP2000" produced by Japanese company "Kanto Denka Kogyo". Alumina "AKP-20" was used which was produced by Japanese company "Sumitomo Kagaku Kogyo". The alumina had a particle diameter of about 0.50 μm. The ultraviolet-curing resin was of the epoxy acrylic type. The metal magnetic powder being 500 g in weight, the alumina, the ultraviolet-curing resin solution being 100 g in weight, 47 wt% prepolymer, 40 wt% monomer, 5 wt% photochemical polymerization initiator, 5 wt% adjuvant, 3 wt% antifoamer, and organic solvent being cyclohexanone were agitated and premixed at a high speed by a dispersing machine. The resultant mixture was kneaded by three rolls, being subjected to a dispersing process.

Experiments were performed on adjustment of ink for a concealing layer in the information recording medium. The experiments on the adjustment of ink for the concealing layer were similar to the experiments on the adjustment of ink for the magnetic layer except that the metal magnetic powder was replaced by titanium oxide powder being 500 g in weight. The titanium oxide powder was "R-580" produced by Japanese company "Ishihara Sangyo". The titanium oxide powder had a particle diameter of about 0.28 μm and a BET specific surface area of 7 m^2/g.

The ink for the magnetic layer was applied to a CD by screen printing which used a screen with a 400 mesh produced by Japanese company "Mesh Kogyo". The resultant paint film of the ink was subjected to an ultraviolet curing process. Four samples of the paint film which were identified by sample numbers "15"-"18" were prepared while the added amount of cyclohexanone was varied and the alumina was absent. The degree of longitudinal strings or lines on the surface of each of the samples of the paint film by a squeegee was visually observed. The result of the observation is indicated in Fig. 230. As shown in Fig. 230, it was found that the viscosity of the ink decreased and the levelling characteristics thereof increased as the added amount of cyclohexanone was increased.

Similar experiments and observation were performed under conditions where N-methyl-2-pyrolidone (NMP) was used as organic solvent. Four samples of the paint film which were identified by sample numbers "19"-"22" were prepared while the added amount of NMP was varied and the alumina was absent. The degree of longitudinal strings or lines on the surface of each of the samples of the paint film by a squeegee was visually observed. The result of the observation is indicated in Fig. 231. As shown in Fig. 231, better surfaces of the paint film were obtained according to this design.

Samples of the information recording medium which were identified by sample numbers "23"-"26" were fabricated as follows. The ink for the magnetic layer which corresponded to the sample "18" was printed on a CD, and then the ink for the concealing layer

which corresponded to one of the samples "19"-"22" was printed on the former ink. Subsequently, the ink films on the CD were subjected to an ultraviolet-curing process to complete the information recording medium.

Measurement was made as to output signals from the samples of the information recording medium. The conditions of the measurement were that the relative speed between each information recording medium and a magnetic head was 1.3 m/s and the linear recording density was 600 BPI, and the read/write track widths were 200 μm. The decibel notation values of the measured output signals are indicated in Fig. 232.

DESCRIPTION OF THE THIRTIETH PREFERRED EMBODIMENT

An information recording medium according to a thirtieth embodiment of this invention is similar in structure to the information recording medium of the twenty-fourth embodiment except for design changes indicated later. The method of fabricating the information recording medium of the thirtieth embodiment is similar to the method of fabricating the information recording medium of the twenty-fourth embodiment except for design changes indicated later. The thirtieth embodiment uses ultraviolet-curing resin as photo-curing resin.

Experiments were performed on adjustment of ink for a magnetic layer in the information recording medium as follows. Used magnetic powder was metal magnetic powder "MAP2000" produced by Japanese company "Kanto Denka Kogyo". Alumina "AKP-20" was used which was produced by Japanese company

"Sumitomo Kagaku Kogyo". The alumina had a particle diameter of about 0.50 μm. The ultraviolet-curing resin was of the epoxy acrylic type. The metal magnetic powder being 500 g in weight, the alumina, the ultraviolet-curing resin solution being 100 g in weight, 47 wt% prepolymer, 40 wt% monomer, 5 wt% photochemical polymerization initiator, 5 wt% adjuvant, 3 wt% antifoamer, and organic solvent being cyclohexanone were agitated and premixed at a high speed by a dispersing machine. The resultant mixture was kneaded by three rolls, being subjected to a dispersing process.

Experiments were performed on adjustment of ink for a concealing layer in the information recording medium. The experiments on the adjustment of ink for the concealing layer were similar to the experiments on the adjustment of ink for the magnetic layer except that the metal magnetic powder was replaced by titanium oxide powder being 500 g in weight. The titanium oxide powder was "R-580" produced by Japanese company "Ishihara Sangyo". The titanium oxide powder had a particle diameter of about 0.28 μm and a BET specific surface area of 7 m^2/g.

The ink for the magnetic layer was applied to a CD by screen printing which used a screen with a 400 mesh produced by Japanese company "Mesh Kogyo". The resultant paint film of the ink was subjected to an ultraviolet curing process. Four samples of the paint film which were identified by sample numbers "15"-"18" were prepared while the added amount of cyclohexanone was varied and the alumina was absent. The degree of longitudinal strings or lines on the surface of each of the samples of the paint film by a

squeegee was visually observed. The result of the observation is indicated in Fig. 230. As shown in Fig. 230, it was found that the viscosity of the ink decreased and the levelling characteristics thereof increased as the added amount of cyclohexanone was increased.

Similar experiments and observation were performed under conditions where N-methyl-2-pyrolidone (NMP) was used as organic solvent. Four samples of the paint film which were identified by sample numbers "19"-"22" were prepared while the added amount of NMP was varied and the alumina was absent. The degree of longitudinal strings or lines on the surface of each of the samples of the paint film by a squeegee was visually observed. The result of the observation is indicated in Fig. 231. As shown in Fig. 231, better surfaces of the paint film were obtained according to this design.

Samples of the information recording medium which were identified by sample numbers "23"-"26" were fabricated as follows. The ink for the magnetic layer which corresponded to the sample "18" was printed on a CD, and then the ink for the concealing layer which corresponded to one of the samples "19"-"22" was printed on the former ink. Subsequently, the ink films on the CD were subjected to an ultraviolet-curing process to complete the information recording medium.

Measurement was made as to output signals from the samples of the information recording medium. The conditions of the measurement were that the relative speed between each information recording medium and a magnetic head was 1.3 m/s

and the linear recording density was 600 BPI, and the read/write track widths were 200 μm. The decibel notation values of the measured output signals are indicated in Fig. 232.

Samples of the information recording medium were fabricated as follows. Various types of the ink for the concealing layer were prepared which used different amounts of cyclohexanone. The samples of the information recording medium were made by using the various types of the ink for the concealing layer respectively. Measurement was made as to output signals from the samples of the information recording medium. It was understood from the result of the measurement that the addition of cyclohexanone reduced the thickness of the concealing layer and therefore improved the output signal characteristics.

DESCRIPTION OF THE THIRTY-FIRST PREFERRED EMBODIMENT

An information recording medium according to a thirty-first embodiment of this invention is similar in structure to the information recording medium of the thirtieth embodiment except for design changes indicated later. The method of fabricating the information recording medium of the thirty-first embodiment is similar to the method of fabricating the information recording medium of the thirtieth embodiment except for design changes indicated later. The thirty-first embodiment has a paint film to which powder having a great hardness is added.

Samples of a paint film which were identified by sample numbers "27"-"30" were prepared while metal magnetic powder was replaced by titanium oxide "R-580" and highly-hard powder was

added at varying amounts. Cyclohexanone was not added. The highly-hard powder was alumina powder "AKP-20" produced by Japanese company "Sumitomo Kagaku Kogyo".

The samples of the paint film were tested for durability with head running. The testing conditions were that a head for a floppy disk was placed on a concealing layer of the information recording medium which corresponded to each of the samples "27"-"30" of the paint film, and the information recording medium was rotated at a speed of 360 rpm. In addition, the relative speed between the head and the information recording medium was 1.3 m/s, and a head load was 25 g. The information recording medium or the head was run by 1-million passes at a normal temperature and a normal humidity. The surface of the concealing layer was evaluated by visual observation. The evaluation index (the performance index) was changeable among five different degrees "1", "2", "3", "4", and "5". The evaluation index "5" corresponded to a state where scratches were absent from the surface. The evaluation index "4" corresponded to a state where small scratches were present in the surface. The evaluation index "3" corresponded to a state where clear scratches were present in the surface. The evaluation index "2" corresponded to a state where great scratches were present in the surface. The evaluation index "1" corresponded to a state where great scratches reaching a magnetic layer were present in the surface. The result of the evaluation is indicated in Fig. 233. As shown in Fig. 233, it was found that the addition of alumina improved the durability.

DESCRIPTION OF THE THIRTY-SECOND PREFERRED EMBODIMENT

With reference to Fig. 226, an information recording medium includes a CD body 2001 on which a magnetic layer 2002 extends. A concealing layer 2003 is superposed on the magnetic layer 2002. Edges of the magnetic layer 2002 are covered by vertically-extending portions 2004 of the concealing layer 2003. The information recording medium was fabricated while ink identified by sample number "30" (see Fig. 233) was used.

The concealing layer in the information recording medium of this embodiment and a concealing layer in an information recording medium of Fig. 227 were tested for durability with respect to head running. The surfaces of the concealing layers were evaluated by visual observation. The result of the evaluation is indicated in Fig. 234. As shown in Fig. 234, this embodiment exhibited better durability.

During the fabrication of the information recording medium of Fig. 226, a label might be printed on the concealing layer 2003 by a screen printing process or an offset printing process before the execution of the ultraviolet-curing process. Alternatively, the label might be printed on the concealing layer 2003 by applying organic dyes through a character pattern mask. The printing on the magnetic layer 2002 and the printing on the concealing layer 2003 might be performed by using screens of different sizes respectively.

DESCRIPTION OF THE THIRTY-THIRD PREFERRED EMBODIMENT

A thirty-third embodiment of this invention relates to an information recording medium. During the fabrication of the information recording medium, a CD was exposed to ultraviolet rays for 3 minutes by a dry processor "UVC-B" produced by Japanese company "Ohku Seisakusho". The exposure to the ultraviolet rays was to provide good bonding with a magnetic layer. Subsequently, ink for a magnetic layer which was identified by sample number "30" (see Fig. 233) was printed on the CD by screen printing.

Experiments were performed in which the resultant information recording medium was rubbed with human nails. In addition, similar experiments were done on a reference information recording medium which was fabricated without exposure to ultraviolet rays. The results of the experiments are indicated in Fig. 235. According to the experiments, it was confirmed that the exposure to the ultraviolet rays was effective to provide good bonding between the CD and the magnetic layer.

DESCRIPTION OF THE THIRTY-FOURTH PREFERRED EMBODIMENT

A thirty-fourth embodiment of this invention relates to a method of providing the recording medium with an identifier, that is, an HB (hybrid) identifier, which indicates the presence or absence of the magnetic recording layer.

In the case of a CD, with respect to data in the optical recording layer, one block is composed of 98 frames of the EFM modulated data structure as shown in Fig. 213. According to an example, in Q bits of the subcode in the frame in the TOC area, code

data in which POINT is set as "BO" is defined as an HB identifier code data 468a. Since BO is not currently used, a conventional CD, a conventional CD ROM, and an HB medium with a magnetic recording layer according to this invention can be discriminated while the compatibility thereamong can be maintained. Since the HB identifying information is stored in the TOC area, the HB recording medium can be identified upon the first reading of the TOC area information. Therefore, this design is advantageous in that an HB recording medium can be identified in a short time.

As shown in Fig. 236(a), an HB recording medium 2 includes a transparent substrate 5 on which an aluminum vapor deposited film 4b and pits 4c are provided. In addition, a magnetic layer 3 is provided thereon. As shown in Fig. 236(b), the pits indicate an EFM modulated signal which has a data sequence 470b containing subcode 470c. In the case of control bits 470e of Q bits 470d in the subcode 470c, recorded HB identifier code data 468a is "0011". According to another way, identifying code data 468a "BO" is recorded in the POINT 470f of the TOC area. The recording medium 2 is advantageous in that the presence and absence of the magnetic recording layer can be detected without changing the structure thereof.

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CLAIM FOR SECOND DIVISIONAL APPLICATION:

1. An apparatus for reproducing information from an optical disc having a transparent substrate and an optical recording layer, the optical recording layer extending on the transparent substrate, the optical recording layer having a first recording area storing data containing data represented by a secret code, the optical recording layer having a second recording area provided with a barcode-like pattern representing data containing information of an ID number for the optical disc, the apparatus comprising:

first means for optically scanning the optical recording layer of the optical disc and reading out information from the optical recording layer;

second means for recovering the data represented by the secret code from the information read out by the first means;

third means for recovering the information of the ID number for the optical disc from the information read out by the first means;

fourth means for using the information of the ID number for the optical disc which is recovered by the third means as a secret code unlocking key, and for decoding the data represented by the secret code which is recovered by the second means into corresponding non-secret data in response to the secret code unlocking key; and

fifth means for outputting the non-secret data generated by the fourth means.



The claim is drawn to the fourteenth embodiment, the seventeenth embodiment, and the eighteenth embodiment, Fig. 145(a), Fig. 147, Fig. 148, Fig. 149, and Fig. 150.

The barcode-like pattern in the claim corresponds to the bar code 387a in Fig. 145(a). The information of the ID number for the optical disc in the claim corresponds to the disk ID number information in the key management table 404 in Fig. 149. The fourth means in the claim corresponds to the key unlocking decoder 406 in Figs. 147 and 149.

* C L M S *