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(54) **STORAGE DEVICE**

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(57) **ABSTRACT**

The storage device used in connection with an information processing apparatus is provided. The storage device includes: an authentication storage area storing an authentication program in advance, wherein the authentication program is executed to authenticate whether each user operating the information processing apparatus is an approved user; an operating system storage area storing an operating system in advance, wherein the operating system is encrypted and is used by the information processing apparatus; an access controller configured to control accesses the authentication storage area and the operating system storage area from the information processing apparatus; and a decoder configured to decrypt the encrypted operating system, wherein upon notification of successful authentication representing that the user is authenticated as the approved user by the authentication program, the access controller allows an access the operating system storage area from the information processing apparatus.

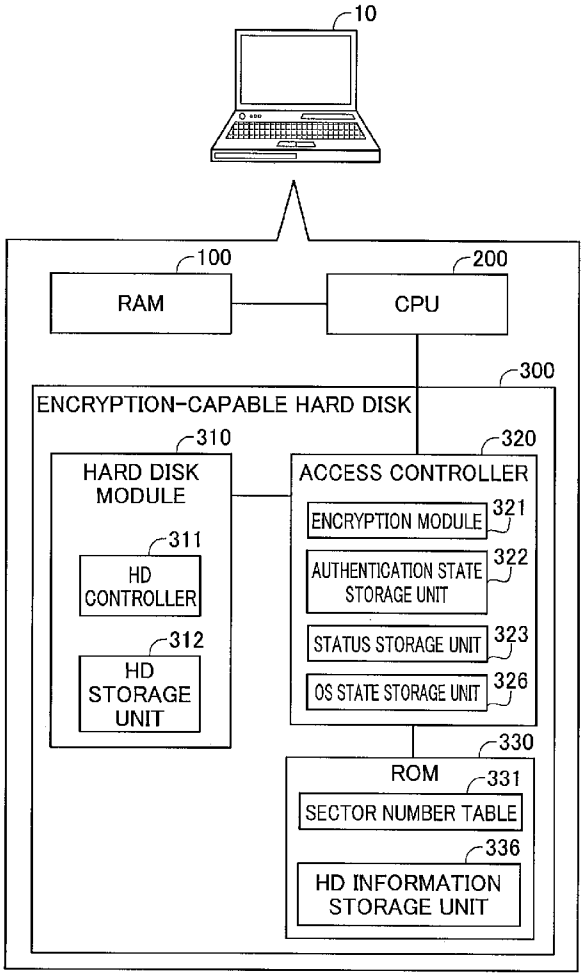


Fig.1

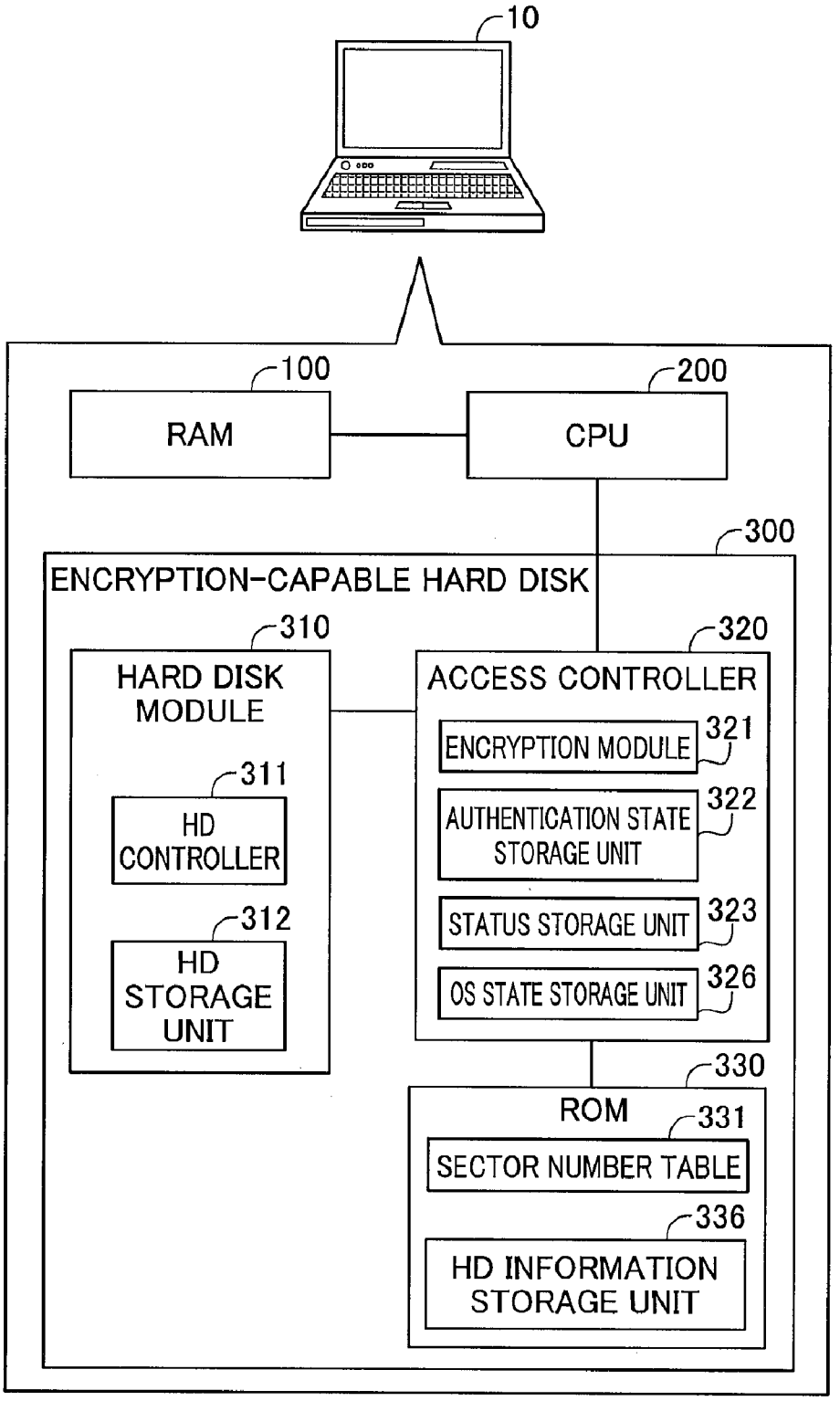

10
100
RAM
200
CPU
300
ENCRYPTION-CAPABLE HARD DISK
310
HARD DISK MODULE
311
HD CONTROLLER
312
HD STORAGE UNIT
320
ACCESS CONTROLLER
ENCRYPTION MODULE
321
AUTHENTICATION STATE STORAGE UNIT
322
STATUS STORAGE UNIT
323
OS STATE STORAGE UNIT
326
330
ROM
331
SECTOR NUMBER TABLE
336
HD INFORMATION STORAGE UNIT

Fig.2

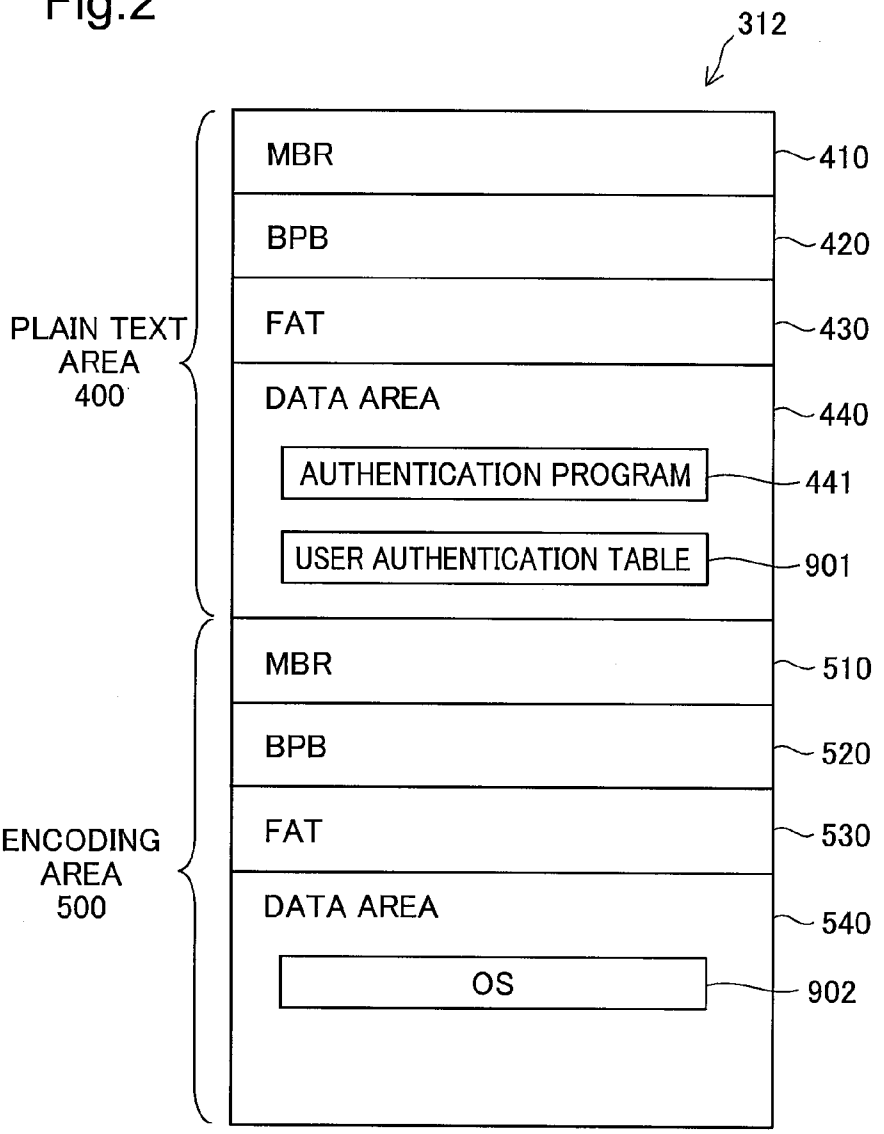


Fig.3

<USER AUTHENTICATION TABLE>

901

USER NAME :UN	PASSWORD :UP
A	235v65
B	abc546
C	py8e66

Fig.4

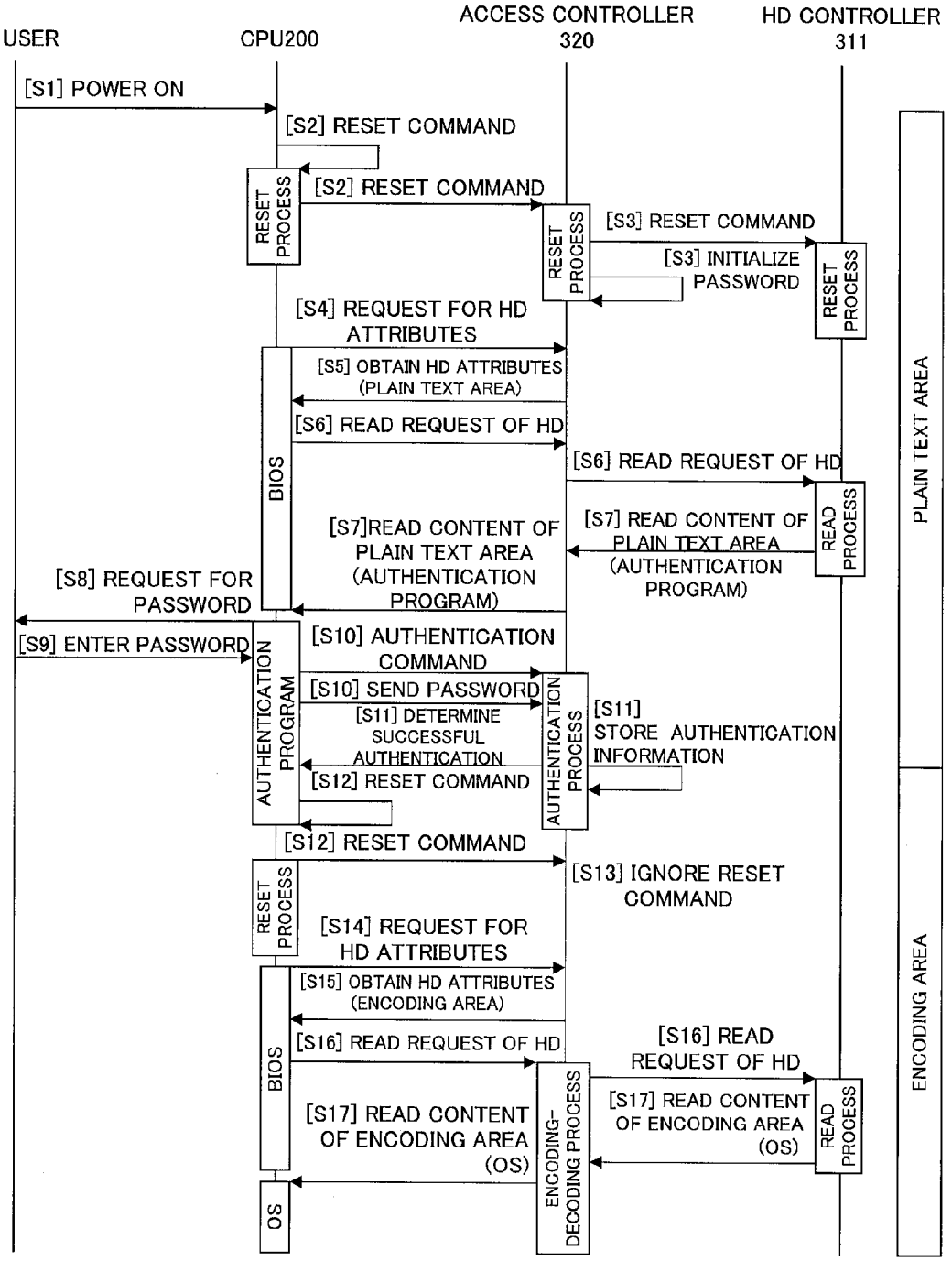

USER
CPU200
ACCESS CONTROLLER 320
HD CONTROLLER 311
[S1] POWER ON
[S2] RESET COMMAND
RESET PROCESS
[S2] RESET COMMAND
RESET PROCESS
[S3] RESET COMMAND
[S3] INITIALIZE PASSWORD
RESET PROCESS
[S4] REQUEST FOR HD ATTRIBUTES
[S5] OBTAIN HD ATTRIBUTES (PLAIN TEXT AREA)
BIOS
[S6] READ REQUEST OF HD
[S6] READ REQUEST OF HD
READ PROCESS
[S7]READ CONTENT OF PLAIN TEXT AREA (AUTHENTICATION PROGRAM)
[S7] READ CONTENT OF PLAIN TEXT AREA (AUTHENTICATION PROGRAM)
PLAIN TEXT AREA
[S8] REQUEST FOR PASSWORD
[S9] ENTER PASSWORD
[S10] AUTHENTICATION COMMAND
[S10] SEND PASSWORD
AUTHENTICATION PROGRAM
[S11] DETERMINE SUCCESSFUL AUTHENTICATION
AUTHENTICATION PROCESS
[S11] STORE AUTHENTICATION INFORMATION
[S12] RESET COMMAND
[S12] RESET COMMAND
RESET PROCESS
[S13] IGNORE RESET COMMAND
[S14] REQUEST FOR HD ATTRIBUTES
[S15] OBTAIN HD ATTRIBUTES (ENCODING AREA)
BIOS
[S16] READ REQUEST OF HD
[S16] READ REQUEST OF HD
READ PROCESS
[S17] READ CONTENT OF ENCODING AREA (OS)
ENCODING-DECODING PROCESS
[S17] READ CONTENT OF ENCODING AREA (OS)
OS
ENCODING AREA

Fig.5A

VISIBLE AREA AFTER POWER SUPPLY TO PC (STEP S5)

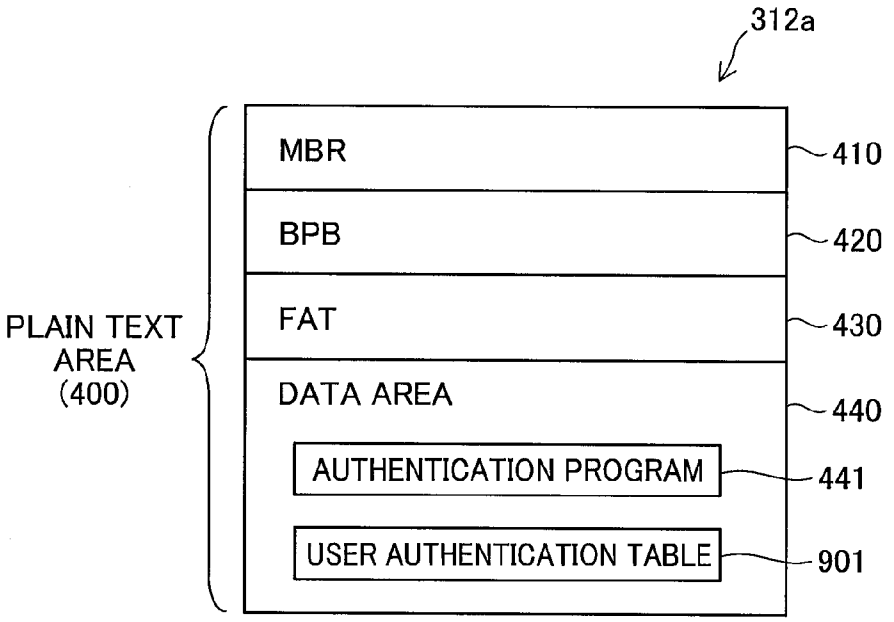


Fig.5B

VISIBLE AREA AFTER SUCCESSFUL AUTHENTICATION (STEP S15)

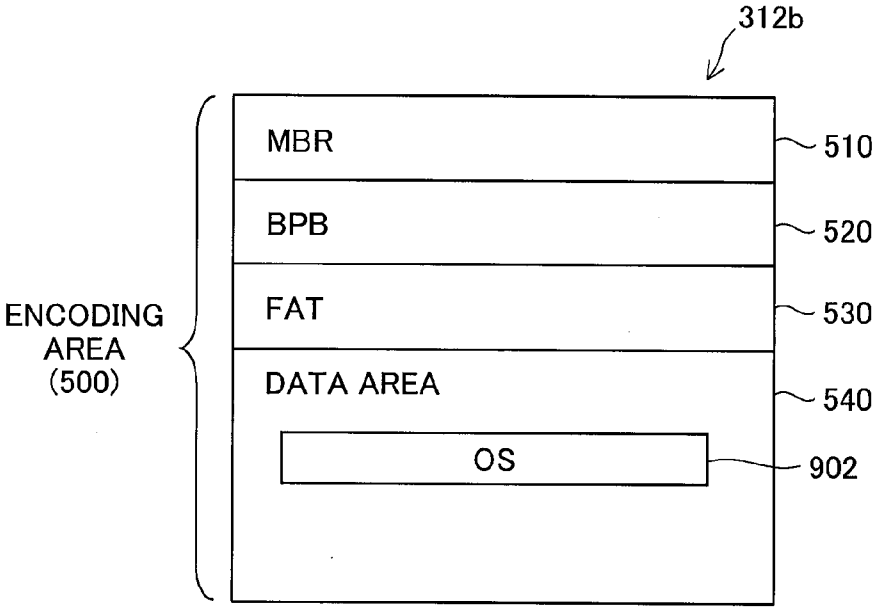


Fig.6

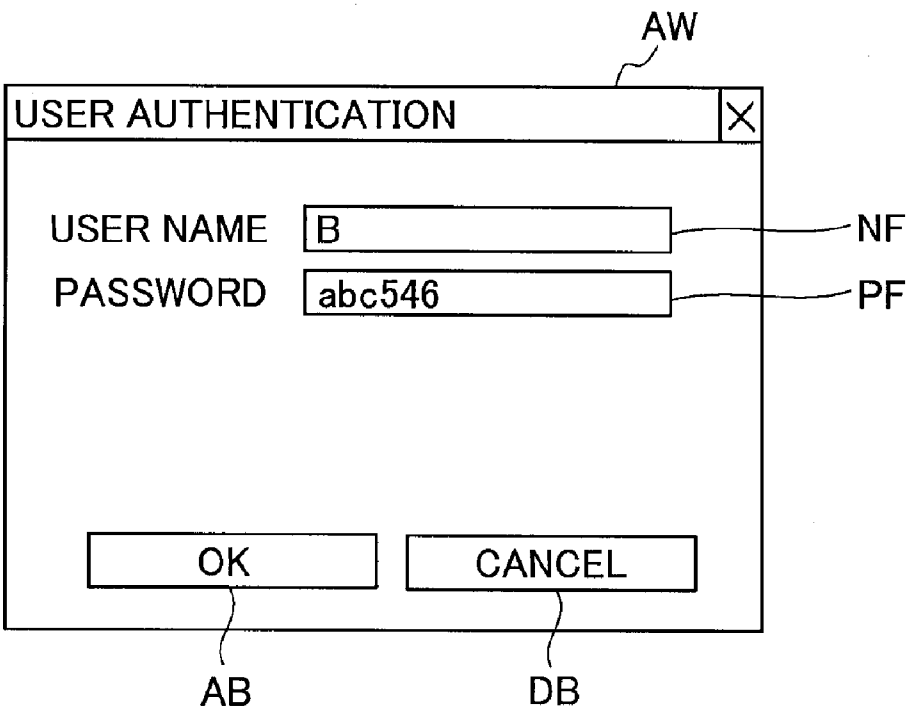

AW
USER AUTHENTICATION
USER NAME
B
NF
PASSWORD
abc546
PF
OK
CANCEL
AB
DB

Fig.7

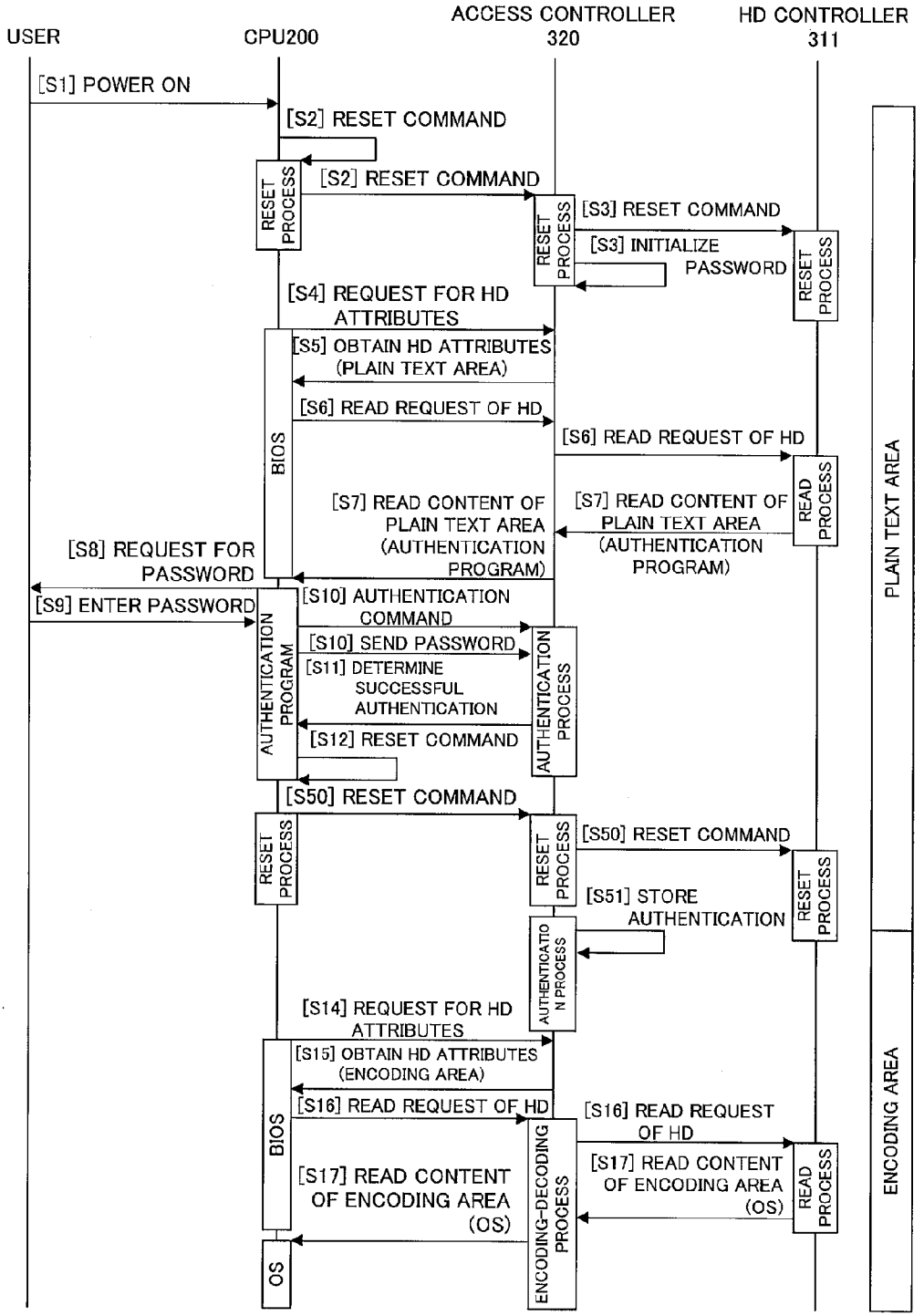

USER
CPU200
ACCESS CONTROLLER 320
HD CONTROLLER 311
[S1] POWER ON
[S2] RESET COMMAND
RESET PROCESS
[S2] RESET COMMAND
RESET PROCESS
[S3] RESET COMMAND
[S3] INITIALIZE PASSWORD
RESET PROCESS
[S4] REQUEST FOR HD ATTRIBUTES
[S5] OBTAIN HD ATTRIBUTES (PLAIN TEXT AREA)
BIOS
[S6] READ REQUEST OF HD
[S6] READ REQUEST OF HD
READ PROCESS
[S7] READ CONTENT OF PLAIN TEXT AREA (AUTHENTICATION PROGRAM)
[S7] READ CONTENT OF PLAIN TEXT AREA (AUTHENTICATION PROGRAM)
[S8] REQUEST FOR PASSWORD
[S9] ENTER PASSWORD
[S10] AUTHENTICATION COMMAND
[S10] SEND PASSWORD
[S11] DETERMINE SUCCESSFUL AUTHENTICATION
AUTHENTICATION PROGRAM
AUTHENTICATION PROCESS
[S12] RESET COMMAND
[S50] RESET COMMAND
RESET PROCESS
RESET PROCESS
[S50] RESET COMMAND
[S51] STORE AUTHENTICATION
RESET PROCESS
AUTHENTICATIO N PROCESS
[S14] REQUEST FOR HD ATTRIBUTES
[S15] OBTAIN HD ATTRIBUTES (ENCODING AREA)
[S16] READ REQUEST OF HD
[S16] READ REQUEST OF HD
BIOS
[S17] READ CONTENT OF ENCODING AREA (OS)
[S17] READ CONTENT OF ENCODING AREA (OS)
READ PROCESS
ENCODING-DECODING PROCESS
OS
PLAIN TEXT AREA
ENCODING AREA

Fig.8

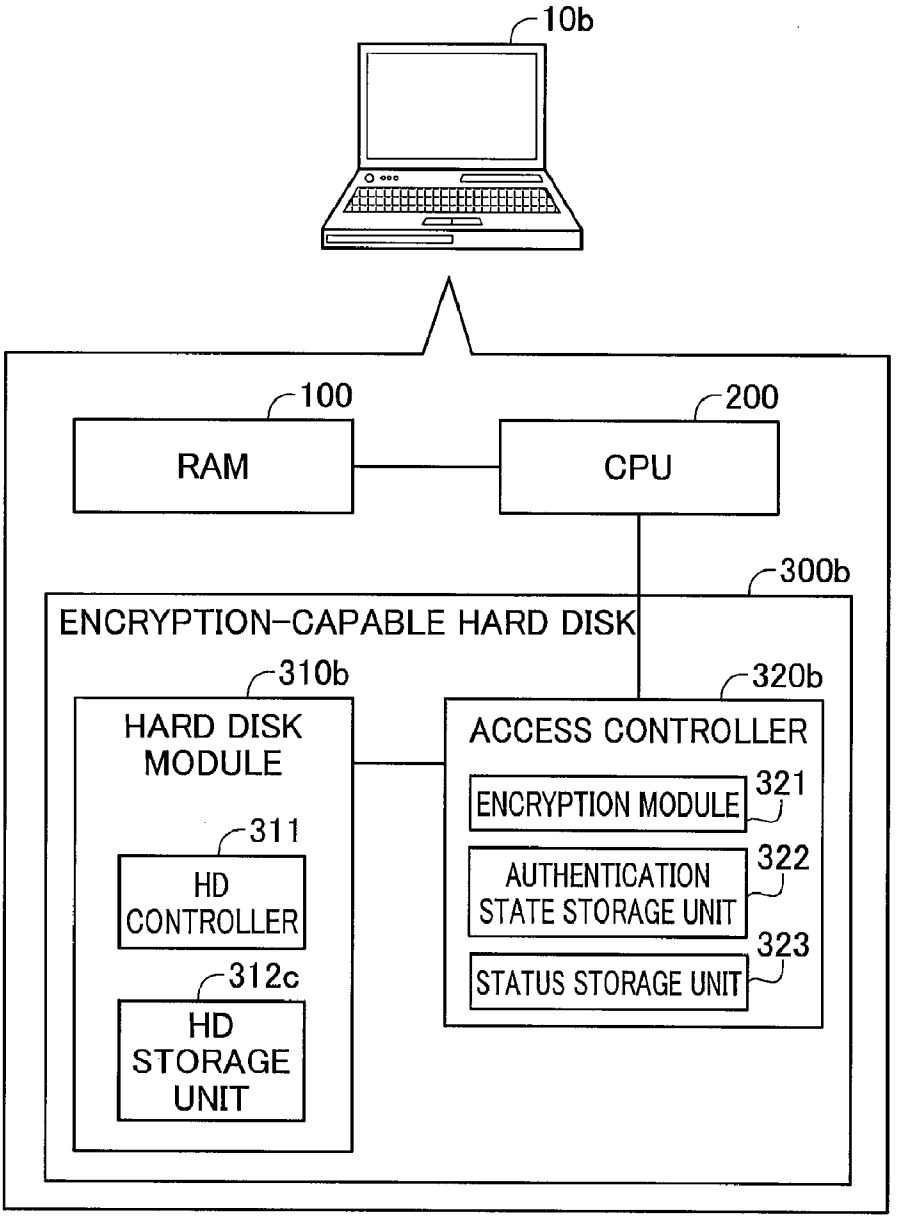

10b
100
RAM
200
CPU
300b
ENCRYPTION-CAPABLE HARD DISK
310b
HARD DISK MODULE
311
HD CONTROLLER
312c
HD STORAGE UNIT
320b
ACCESS CONTROLLER
ENCRYPTION MODULE
321
AUTHENTICATION STATE STORAGE UNIT
322
STATUS STORAGE UNIT
323

Fig.9

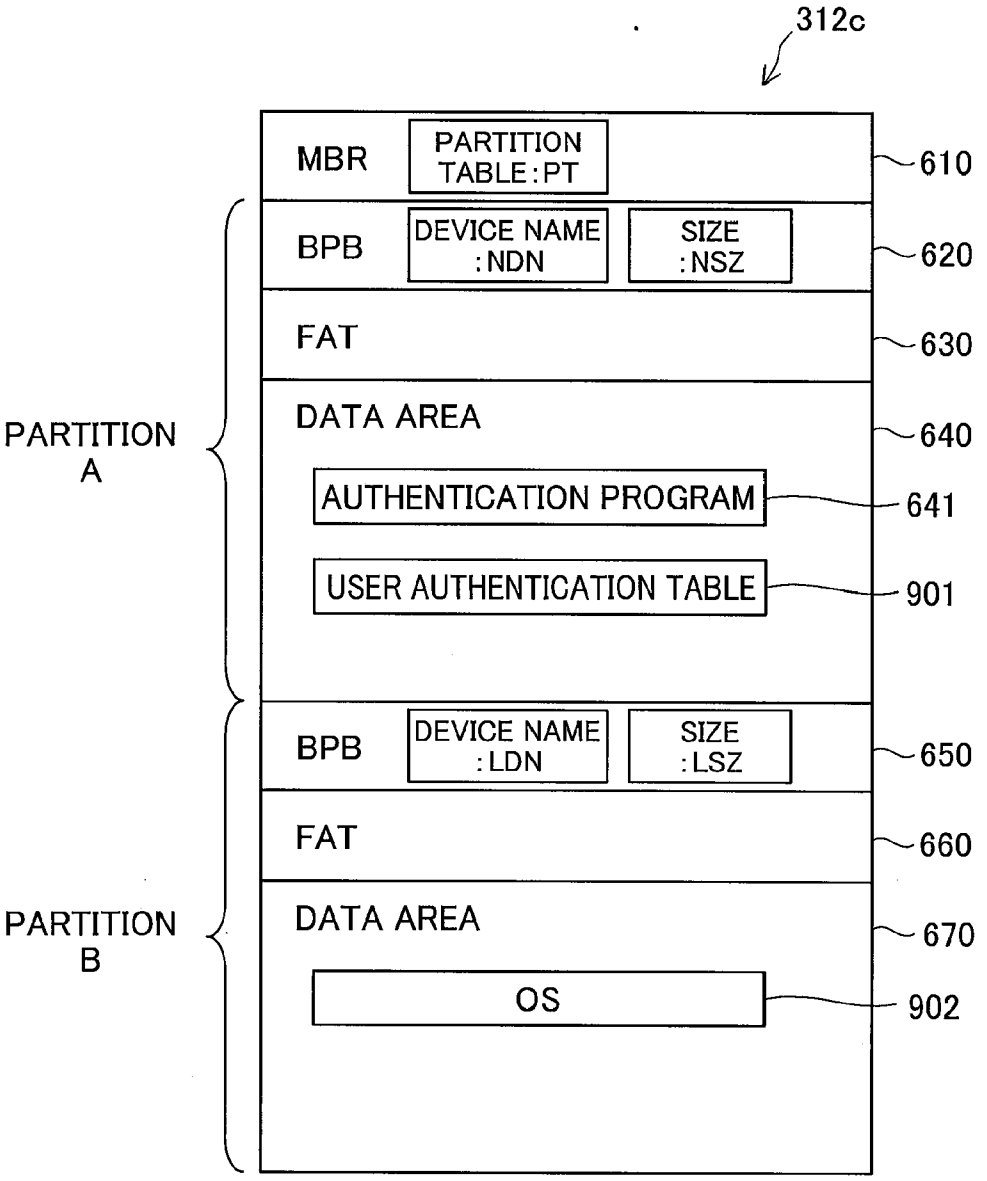

312c
MBR
PARTITION TABLE : PT
610
BPB
DEVICE NAME : NDN
SIZE : NSZ
620
FAT
630
DATA AREA
640
AUTHENTICATION PROGRAM
641
USER AUTHENTICATION TABLE
901
PARTITION A
BPB
DEVICE NAME : LDN
SIZE : LSZ
650
FAT
660
DATA AREA
670
OS
902
PARTITION B

Fig.10

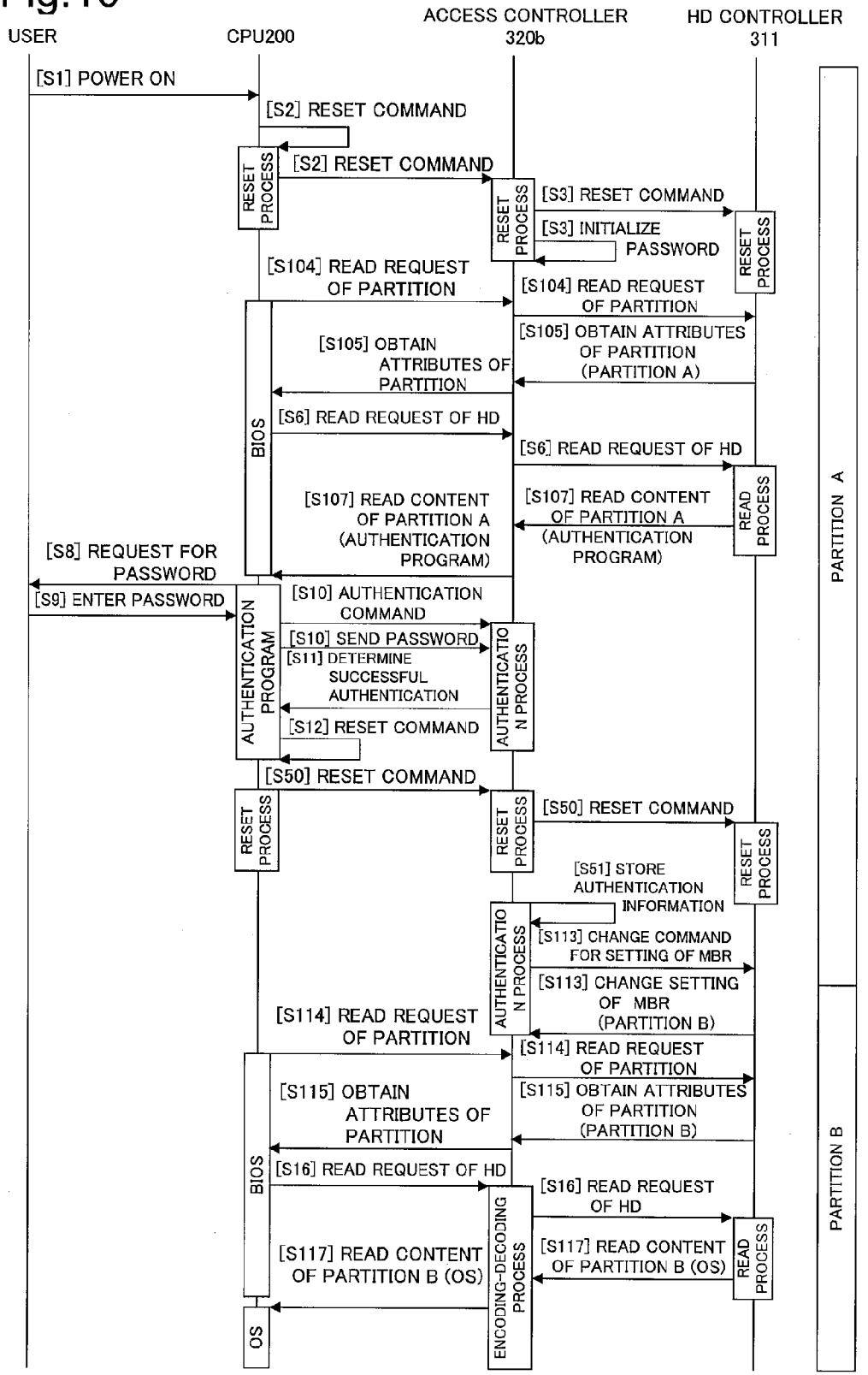

USER
CPU200
ACCESS CONTROLLER 320b
HD CONTROLLER 311
[S1] POWER ON
[S2] RESET COMMAND
RESET PROCESS
[S2] RESET COMMAND
RESET PROCESS
[S3] RESET COMMAND
[S3] INITIALIZE PASSWORD
RESET PROCESS
[S104] READ REQUEST OF PARTITION
[S104] READ REQUEST OF PARTITION
[S105] OBTAIN ATTRIBUTES OF PARTITION (PARTITION A)
[S105] OBTAIN ATTRIBUTES OF PARTITION
BIOS
[S6] READ REQUEST OF HD
[S6] READ REQUEST OF HD
READ PROCESS
[S107] READ CONTENT OF PARTITION A (AUTHENTICATION PROGRAM)
[S107] READ CONTENT OF PARTITION A (AUTHENTICATION PROGRAM)
[S8] REQUEST FOR PASSWORD
[S9] ENTER PASSWORD
AUTHENTICATION PROGRAM
[S10] AUTHENTICATION COMMAND
[S10] SEND PASSWORD
AUTHENTICATION PROCESS
[S11] DETERMINE SUCCESSFUL AUTHENTICATION
[S12] RESET COMMAND
[S50] RESET COMMAND
RESET PROCESS
RESET PROCESS
[S50] RESET COMMAND
RESET PROCESS
[S51] STORE AUTHENTICATION INFORMATION
AUTHENTICATION PROCESS
[S113] CHANGE COMMAND FOR SETTING OF MBR
[S113] CHANGE SETTING OF MBR (PARTITION B)
[S114] READ REQUEST OF PARTITION
[S114] READ REQUEST OF PARTITION
[S115] OBTAIN ATTRIBUTES OF PARTITION (PARTITION B)
[S115] OBTAIN ATTRIBUTES OF PARTITION
BIOS
[S16] READ REQUEST OF HD
[S16] READ REQUEST OF HD
READ PROCESS
[S117] READ CONTENT OF PARTITION B (OS)
[S117] READ CONTENT OF PARTITION B (OS)
ENCODING-DECODING PROCESS
OS
PARTITION A
PARTITION B

Fig.11

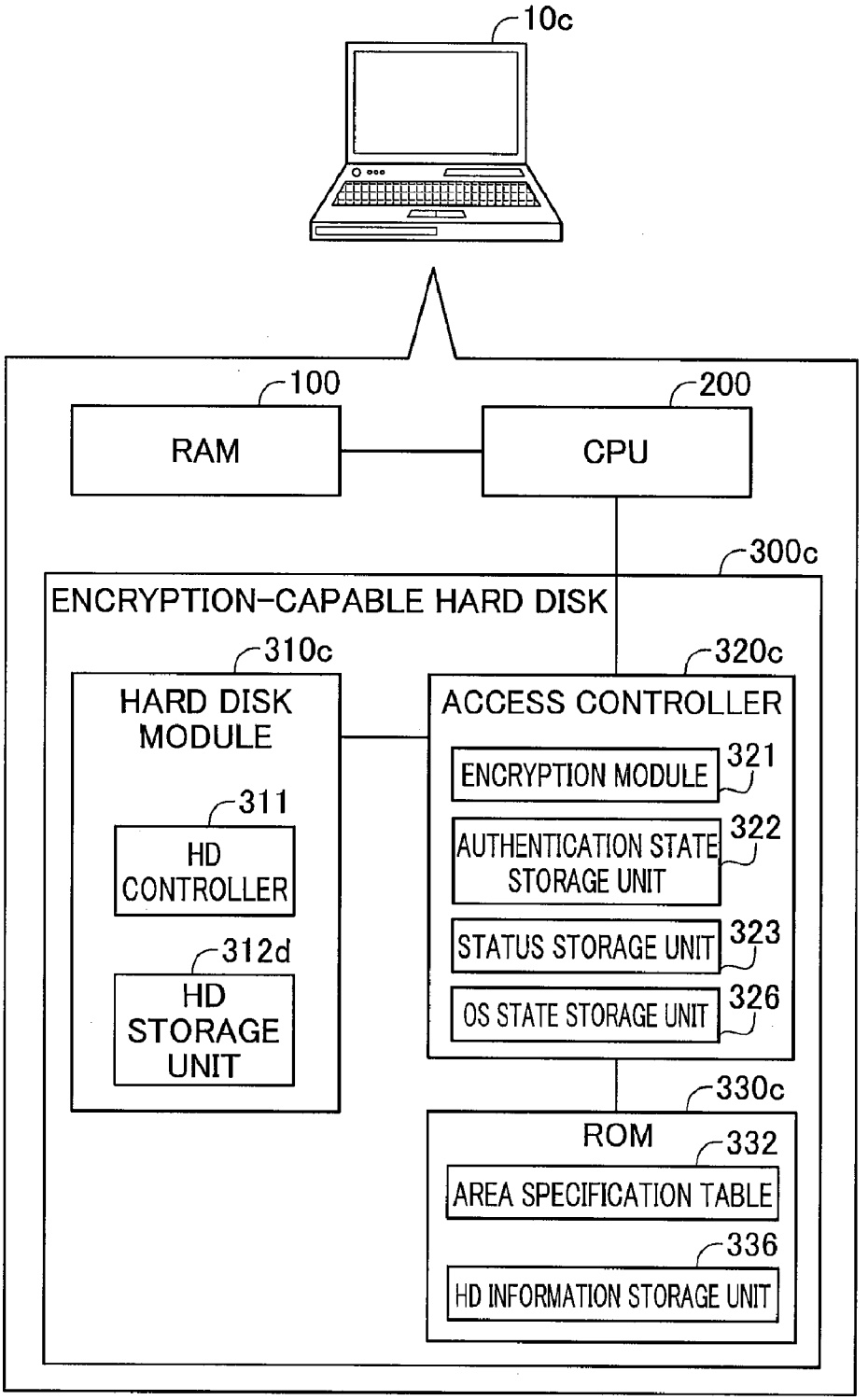

10c
100
RAM
200
CPU
300c
ENCRYPTION-CAPABLE HARD DISK
310c
HARD DISK MODULE
311
HD CONTROLLER
312d
HD STORAGE UNIT
320c
ACCESS CONTROLLER
ENCRYPTION MODULE
321
AUTHENTICATION STATE STORAGE UNIT
322
STATUS STORAGE UNIT
323
OS STATE STORAGE UNIT
326
330c
ROM
332
AREA SPECIFICATION TABLE
336
HD INFORMATION STORAGE UNIT

Fig.12

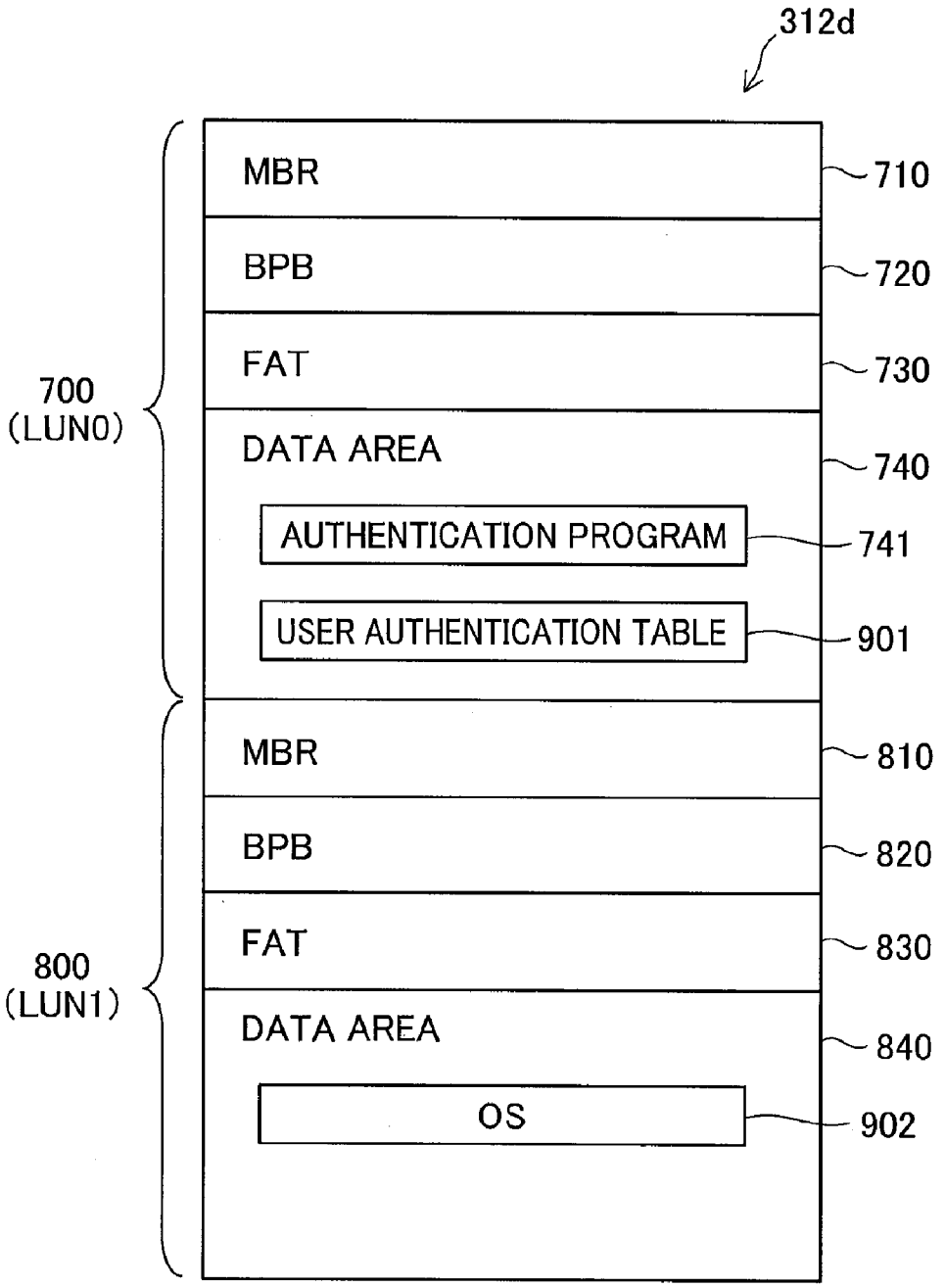

312d
MBR
710
BPB
720
FAT
730
700
(LUN0)
DATA AREA
740
AUTHENTICATION PROGRAM
741
USER AUTHENTICATION TABLE
901
MBR
810
BPB
820
FAT
830
800
(LUN1)
DATA AREA
840
OS
902

Fig.13

<AREA SPECIFICATION TABLE>

332

LUN NUMBER :LN	PHYSICAL AREA INFORMATION			LOGICAL AREA INFORMATION		
	TOTAL CAPACITY :PB	START ADDRESS :PSA	END ADDRESS :PEA	TOTAL CAPACITY :LB	START ADDRESS :LSA	END ADDRESS :LEA
0	10GB	00000000	11111111	10GB	00000000	11111111
1	40GB	11111111	55555555	40GB	00000000	44444444

Fig.14

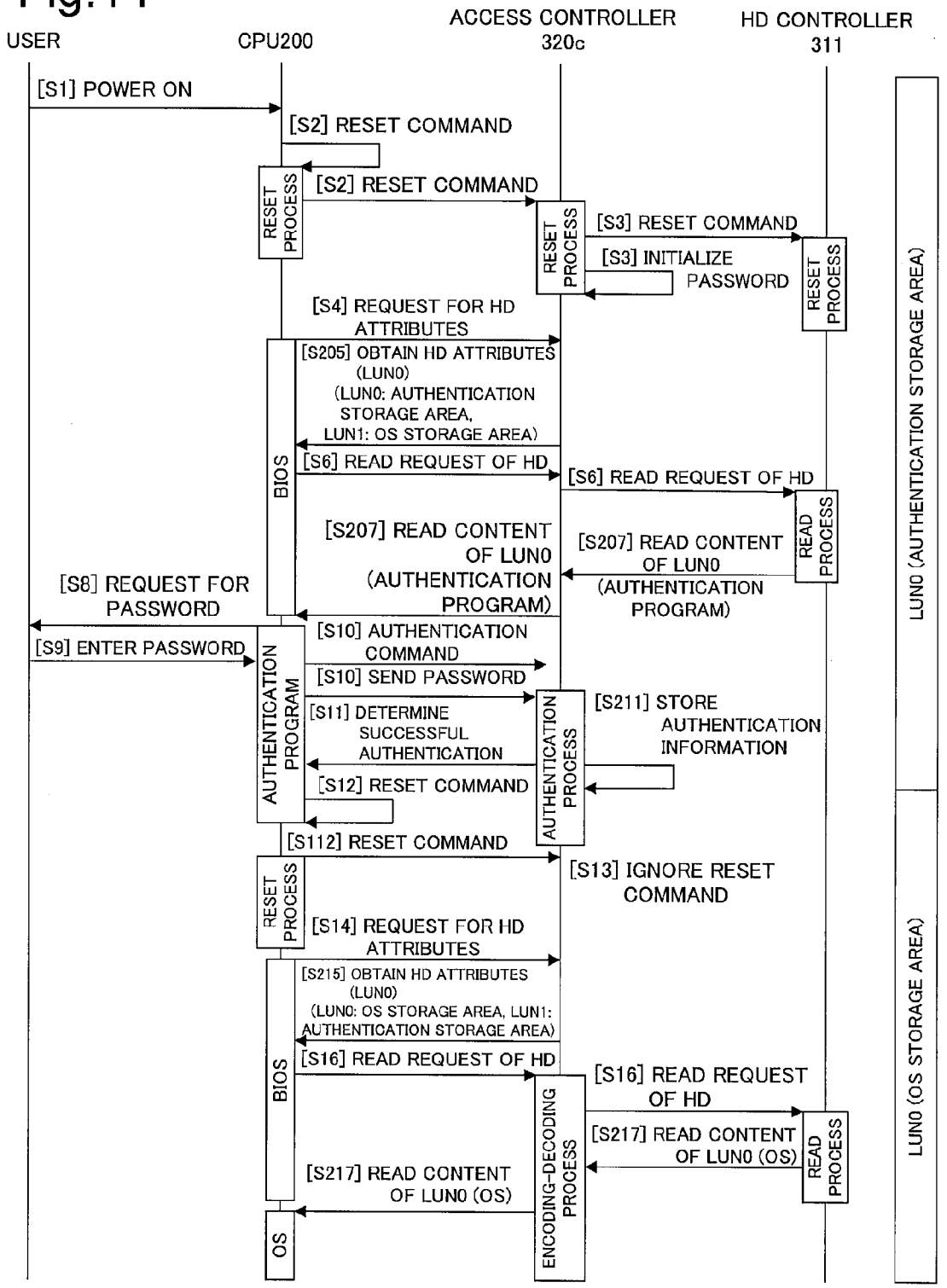

USER
CPU200
ACCESS CONTROLLER 320c
HD CONTROLLER 311
[S1] POWER ON
[S2] RESET COMMAND
RESET PROCESS
[S2] RESET COMMAND
RESET PROCESS
[S3] RESET COMMAND
[S3] INITIALIZE PASSWORD
RESET PROCESS
[S4] REQUEST FOR HD ATTRIBUTES
[S205] OBTAIN HD ATTRIBUTES (LUN0)
(LUN0: AUTHENTICATION STORAGE AREA, LUN1: OS STORAGE AREA)
BIOS
[S6] READ REQUEST OF HD
[S6] READ REQUEST OF HD
READ PROCESS
[S207] READ CONTENT OF LUN0 (AUTHENTICATION PROGRAM)
[S207] READ CONTENT OF LUN0 (AUTHENTICATION PROGRAM)
[S8] REQUEST FOR PASSWORD
[S9] ENTER PASSWORD
[S10] AUTHENTICATION COMMAND
[S10] SEND PASSWORD
AUTHENTICATION PROGRAM
[S11] DETERMINE SUCCESSFUL AUTHENTICATION
AUTHENTICATION PROCESS
[S211] STORE AUTHENTICATION INFORMATION
[S12] RESET COMMAND
[S112] RESET COMMAND
[S13] IGNORE RESET COMMAND
RESET PROCESS
[S14] REQUEST FOR HD ATTRIBUTES
[S215] OBTAIN HD ATTRIBUTES (LUN0)
(LUN0: OS STORAGE AREA, LUN1: AUTHENTICATION STORAGE AREA)
BIOS
[S16] READ REQUEST OF HD
[S16] READ REQUEST OF HD
ENCODING-DECODING PROCESS
[S217] READ CONTENT OF LUN0 (OS)
READ PROCESS
[S217] READ CONTENT OF LUN0 (OS)
OS
LUN0 (AUTHENTICATION STORAGE AREA)
LUN0 (OS STORAGE AREA)

Fig.15

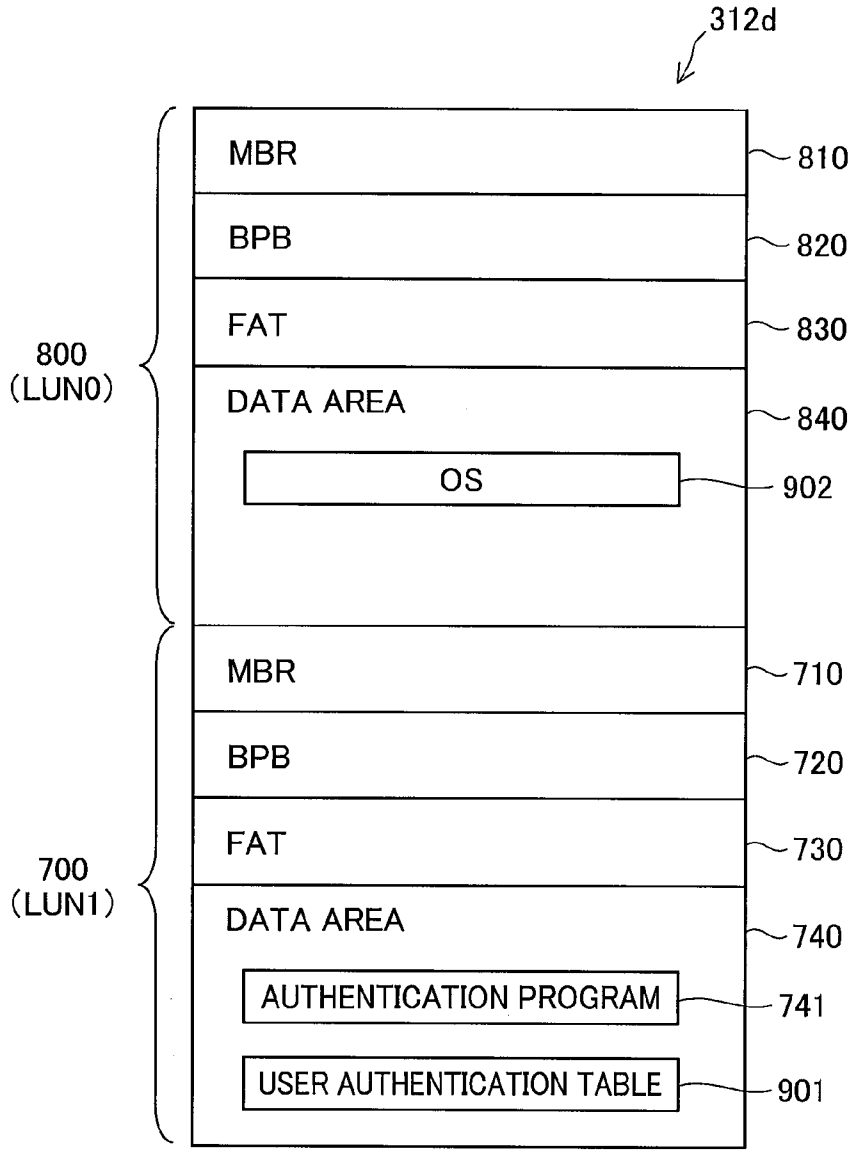
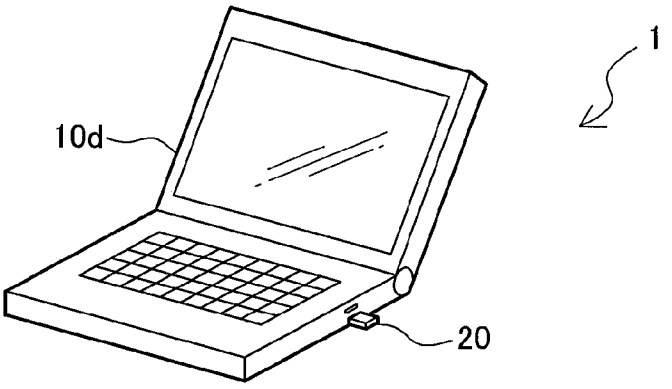

312d
MBR
810
BPB
820
FAT
830
800
(LUN0)
DATA AREA
840
OS
902
MBR
710
BPB
720
FAT
730
700
(LUN1)
DATA AREA
740
AUTHENTICATION PROGRAM
741
USER AUTHENTICATION TABLE
901

Fig.16


1
10d
20

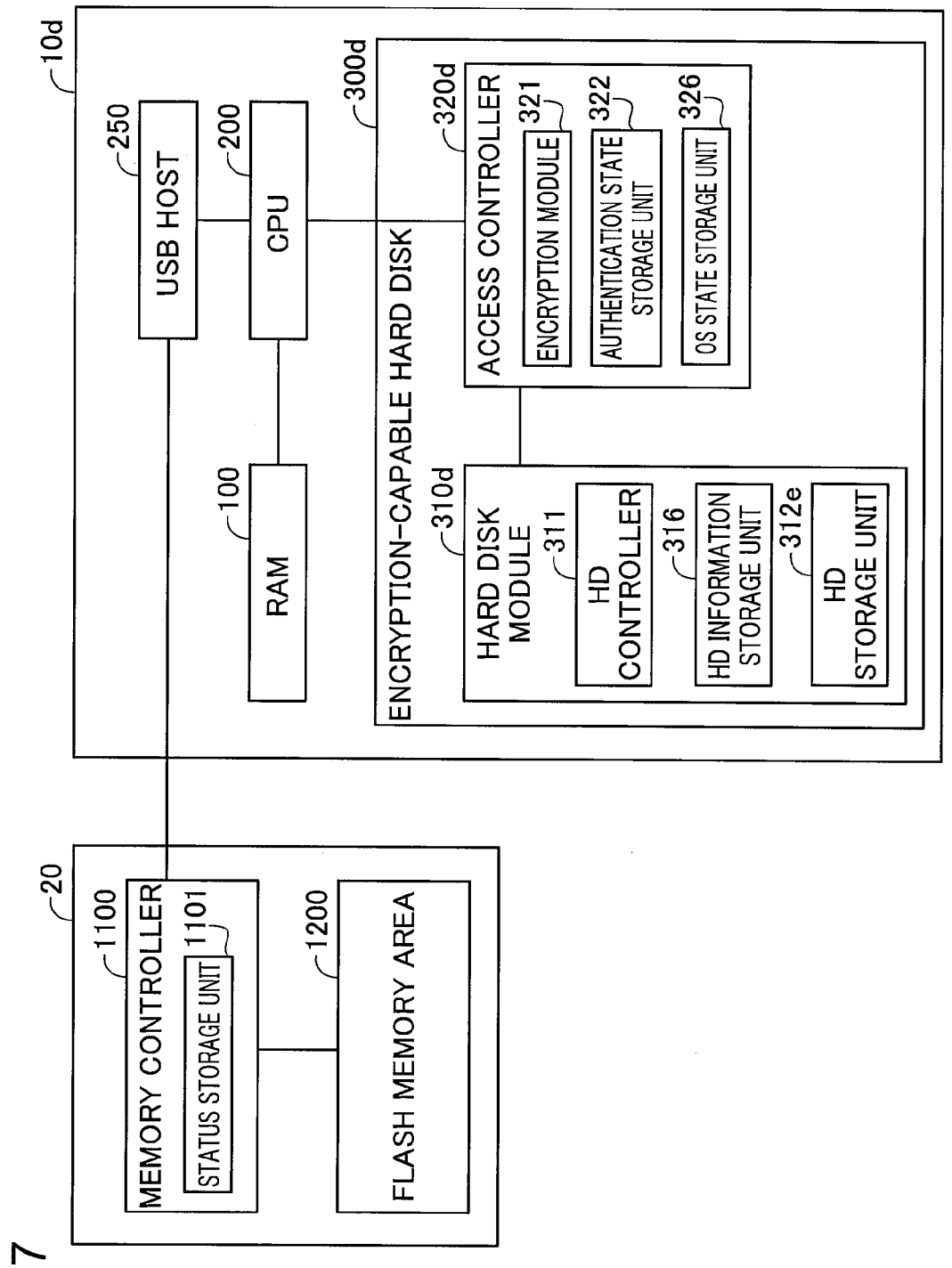

10d
250
USB HOST
200
CPU
300d
320d
ACCESS CONTROLLER
321
ENCRYPTION MODULE
322
AUTHENTICATION STATE STORAGE UNIT
326
OS STATE STORAGE UNIT
ENCRYPTION-CAPABLE HARD DISK
100
RAM
310d
HARD DISK MODULE
311
HD CONTROLLER
316
HD INFORMATION STORAGE UNIT
312e
HD STORAGE UNIT
20
1100
MEMORY CONTROLLER
1101
STATUS STORAGE UNIT
1200
FLASH MEMORY AREA

Fig.17

Fig.18A

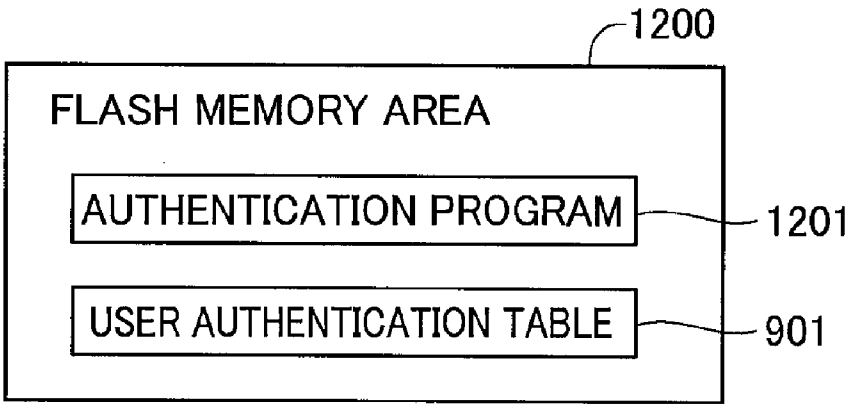


Fig.18B

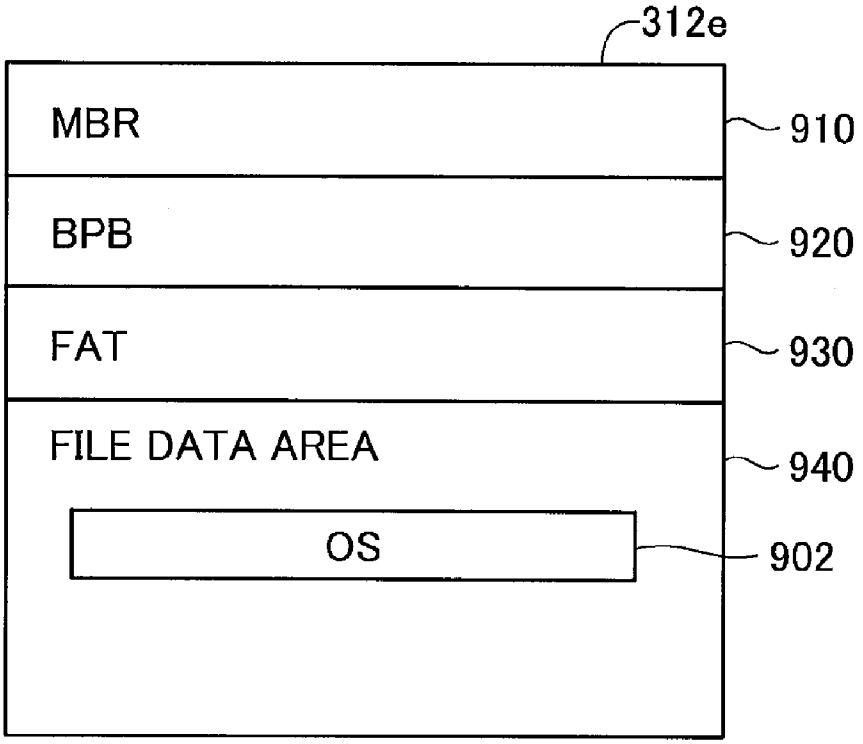
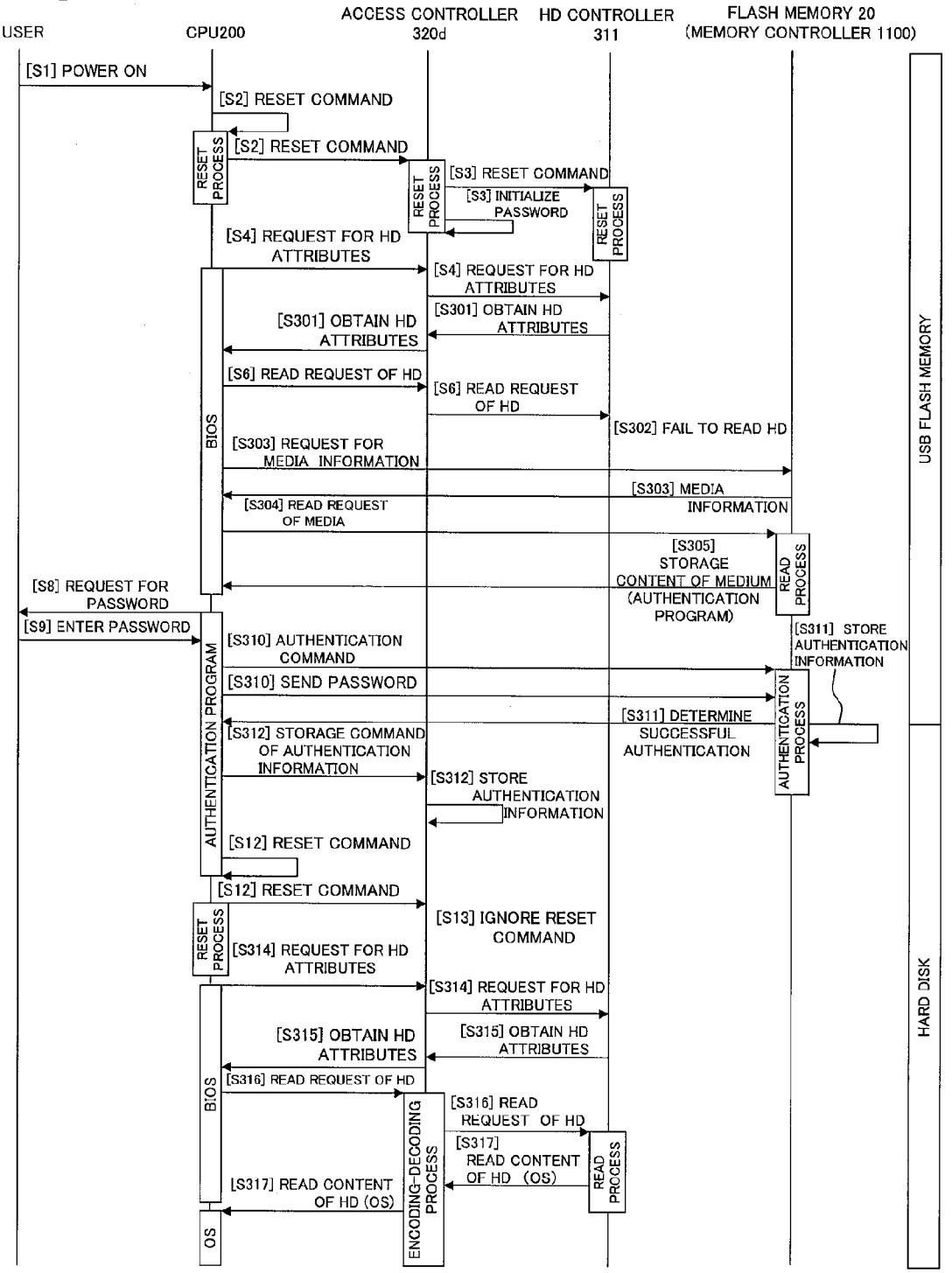


Fig.19


USER
CPU200
ACCESS CONTROLLER 320d
HD CONTROLLER 311
FLASH MEMORY 20 (MEMORY CONTROLLER 1100)
USB FLASH MEMORY
HARD DISK
[S1] POWER ON
[S2] RESET COMMAND
RESET PROCESS
[S2] RESET COMMAND
[S3] RESET COMMAND
[S3] INITIALIZE PASSWORD
[S4] REQUEST FOR HD ATTRIBUTES
[S4] REQUEST FOR HD ATTRIBUTES
[S301] OBTAIN HD ATTRIBUTES
[S301] OBTAIN HD ATTRIBUTES
[S6] READ REQUEST OF HD
[S6] READ REQUEST OF HD
[S302] FAIL TO READ HD
BIOS
[S303] REQUEST FOR MEDIA INFORMATION
[S303] MEDIA INFORMATION
[S304] READ REQUEST OF MEDIA
[S305] STORAGE CONTENT OF MEDIUM (AUTHENTICATION PROGRAM)
READ PROCESS
[S8] REQUEST FOR PASSWORD
[S9] ENTER PASSWORD
[S311] STORE AUTHENTICATION INFORMATION
[S310] AUTHENTICATION COMMAND
[S310] SEND PASSWORD
AUTHENTICATION PROGRAM
AUTHENTICATION PROCESS
[S311] DETERMINE SUCCESSFUL AUTHENTICATION
[S312] STORAGE COMMAND OF AUTHENTICATION INFORMATION
[S312] STORE AUTHENTICATION INFORMATION
[S12] RESET COMMAND
[S12] RESET COMMAND
[S13] IGNORE RESET COMMAND
[S314] REQUEST FOR HD ATTRIBUTES
[S314] REQUEST FOR HD ATTRIBUTES
[S315] OBTAIN HD ATTRIBUTES
[S315] OBTAIN HD ATTRIBUTES
[S316] READ REQUEST OF HD
[S316] READ REQUEST OF HD
[S317] READ CONTENT OF HD (OS)
[S317] READ CONTENT OF HD (OS)
ENCODING-DECODING PROCESS
OS

STORAGE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the priority based on Japanese Patent Application No. 2009-85541 filed on Mar. 31, 2009, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a storage device having an operating system stored therein.

[0004] 2. Description of the Related Art

[0005] Several operating system activation methods and devices utilizing such activation methods have been proposed.

[0006] In order to assure the security, these conventional methods and devices typically perform authentication at the time of activation of an operating system (hereafter may be abbreviated as 'OS'). Some processing is then required for a storage unit with a BIOS or an OS stored therein. One available technique for the enhanced security is providing an additional function of prohibiting activation of the OS until successful boot-time authentication for a boot program of a hard disk. This conventional technique, however, readily analyze information stored in a hard disk when the hard disk is recognized as a slave hard disk of another computer.

[0007] Another available technique for the enhanced security is encrypting the whole storage of a hard disk. Such encryption, however, requires development of an exclusive hard disk driver corresponding to each OS. The resulting dependency on the OS or the hardware configuration may, however, have some disadvantages, for example, the lowered performance and the difficulty in encrypting the whole storage of the hard disk. Still another available technique for the enhanced security is providing the BIOS with an additional authentication function at the time of activation of an OS and locking the storage of the hard disk itself with an ATA (advanced technology attachment) security command. This technique is, however, not applicable to the existing computers having the BIOS implemented without the additional authentication function at the time of activation of the OS. The BIOS-based authentication is not performable in combination with physical authentication utilizing, for example, an external storage medium. This technique accordingly has a possibility of failed protection of information stored in the hard disk in the event of leakage or decoding of a password.

SUMMARY

[0008] An object of the present invention is to provide technology that makes possible an OS to be activated based on a result of authentication implemented according to an authentication program stored in a storage device and enhances security of information stored in the storage device.

[0009] According to one aspect of the present invention, a storage device used in connection with an information processing apparatus is provided. A storage device comprises: an authentication storage area storing an authentication program in advance, wherein the authentication program is executed to authenticate whether each user operating the information processing apparatus is an approved user; an operating system storage area storing an operating system in advance, wherein the operating system is encrypted and is used by the information processing apparatus; an access controller configured to control accesses the authentication storage area and the operating system storage area from the information processing apparatus; and a decoder configured to decrypt the encrypted operating system, wherein upon notification of successful authentication representing that the user is authenticated as the approved user by the authentication program, the access controller allows an access the operating system storage area from the information processing apparatus.

[0010] According to this configuration, in the case of successful authentication representing that the user is authenticated as the approved user by the authentication program, the storage device according to this aspect of the invention allows an access from the information processing apparatus to the operating system storage area. This arrangement enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device. The operating system is stored in advance in an encrypted state. This arrangement effectively enhances the security of information stored in the storage device.

[0011] Another embodiment of the present invention, the storage device may be configured to make one of the authentication storage area and the operating system storage area visible and the other area invisible from the information processing apparatus, wherein after the information processing apparatus is powered on, the access controller makes the authentication storage area visible and the operating system storage area invisible, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and after the successful authentication by the authentication program, the access controller makes the authentication storage area invisible and the operating system storage area visible and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

[0012] According to this configuration, the authentication program is activated and implemented immediately after the information processing apparatus is powered on connecting with the storage device of this application. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device and effectively enhances the security of information stored in the storage device.

[0013] Another embodiment of the present invention, the storage device wherein the authentication storage area and the operating system storage area are set to have identical attributes including a device name and a device size.

[0014] According to this configuration, the storage device of this embodiment, a region assigned to the authentication storage area and a region assigned to the operating system storage area are set to have identical attributes including a device name and a device size. This arrangement effectively prevents malfunction of the information processing apparatus.

[0015] Another embodiment of the present invention, the storage device wherein in response to an attribute request for an attribute including a device size of the authentication storage area from the information processing apparatus, the access controller sends back a false device size that is greater than an actual device size of the authentication storage area.

[0016] According to this configuration, the storage device of this embodiment is allowed to send back the false device size that is greater than the actual device size of the authentication storage area, in response to an inquiry about the device size of the authentication storage area from the information processing apparatus. This arrangement effectively prevents unnecessary expansion of the actual device size of the authentication storage area.

[0017] Another embodiment of the present invention, the storage device wherein the authentication storage area and the operating system storage area are assigned to different partitions, the storage device having a master boot record including a partition table that stores therein information on the respective partitions, wherein after the information processing apparatus is powered on, the access controller sets the master boot record to preferentially activate a partition assigned to the authentication storage area, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and after the successful authentication by the authentication program, the access controller sets the master boot record to preferentially activate a partition assigned to the operating system storage area and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

[0018] According to this configuration, the authentication program is activated and implemented immediately after the information processing apparatus is powered on, connecting with the storage device of this application. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device and effectively enhances the security of information stored in the storage device.

[0019] Another embodiment of the present invention, the storage device wherein the access controller makes the partition assigned to the authentication storage area visible after the information processing apparatus is powered on, and makes the partition assigned to the authentication storage area invisible after the successful authentication by the authentication program.

[0020] According to this configuration, after the successful authentication by the authentication program, the storage device of this embodiment makes the partition assigned to the authentication storage area invisible. This arrangement effectively prevents malfunction of the information processing apparatus.

[0021] Another embodiment of the present invention, the storage device wherein the authentication storage area and the operating system storage area are assigned to different logical units, the storage device comprising an area specification module that stores therein information on assignment of the logical units including logical unit numbers for identifying the respective logical units, wherein after the information processing apparatus is powered on, the access controller sets the logical unit number stored in the area specification module to preferentially activate a logical unit assigned to the authentication storage area, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and after the successful authentication by the authentication program, the access controller sets the logical unit number stored in the area specification module to preferentially activate a logical unit assigned to the operating system storage area and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

[0022] According to this configuration, the authentication program is activated and implemented immediately after the information processing apparatus is powered on connecting with the storage device of this application. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device and effectively enhances the security of information stored in the storage device.

[0023] Another embodiment of the present invention, the storage device wherein after the information processing apparatus is powered on, the access controller makes the logical unit assigned to the authentication storage area accessible and the logical unit assigned to the operating system storage area inaccessible, and after the successful authentication by the authentication program, the access controller makes the logical unit assigned to the authentication storage area inaccessible and the logical unit assigned to the operating system storage area accessible.

[0024] According to this configuration, after the successful authentication by the authentication program, the storage device of this embodiment makes the logical unit assigned to the authentication storage area inaccessible. This arrangement effectively prevents malfunction of the information processing apparatus.

[0025] Another embodiment of the present invention, the storage device further including an authentication state storage unit configured to store a result of authentication, wherein after the successful authentication by the authentication program, when a reset command issued for activation of the operating system is received from the information processing apparatus subsequent to storage of the status of successful authentication into the authentication state storage unit, the access controller ignores the reset command under a condition of recognizing both the storage of the status of successful authentication in the authentication state storage unit and inactivation of the operation system on the information processing apparatus.

[0026] According to this configuration, in the case where the storage content in the authentication state storage unit represents the status of successful authentication, the storage device of this application ignores the reset command issued for activation of the operating system by the information processing apparatus. This arrangement effectively prevents the storage device from being reset in the state of storage of the authentication information. Namely the storage device of this application desirably protects the authentication information from being deleted in the course of the reset process.

[0027] Another embodiment of the present invention, the storage device further including an authentication state storage unit configured to store a result of authentication, wherein the access controller resets the storage device in response to a reset command issued for activation of the operating system from the information processing apparatus and subsequently stores the status of successful authentication into the authentication state storage unit.

[0028] According to this configuration, after performing the reset process of the storage device, the storage device of this application stores the status of successful authentication

into the authentication state storage unit. This arrangement effectively prevents the storage device from being reset in the state of storage of the authentication information. Namely the storage device of this application desirably protects the authentication information from being deleted in the course of the reset process.

[0029] The principle of the present invention is actualized by diversity of applications, for example, the storage device having any of the above arrangements, a system including such a storage device, an OS activation method adopted on such a storage device, computer usable mediums including the functions of the device or the system and the functional steps of the method, and recording media with such computer programs recorded therein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. **1** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with one embodiment of the invention;

[0031] FIG. **2** is an explanatory view showing the schematic structure of the HD storage unit in the first embodiment;

[0032] FIG. **3** is an explanatory view showing one example of the user authentication table;

[0033] FIG. **4** is a sequence diagram showing a flow of an OS activation process implemented in the first embodiment;

[0034] FIGS. **5**A and **5**B are explanatory views showing the schematic structures of the HD storage unit seen from the PC;

[0035] FIG. **6** is an explanatory view showing one example of an authentication window open in the authentication process;

[0036] FIG. **7** is a sequence diagram showing a flow of an OS activation process implemented in a second embodiment;

[0037] FIG. **8** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with a third embodiment;

[0038] FIG. **9** is an explanatory view showing the schematic structure of the HD storage unit in the third embodiment;

[0039] FIG. **10** is a sequence diagram showing a flow of an OS activation process implemented in the third embodiment;

[0040] FIG. **11** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with a fourth embodiment;

[0041] FIG. **12** is an explanatory view showing the schematic structure of the HD storage unit in the fourth embodiment;

[0042] FIG. **13** is an explanatory view showing one example of the area specification table after the PC is powered on;

[0043] FIG. **14** is a sequence diagram showing a flow of an OS activation process implemented in the fourth embodiment;

[0044] FIG. **15** is an explanatory view showing the schematic structure of the HD storage unit after the change of the settings;

[0045] FIG. **16** is an explanatory view showing the appearance of a system including a storage device in accordance with a fifth embodiment;

[0046] FIG. **17** is an explanatory view schematically illustrating the configuration of the system including the storage device of the fifth embodiment;

[0047] FIGS. **18**A and **18**B are explanatory views showing the schematic structures of the flash memory area and the HD storage unit in the fifth embodiment; and

[0048] FIG. **19** is a sequence diagram showing a flow of an OS activation process implemented in the fifth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0049] Next, aspects of the present invention will be described in the following order on the basis of embodiments:

A. First Embodiment

[0050] FIG. **1** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with one embodiment of the invention. A computer **10** functioning as the information processing apparatus (hereafter may simply be referred to as 'PC') includes a RAM **100**, a CPU **200**, and an encryption-capable hard disk **300** as the storage device (hereafter may simply be referred to as 'hard disk'). The hard disk **300** has a hard disk module **310**, an access controller **320**, and a ROM **330**. The hard disk module **310** includes an HD controller **311** and an HD storage unit **312**. The HD storage unit **312** is made of a storage medium, and the HD controller **311** is configured to control the operations of the HD storage unit **312**.

[0051] The access controller **320** includes an encryption module **321**, an authentication state storage unit **322**, a status storage unit **323**, and an OS state storage unit **326**. The access controller **320** has a control function to control accesses to an authentication storage area and to an operating system storage area (explained later). The function of the access controller **320** will be discussed later. The encryption module **321** constructed as a decoder has encoding and decoding functions to encrypt and decrypt data stored in the HD storage unit **312**. The combination of the authentication state storage unit **322** with the status storage unit **323** has a function of storing a status representing either successful authentication or unsuccessful authentication determined according to a preset authentication program as discussed later in detail. The OS state storage unit **326** has a function of storing a state representing either activation or inactivation of the operating system in the PC **10**. In this embodiment, there are two different OS states to be settable: a value '0' representing 'OS active state' and a value '1' representing 'OS inactive state'. The value '1' representing 'OS inactive state' is set in the OS state storage unit **326** as an initial value immediately after the PC **10** is powered on. These settings of the OS states are only illustrative and not restrictive in any sense. The OS states may be determined arbitrarily.

[0052] The ROM **330** is a memory device including a sector number table **331** and an HD information storage unit **336**. The sector number table **331** is structured to include addresses of first sectors in a plain text area and an encoding area (explained below) previously stored therein. The HD information storage unit **336** stores therein attributes of the hard disk including a device name and a device size of the HD storage unit **312**.

[0053] FIG. **2** is an explanatory view showing the schematic structure of the HD storage unit **312** in the first embodiment. The HD storage unit **312** includes a plain text area (**400**) as the authentication storage area and an encoding area (**500**) as the operating system storage area. The plain text area (**400**)

includes an MBR (master boot record) **410**, a BPB (BIOS parameter block) **420**, an FAT (file allocation table) **430**, and a data area **440**. The encoding area (**500**) includes an MBR **510**, a BPB **520**, an FAT **530**, and a data area **540**. The MBRs **410** and **510** are sectors read first at the time of start-up and are constructed to store information relating to a start-up. The BPBs **420** and **520** are constructed to store physical attributes of the hard disk, for example, the number of sectors per cluster. The FATs **430** and **530** are constructed to store disk management data used for recording, for example, file location information.

[0054] The data area **440** of the plain text area **400** has an authentication program **441** and a user authentication table **901** previously stored therein. The authentication program **441** is implemented to authenticate each user operating the PC **10** as an approved user as discussed later in detail. The details of the user authentication table **901** will be discussed later. An OS **902** used on the PC **10** is stored in advance in an encrypted state in the data area **540** of the encoding area **500**. The OS **902** may be a known operating system, for example, Windows (registered trademark) by Microsoft Corporation.

[0055] The access controller **320** performs access control to make only the plain text area **400** visible from the PC **10** at the time of start-up of the PC **10** and to make only the encoding area **500** visible from the PC **10** after the successful authentication by the authentication program **441**. The access controller **320** refers to the storage content in the authentication state storage unit **322** and determines which of the plain text area **400** and the encoding area **500** is to be made visible.

[0056] FIG. **3** is an explanatory view showing one example of the user authentication table **901**. The user authentication table **901** includes user names UN and passwords UP. A field of user name UN stores the names of respective users registered. A field of password UP stores passwords set for the respective users. The user authentication table **901** is used in an authentication process discussed later.

[0057] FIG. **4** is a sequence diagram showing a flow of an OS activation process implemented in the first embodiment. In response to the user's power-on operation of the PC **10** (step S**1**), the CPU **200** of the PC **10** starts an initialization process to reset the CPU **200** itself and issues a reset command to the access controller **320** in the hard disk **300** (step S**2**). The access controller **320** receives the reset command and determines whether the storage content in the authentication state storage unit **322** represents a status of successful authentication. At this moment, the storage content in the authentication state storage unit **322** does not represent the status of successful authentication, so that the access controller **320** issues a reset command to the HD controller **311** and performs a password initialization process (step S**3**). A concrete procedure of the password initialization process resets a key set by the encryption module **321** and initializes the storage contents both in the authentication state storage unit **322** and the status storage unit **323**.

[0058] FIGS. **5**A and **5**B are explanatory views showing the schematic structures of the HD storage unit **312** seen from the PC **10**. The BIOS implemented by the CPU **200** issues an attribute request to the access controller **320** to obtain attributes of the hard disk including the device name and the device size (step S**4**). In response to reception of the attribute request, the access controller **320** sends back a device name and a device size of a plain text area stored in the HD information storage unit **336** of the ROM **330** (step S**5**). FIG. **5**A shows a visible area seen from the CPU **200** in this state. The BIOS subsequently issues a read request via the access controller **320** to read the hard disk (step S**6**). According to a concrete procedure, the BIOS activates a start-up program stored in the MBR **410**, and the activated start-up program informs the BIOS of a first sector of the authentication program **441**. The BIOS then issues a read request of the authentication program **441**. In response to reception of the read request, the HD controller **311** sends the authentication program **441** via the access controller **320** (step S**7**).

[0059] FIG. **6** is an explanatory view showing one example of an authentication window open in the authentication process. A user authentication window AW includes a user name entry field NF, a password entry field PF, an OK button AB, and a Cancel button DB. The CPU **200** receives the authentication program **441** and executes the received authentication program **441** to perform an authentication process. According to a concrete procedure, the CPU **200** opens the user authentication window AW (FIG. **6**) on the screen of the PC **10** and requests a user to enter a user name and a password (step S**8**). When the user enters the user name and the password and subsequently presses the OK button AB (step S**9**), the CPU **200** issues an authentication command to the access controller **320**. According to a concrete procedure, the CPU **200** sends a value entered in the user name entry field NF and a value entered in the password entry field PF to the access controller **320** (step S**10**).

[0060] In response to reception of the authentication command, the access controller **320** performs the authentication process. The authentication process determines whether any entry corresponding to the received combination of the user name and the password exists in the user authentication table **901** (FIG. **3**). The access controller **320** determines successful authentication in the case of existence of such an entry and determines unsuccessful authentication in the case of non-existence of such an entry. The access controller **320** sends back the result of the authentication process to the CPU **200**. Upon determination of the successful authentication, the access controller **320** stores authentication information (step S**11**). According to a concrete procedure, the access controller **320** stores a value '1' representing a 'status of successful authentication' into both the authentication state storage unit **322** and the status storage unit **323**. In this embodiment, the authentication information is defined by either a value '0' representing a 'status of unsuccessful authentication' or the value '1' representing the 'status of successful authentication'. These settings of the authentication information are only illustrative and not restrictive in any sense. The authentication information may be determined arbitrarily.

[0061] After the successful authentication by the authentication program **441**, the CPU **200** resets the CPU **200** itself and issues a reset command to the access controller **320** (step S**12**). The reset command is issued to allow for activation of the OS **902**. Upon satisfaction of all the conditions given below, the access controller **320** ignores this reset command (step S**13**):

[0062] Condition 1) The storage content in the authentication state storage unit **322** represents the status of successful authentication;

[0063] Condition 2) The storage content in the OS state storage unit **326** represents the OS inactive state; and

[0064] Condition 3) The access controller **320** receives the reset command from the CPU **200**.

Such ignorance effectively prevents the storage device from being reset in the state of storage of the authentication infor-

mation. Namely this sequence of control operations desirably protects the authentication information from being deleted in the course of the reset process.

[0065] After the reset process of the CPU **200**, the BIOS implemented by the CPU **200** issues an attribute request to the access controller **320** to obtain the attributes of the hard disk including the device name and the device size (step S**14**). In response to reception of the attribute request, the access controller **320** refers to the storage content in the status storage unit **323**. Since the storage content in the status storage unit **323** represents the status of successful authentication, the access controller **320** sends back a device name and a device size of an encoding area stored in the HD information storage unit **336** of the ROM **330** (step S**15**). FIG. **5**B shows a visible area seen from the CPU **200** in this state. The BIOS subsequently issues a read request via the access controller **320** to read the hard disk (step S**16** in FIG. **4**). According to a concrete procedure, the BIOS activates a start-up program stored in the MBR **510**, and the activated start-up program informs the BIOS of a first sector of the OS **902**. The BIOS then issues a read request of the OS **902**. In response to reception of the read request, the HD controller **311** sends the OS **902** to the access controller **320**. The access controller **320** receives the OS **902**, decrypt the OS **902** by means of the encryption module **321**, and sends the decrypted OS **902** to the CPU **200** (step S**17**). The CPU **200** receives the decrypted OS **902** and activates the received OS **902**. This sequence of control operations enables the operating system to be activated on the PC **10**. After activation of the operating system, the CPU **200** notifies the access controller **320** of the activation of the operating system. The access controller **320** notified of the activation of the operating system stores the value '0' representing the 'OS active state' into the OS state storage unit **326**. The access controller **320** may alternatively detect the activation of the operating system, in response to a reading operation of a sector with the OS **902** stored therein, in place of the notification by the CPU **200**.

TABLE 1

	AFTER POWER SUPPLY	AFTER SUCCESSFUL AUTHENTICATION	AFTER ACTIVATION OF OS
AUTHENTICATION STATE STORAGE UNIT 322	0	1	1
OS STATE STORAGE UNIT 326	1	1	0

Table 1 shows one example of the storage contents in the authentication state storage unit **322** and the OS state storage unit **326** after the PC **10** is powered on, after the successful authentication by the authentication program **441**, and after the activation of the operating system.

[0066] One modified application may combine the functions of these two storage units (the authentication state storage unit **322** and the OS state storage unit **326**) to one integral state storage unit. One example of the storage contents in the integral state storage unit having the combined functions of the two storage units is shown in Table 2.

TABLE 2

	AFTER POWER SUPPLY	AFTER SUCCESSFUL AUTHENTICATION	AFTER ACTIVATION OF OS
STATE STORAGE UNIT	0	1	0

As in the illustrated example of Table 1, in the illustrated example of Table 2, a value '1' representing a 'status of successful authentication' is stored into the integral state storage unit after the successful authentication by the authentication program **441**. The access controller **320** is subsequently notified of the activation of the operating system and stores a value '0' representing an 'OS active state' into the integral state storage unit. In this modified application, upon satisfaction of all the conditions given below, the access controller **320** may ignore the reset command at step S**13** in FIG. **4**:

[0067] Condition 1) The storage content in the state storage unit represents the status of successful authentication; and

[0068] Condition 3) The access controller **320** receives the reset command from the CPU **200**.

The hard disk **300** is constructed to make one of the plain text area assigned to the authentication storage area and the encoding area assigned to the operating system storage area visible from the PC **10**. Such visibility is attained according to the following sequence of control operations implemented by the access controller **320**:

[0069] After PC **10** is Powered On: The control sends back the attributes of the plain text area, in response to the attribute request from the BIOS (step S**4** in FIG. **4**). This response makes the plain text area visible and the encoding area invisible. The hard disk recognized by the CPU **200** in this state is an HD storage unit **312***a* shown in FIG. **5**A.

[0070] After Successful Authentication by Authentication Program **441**: The control sends back the attributes of the encoding area, in response to the attribute request from the BIOS (step S**14** in FIG. **4**). This response makes the plain text area invisible and the encoding area visible. The hard disk recognized by the CPU **200** in this state is an HD storage unit **312***b* shown in FIG. **5**B.

[0071] The plain text area and the encoding area are preferably structured to have the identical attributes of the hard disk including the device name and the device size. This arrangement enables the CPU **200** to recognize the identical attributes of the hard disk before and after the authentication and thereby prevents malfunction of the CPU **200**.

[0072] As described above, in the case of successful authentication representing that the user is authenticated as the approved user by the authentication program, the control flow of the first embodiment allows an access from the information processing apparatus to the operating system storage area. This arrangement enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device. The operating system is stored in advance in the encrypted state. This arrangement effectively enhances the security of the information stored in the storage device.

B. Second Embodiment

[0073] FIG. **7** is a sequence diagram showing a flow of an OS activation process implemented in a second embodiment. The differences from the OS activation process of the first

embodiment shown in FIG. **4** are that the storage of the authentication information as part of step S**11** is replaced by the processing of step S**51** and that the processing of steps S**12** and S**13** is replaced by the processing of step S**50**. Otherwise the control flow of the second embodiment is similar to that of the first embodiment. A hard disk **300** of the second embodiment does not include the OS state storage unit **326** but otherwise has a similar structure to that of the hard disk **300** of the first embodiment.

[0074] After the successful authentication by the authentication program **441**, the CPU **200** resets the CPU **200** itself and issues a reset command to the access controller **320**. The reset command is issued to allow for activation of the OS **902**. In response to reception of the reset command, the access controller **320** issues a reset command to the HD controller **311** (step S**50**). After completion of the reset process, the access controller **320** stores the authentication information (step S**51**).

[0075] As described above, the control flow of the second embodiment stores the status of successful authentication into the authentication state storage unit, after performing the reset process of the storage device. Such control effectively prevents the storage device from being reset in the state of storage of the authentication information. This arrangement desirably protects the authentication information from being deleted in the course of the reset process.

C. Third Embodiment

[0076] FIG. **8** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with a third embodiment. A hard disk **300***b* of the third embodiment does not have the ROM **330** (FIG. **1**). As described below in detail, the differences from the configuration of the second embodiment include the internal structures of a hard disk module **310***b* and an HD storage unit **312***c* and the sequence of control operations implemented by an access controller **320***b*.

[0077] FIG. **9** is an explanatory view showing the schematic structure of the HD storage unit **312***c* in the third embodiment. The primary difference from the configuration of the second embodiment (FIG. **2**) is that the HD storage unit **312***c* of the third embodiment is divided into a partition A as the authentication storage area and a partition B as the operating system storage area. An MBR **610** has a partition table PT to be referred to for management of the partitions A and B. The partition table PT stores in advance information representing starting positions and terminal positions of the respective partitions A and B, as well as information for specifying which of the partitions A and B is an active partition representing an active area. In the following description of this embodiment, it is assumed that the partition A (authentication storage area) is set to a default active partition.

[0078] The partition A includes a BPB **620**, an FAT **630**, and a data area **640**. The partition B includes a BPB **650**, an FAT **660**, and a data area **670**. An authentication program **641** and a user authentication table **901** are stored in advance in the data area **640** of the partition A. An OS **902** used on a PC **10***b* is stored in advance in an encrypted state in the data area **670** of the partition B.

[0079] FIG. **10** is a sequence diagram showing a flow of an OS activation process implemented in the third embodiment. The differences from the OS activation process of the second embodiment shown in FIG. **7** are discussed below. The steps that are not specifically explained here (that is, the steps in FIG. **10** expressed by the same step numbers as those in FIG. **7**) are identical with those of the second embodiment.

[0080] In response to reception of a read request of a partition (step S**104**), an HD controller **311** sends back a device name NDN and a device size NSZ stored in the BPB **620** of the partition A (FIG. **9**) (step S**105** in FIG. **10**). In response to subsequent reception of a read request of a hard disk in the partition A (step S**6**), the HD controller **311** sends the authentication program **641** stored in the data area **640** of the partition A via the access controller **320***b* (step S**107**). The authentication process implemented according to the authentication program **641** in the third embodiment is identical with the authentication process implemented in the first embodiment (FIG. **4**).

[0081] After completion of a reset process at step S**50**, the access controller **320***b* stores the authentication information (step S**51**). The access controller **320***b* subsequently issues a command to the HD controller **311** to change the active partition set in the partition table PT to the partition B (step S**113**).

[0082] In response to reception of a read request of the partition from the BIOS after the reset process of the CPU **200** (step S**114**), the access controller **320***b* issues a read request of the partition to the HD controller **311** (step S**114**). In response to reception of the read request of the partition, the HD controller **311** sends back a device name LDN and a device size LSZ of the partition B (FIG. **9**) currently set to the active partition (step S**115**). In response to subsequent reception of a read request of a hard disk in the partition B from the BIOS (step S**16**), the HD controller **311** sends the OS **902** of the partition B to the access controller **320***b* (step S**117**). The subsequent control operations implemented in the third embodiment are identical with those implemented in the first embodiment.

[0083] The hard disk **300***b* of this embodiment has the storage unit divided into the different partitions, the partition A as the authentication storage area and the partition B as the operating system storage area. Immediately after the PC **10***b* is powered on, the access controller **320***b* controls the MBR **610** to set the partition A to the active partition (specifically, to activate the partition A preferentially). After the successful authentication by the authentication program **641**, the access controller **320***b* controls the MBR **610** to set the partition B to the active partition. The CPU **200** is capable of recognizing both the authentication storage area and the operating system storage area, regardless of before and after the authentication process.

[0084] As described above, the authentication program is activated and implemented immediately after the information processing apparatus is powered on connecting with the storage device of the third embodiment. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement of the third embodiment enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device, and effectively enhances the security of the information stored in the storage device.

D. Fourth Embodiment

[0085] FIG. **11** is an explanatory view schematically illustrating the configuration of an information processing apparatus connecting with a storage device in accordance with a fourth embodiment. A hard disk **300***c* of the fourth embodi-

ment has a ROM **330***c* including an area specification table **332**, in place of the sector number table **331** (FIG. **1**). As described later in detail, the differences from the configuration of the first embodiment include the internal structures of a hard disk module **310***c* and an HD storage unit **312***d* and the sequence of control operations implemented by an access controller **320***c*. Otherwise the configuration of the fourth embodiment is similar to the configuration of the first embodiment.

[0086] FIG. **12** is an explanatory view showing the schematic structure of the HD storage unit **312***d* in the fourth embodiment. The primary difference from the configuration of the first embodiment shown in FIG. **2** is that the HD storage unit **312***d* of the fourth embodiment has a first logical unit **700** as the authentication storage area and a second logical unit **800** as the operating system storage area. Logical unit numbers LUN**0** and LUN**1** are respectively assigned to the logical units **700** and **800** for the purpose of identification of the respective logical units. The logical unit LUN**0** has substantially the same structure as that of the plain text area (FIG. **2**), and the logical unit LUN**1** has substantially the same structure as that of the encoding area (FIG. **2**).

[0087] FIG. **13** is an explanatory view showing one example of the area specification table **332** after the PC is powered on. The area specification table **332** functioning as an area specification module includes LUN numbers LN given as information relating to assignment of the respective logical units, physical area information, and logical area information. The physical area information includes a total capacity PB, a start address PSA, and an end address PEA. The physical area information represents information on the physical (actual) storage capacity in the HD storage unit **312***d*. The logical area information includes a total capacity LB, a start address LSA, and an end address LEA. The logical area information represents information on the logical storage capacity in the HD storage unit **312***d*. In the table of FIG. **13**, the total capacity of a physical area is set equal to the total capacity of a logical area. Such setting is, however, not essential, and the total capacity of the logical area may be different from the total capacity of the physical area. An entry having the LUN number LN=0 represents area information relating to the logical unit LUN**0** (assigned to the authentication storage area). An entry having the LUN number LN=1 represents area information relating to the logical unit LUN**1** (assigned to the operating system storage area). Unless otherwise specified in an explicit manner to the BIOS, the logical unit LUN**0** is set to a preferentially activated area. The procedure of this embodiment does not make any explicit setting to the BIOS, so that the logical unit assigned to the authentication storage area is set as a preferentially activated area in the area specification table **332** after the PC is powered on (FIG. **13**).

[0088] FIG. **14** is a sequence diagram showing a flow of an OS activation process implemented in the fourth embodiment. The differences from the OS activation process of the first embodiment shown in FIG. **4** are discussed below. The steps that are not specifically explained here (that is, the steps in FIG. **14** expressed by the same step numbers as those in FIG. **4**) are identical with those of the first embodiment.

[0089] In response to reception of an attribute request to obtain the attributes of the hard disk (step S**4**), the access controller **320***c* sends back a device name and a device size of the LUN**0** (assigned to the authentication storage area) stored in an HD information storage unit **336** of the ROM **330***c* (step S**205**). In response to subsequent reception of a read request of the hard disk (step S**6**), an HD controller **311** sends an authentication program **741** stored in a data area **740** of the logical unit LUN**0** (assigned to the authentication storage area) via the access controller **320***c* (step S**207**). The authentication process implemented according to the authentication program **741** in the fourth embodiment is identical with the authentication process implemented in the first embodiment (FIG. **4**).

[0090] After the successful authentication by the authentication program **741**, the access controller **320***c* sends back the result of the authentication process to the CPU **200** (step **811**). Upon determination of the successful authentication, the access controller **320***c* stores authentication information. The access controller **320***c* also changes the settings in the area specification table **332** stored in the ROM **330***c* (step S**211**). According to a concrete procedure, the access controller **320***c* changes the value set in an LUN number LN field of the authentication storage area to '1', while changing the value set in an LUN number LN field for the operating system storage area to '0'. Such change of the settings enables the logical unit assigned to the operating system storage area to be activated preferentially.

[0091] FIG. **15** is an explanatory view showing the schematic structure of the HD storage unit **312***d* after the change of the settings. In response to reception of an attribute request to obtain the attributes of the hard disk from the BIOS after the reset process of the CPU **200** (step S**14**), the access controller **320***c* refers to the storage content in a status storage unit **323**. Since the storage content in the status storage unit **323** represents the status of successful authentication, the access controller **320***c* sends back a device name and a device size of the logical unit LUN**0** (assigned to the operating system storage area) stored in the HD information storage unit **336** of the ROM **330***c* (step S**215**). In response to subsequent reception of a read request of the hard disk from the BIOS (step S**16**), the HD controller **311** sends the OS **902** of the logical unit LUN**0** (assigned to the operating system storage area) to the access controller **320***c* (step S**217**). The subsequent control operations implemented in the fourth embodiment are identical with those implemented in the first embodiment.

[0092] The hard disk **300***c* of this embodiment has the authentication storage area and the operating system storage area assigned to different logical units. After the PC **10***c* is powered on, the access controller **320***c* determines the setting of the logical unit number in the area specification table **332** to preferentially activate the logical unit assigned to the authentication storage area. The hard disk recognized by the CPU **200** in this state is the HD storage unit **312***d* shown in FIG. **12**. After the successful authentication by the authentication program **741**, the access controller **320***c* determines the setting of the logical unit number to preferentially activate the logical unit assigned to the operating system storage area. The hard disk recognized by the CPU **200** in this state is the HD storage unit **312***d* shown in FIG. **15**.

[0093] The access controller **320***c* may perform a sequence of access control discussed below, in addition to controlling the priority order of activation of the logical units based on the settings of the logical unit numbers:

[0094] After PC **10***c* is Powered On: The control sends back the attributes of only the logical unit assigned to the authentication storage area, in response to an attribute request from the BIOS (step S**4** in FIG. **14**). This response makes the logical unit assigned to the authen-

tication storage area accessible, while making the logical unit assigned to the operating system storage area inaccessible.

[0095] After Successful Authentication by Authentication Program **741**: The control sends back the attributes of only the logical unit assigned to the operating system storage area, in response to an attribute request from the BIOS (step S**14** in FIG. **14**). This response makes the logical unit assigned to the operating system storage area accessible, while making the logical unit assigned to the authentication storage area inaccessible.

[0096] Such access control makes the logical unit assigned to the authentication storage area inaccessible after the successful authentication by the authentication program. This arrangement desirably prevents malfunction of the information processing apparatus (PC).

[0097] As described above, the authentication program is activated and implemented immediately after the information processing apparatus is powered on connecting with the storage device of the fourth embodiment. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement of the fourth embodiment enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device, and effectively enhances the security of the information stored in the storage device.

E. Fifth Embodiment

[0098] FIG. **16** is an explanatory view showing the appearance of a system including a storage device in accordance with a fifth embodiment. FIG. **17** is an explanatory view schematically illustrating the configuration of the system including the storage device of the fifth embodiment. The differences from the configuration of the first embodiment shown in FIG. **1** include a USB flash memory **20** and a USB host **250** as additional components and a hard disk **300***d* in place of the hard disk **300**. Otherwise the configuration and the operations of the system of the fifth embodiment are substantially equivalent to those of the first embodiment.

[0099] The USB host **250** functions as a driver of the USB flash memory **20**. The hard disk **300***d* includes a hard disk module **310***d* and an access controller **320***d*. The hard disk module **310***d* includes an HD controller **311**, an HD information storage unit **316**, and an HD storage unit **312***e*. The HD information storage unit **316** stores therein attributes of the hard disk including a device name and a device size of the HD storage unit **312***e*. The access controller **320***d* includes an encryption module **321**, an authentication state storage unit **322**, and OS state storage unit **326** as discussed later in detail. The USB flash memory **20** includes a memory controller **1100** and a flash memory area **1200**. The flash memory area **1200** is made of a storage medium. The memory controller **1100** is configured to include a status storage unit **1101** and control the operations of the flash memory area **1200**.

[0100] FIGS. **18**A and **18**B are explanatory views showing the schematic structures of the flash memory area **1200** and the HD storage unit **312***e* in the fifth embodiment. The primary difference from the configuration of the first embodiment shown in FIG. **2** is that an authentication storage area and an operating system storage area are stored in different media (the USB flash memory **20** and the hard disk **300***d*) in the configuration of the fifth embodiment. As shown in FIG. **18**A, an authentication program **1201** and a user authentication table **901** are stored in advance in the flash memory area **1200** specified as the authentication storage area. The details of the authentication program **1201** will be discussed later. As shown in FIG. **18**B, the HD storage unit **312***e* specified as the operating system storage area includes an MBR **910**, a BPB **920**, an FAT **930**, and a data area **940**. An OS **902** used on the PC **10***d* is stored in advance in an encrypted state in the data area **940**.

[0101] FIG. **19** is a sequence diagram showing a flow of an OS activation process implemented in the fifth embodiment. The differences from the OS activation process of the first embodiment shown in FIG. **4** are discussed below. The steps that are not specifically explained here (that is, the steps in FIG. **19** expressed by the same step numbers as those in FIG. **4**) are identical with those of the first embodiment.

[0102] In response to reception of an attribute request to obtain the attributes of the hard disk (step S**4**), the HD controller **311** sends back a device name and a device size stored in the HD information storage unit **316** of the hard disk module **310***d* (step S**301** in FIG. **19**). The CPU **200** subsequently issues a read request of the hard disk (step S**6**). The data area **940** is, however, encrypted and is unreadable, so that the CPU **200** fails to read the hard disk (step S**302**).

[0103] The CPU **200** refers to a priority order of activation of the drives by the BIOS and issues a request for media information to the memory controller **1100** included in the USB flash memory **20** (step S**303**). The CPU **200** obtains the media information and subsequently issues a read request of the medium to the memory controller **1100** (step S**304**). In response to this read request of the medium, the memory controller **1100** sends the authentication program **1201** stored in the flash memory area **1200** of the storage medium to the CPU **200** (step S**305**).

[0104] The CPU **200** receives the authentication program **1201** and executes the received authentication program **1201** to perform an authentication process. According to a concrete procedure similar to that discussed in the first embodiment, the CPU **200** accepts the user's entries of a user name and a password and sends a value entered in the user name entry field NF and a value entered in the password entry field PF to the memory controller **1100** (step S**310**). The memory controller **1100** receives the entered values and performs the authentication process with referring to the user authentication table **901** set in the flash memory area **1200** by a procedure similar to that discussed in the first embodiment.

[0105] The memory controller **1100** sends back the result of the authentication process to the CPU **200**. Upon determination of the successful authentication, the memory controller **1100** stores authentication information (step S**311**). According to a concrete procedure, the memory controller **1100** stores information representing a status of successful authentication into the status storage unit **1101**. The CPU **200** receives the information representing the status of successful authentication and subsequently issues a storage command of the authentication information to the access controller **320***d*. In response to reception of the storage command, the access controller **320***d* stores the information representing the status of successful authentication into the authentication state storage unit **322** (step S**312**).

[0106] After the reset process of the CPU **200**, the BIOS issues an attribute request to obtain the attributes of the hard disk. The attribute request is sent to the HD controller **311** via the access controller **320***d* (step S**314**). In response to the attribute request, the HD controller **311** sends back a device

name and a device size stored in the HD information storage unit **316** of the hard disk module **310***d* (step S**315**). The BIOS then issues a read request of the hard disk via the access controller **320***d* (step S**316**). In response to the read request, the HD controller **311** sends the OS **902** stored in the HD storage unit **312***e* via the access controller **320***d* (step S**317**). The subsequent control operations implemented in the fifth embodiment are identical with those implemented in the first embodiment.

[0107] As described above, in the configuration of the fifth embodiment, the access controller decodes the storage content in the HD storage unit after the successful authentication by the authentication program. The authentication program is activated and implemented immediately after the power supply. After the successful authentication by the authentication program, the operating system is decrypted and activated. This arrangement of the fifth embodiment enables the OS to be activated, based on the result of authentication according to the authentication program stored in the storage device, and effectively enhances the security of the information stored in the storage device.

F. Modifications

[0108] The embodiments and their applications discussed above are to be considered in all aspects as illustrative and not restrictive. There may be many modifications, changes, and alterations without departing from the scope or spirit of the main characteristics of the present invention. Some examples of possible modification are given below.

F1. Modification 1

[0109] In the first embodiment discussed above, some conditions are specified as the conditions for ignoring the reset command sent from the CPU to the access controller. The conditions for ignoring the reset command are, however, not restricted to those specified in the above embodiment but may be determined arbitrarily within the scope of the invention. For example, conditions 1a and 2a or conditions 1b and 2b given below may be set, in place of the conditions 1 through 3 mentioned in the above embodiment:

[0110] Condition 1a) The storage content in the authentication state storage unit represents the status of successful authentication; and

[0111] Condition 2a) The access controller receives a reset command from the CPU in a preset time period (for example, 3 seconds) after the status of successful authentication is stored in the authentication state storage unit.

[0112] Condition 1b) The storage content in the authentication state storage unit represents the status of successful authentication; and

[0113] Condition 2b) A reset command received by the access controller is within a preset ordinal number of reset commands (for example, first through third reset commands) after the status of successful authentication is stored in the authentication state storage unit.

F2. Modification 2

[0114] In the first and the second embodiments discussed above, the authentication storage area and the operating system storage area are set to have the identical attributes (for example, the device name and the device size). The access controller directly sends back these identical attributes, in response to an attribute request for the attributes of the hard disk from the BIOS. In one modified application, the authentication storage area and the operating system storage area may be set to have different attributes. The access controller may send back false attributes different from the true attributes, in response to an attribute request for the attributes of the hard disk from the BIOS. By way of example, in response to a request for the device size of the authentication storage area from the BIOS, the access controller may send back a greater device size than the actual device size of the authentication storage area (for example, a size equivalent to the size of the operating system storage area). The BIOS accordingly has the apparent recognition that the authentication storage area and the operating system storage area have the identical attributes. This modified arrangement thus effectively prevents an unnecessary expansion of the actual device size of the authentication storage area.

F3. Modification 3

[0115] In the fourth embodiment discussed above, both the authentication storage area and the operating system storage area are controlled to be visible from the information processing apparatus. In one modified application, the access controller may perform a sequence of control operations to make the authentication storage area visible immediately after the information processing apparatus is powered on and to make the authentication storage area invisible after the successful authentication by the authentication program. According to a concrete procedure, like the procedure of the first embodiment, the access controller may specify the content of a reply to the attribute request for the attributes of the hard disk from the CPU (determine whether a reply includes the attributes of the authentication storage area or includes the attributes of the operating system storage area). This modified arrangement effectively prevents malfunction of the information processing apparatus at the time of activation of the OS after the successful authentication.

F4. Modification 4

[0116] In the first, the fourth, and the fifth embodiments discussed above, under storage of the status of the successful authentication, the access controller ignores a reset command issued for activation of the operating system. In the second and the third embodiments discussed above, on the other hand, the access controller performs the reset process in response to a reset command issued for activation of the operating system, prior to storage of the status of successful authentication into the authentication state storage unit. These different control operations are, however, not characteristic of the control flows of the respective embodiments. Either of the control operations may be implemented in combination with any of the control flows of the above embodiments.

F5. Modification 5

[0117] In the embodiments discussed above, the OS is stored in advance in an encrypted state in the operating system storage area. Such encryption technique is not restricted to the OS but may be applicable to arbitrary user data. In one modified application, the system configuration may be designed for encryption of arbitrary user data, as well as for encryption of the OS. In this application, at the time of writing user data, the encryption module encodes the user data and stores the encoded user data. At the time of reading user data,

the encryption module decodes the stored user data and reads out the decoded user data according to a procedure similar to the procedure of reading the OS discussed above. This modified arrangement desirably enhances the security of user data as well as the OS.

F6. Modification 6

[0118] The system of the fifth embodiment described above asks the user to enter a password. In one modified application, a password may be stored in advance in the USB flash memory. This modified arrangement allows for omission of the user's entry of the password. The USB flash memory of this modified arrangement functions itself as a key.

F7. Modification 7

[0119] In the first through the fourth embodiments discussed above, the hard disk is explained as one typical example of the storage device. In the fifth embodiment discussed above, the USB flash memory is explained as one typical example of the storage medium including the authentication storage area. These examples are, however, only for the illustrative purpose and are not at all restrictive. The principle of the invention is also applicable to diversity of other storage devices and other storage media. By way of example, the hard disk may be replaced with an SSD (solid state drive). The USB flash memory may be replaced with, for example, an SD card, a CD-ROM, or a DVD-ROM.

What is claimed is:

1. A storage device used in connection with an information processing apparatus, the storage device comprising:

an authentication storage area storing an authentication program in advance, wherein the authentication program is executed to authenticate whether each user operating the information processing apparatus is an approved user;

an operating system storage area storing an operating system in advance, wherein the operating system is encrypted and is used by the information processing apparatus;

an access controller configured to control accesses the authentication storage area and the operating system storage area from the information processing apparatus; and

a decoder configured to decrypt the encrypted operating system,

wherein upon notification of successful authentication representing that the user is authenticated as the approved user by the authentication program, the access controller allows an access the operating system storage area from the information processing apparatus.

2. The storage device according to claim **1**, the storage device being configured to make one of the authentication storage area and the operating system storage area visible and the other area invisible from the information processing apparatus,

wherein after the information processing apparatus is powered on, the access controller makes the authentication storage area visible and the operating system storage area invisible, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and

after the successful authentication by the authentication program, the access controller makes the authentication storage area invisible and the operating system storage area visible and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

3. The storage device according to claim **2**, wherein the authentication storage area and the operating system storage area are set to have identical attributes including a device name and a device size.

4. The storage device according to claim **2**, wherein in response to an attribute request for an attribute including a device size of the authentication storage area from the information processing apparatus, the access controller sends back a false device size that is greater than an actual device size of the authentication storage area.

5. The storage device according to claim **1**, wherein the authentication storage area and the operating system storage area are assigned to different partitions,

the storage device having a master boot record including a partition table that stores therein information on the respective partitions,

wherein after the information processing apparatus is powered on, the access controller sets the master boot record to preferentially activate a partition assigned to the authentication storage area, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and

after the successful authentication by the authentication program, the access controller sets the master boot record to preferentially activate a partition assigned to the operating system storage area and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

6. The storage device according to claim **5**, wherein the access controller makes the partition assigned to the authentication storage area visible after the information processing apparatus is powered on, and makes the partition assigned to the authentication storage area invisible after the successful authentication by the authentication program.

7. The storage device according to claim **1**, wherein the authentication storage area and the operating system storage area are assigned to different logical units,

the storage device comprising an area specification module that stores therein information on assignment of the logical units including logical unit numbers for identifying the respective logical units,

wherein after the information processing apparatus is powered on, the access controller sets the logical unit number stored in the area specification module to preferentially activate a logical unit assigned to the authentication storage area, thereby allowing the authentication program to be activated and implemented on the information processing apparatus, and

after the successful authentication by the authentication program, the access controller sets the logical unit number stored in the area specification module to preferentially activate a logical unit assigned to the operating system storage area and controls the decoder to decrypt the operating system, thereby allowing the operating system to be activated and implemented on the information processing apparatus.

8. The storage device according to claim **7**, wherein after the information processing apparatus is powered on, the

access controller makes the logical unit assigned to the authentication storage area accessible and the logical unit assigned to the operating system storage area inaccessible, and

after the successful authentication by the authentication program, the access controller makes the logical unit assigned to the authentication storage area inaccessible and the logical unit assigned to the operating system storage area accessible.

9. The storage device according to claim **1**, the storage device further including an authentication state storage unit configured to store a result of authentication,

wherein after the successful authentication by the authentication program, when a reset command issued for activation of the operating system is received from the information processing apparatus subsequent to storage of the status of successful authentication into the authentication state storage unit, the access controller ignores the reset command under a condition of recognizing both the storage of the status of successful authentication in the authentication state storage unit and inactivation of the operation system on the information processing apparatus.

10. The storage device according to claim **1**, the storage device further including an authentication state storage unit configured to store a result of authentication,

wherein the access controller resets the storage device in response to a reset command issued for activation of the operating system from the information processing apparatus and subsequently stores the status of successful authentication into the authentication state storage unit.

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