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(54) STORAGE SYSTEM

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(57) **ABSTRACT**

Data transfer is performed to and from a host computer using a first block as the minimum unit. Data transfer is performed to and from a storage area using a second block as the minimum unit. A second block set of the storage area stores data obtained from performing data conversion processes that change the size of the data itself, with a first block set as the unit. Here a correspondence relationship is generated between the first block set and the second block set. In response to a read request from the host computer, a second block set, which corresponds to the first block set that includes the first block that is requested, is read, a reverse-conversion process is performed, and the data is sent to the host computer.

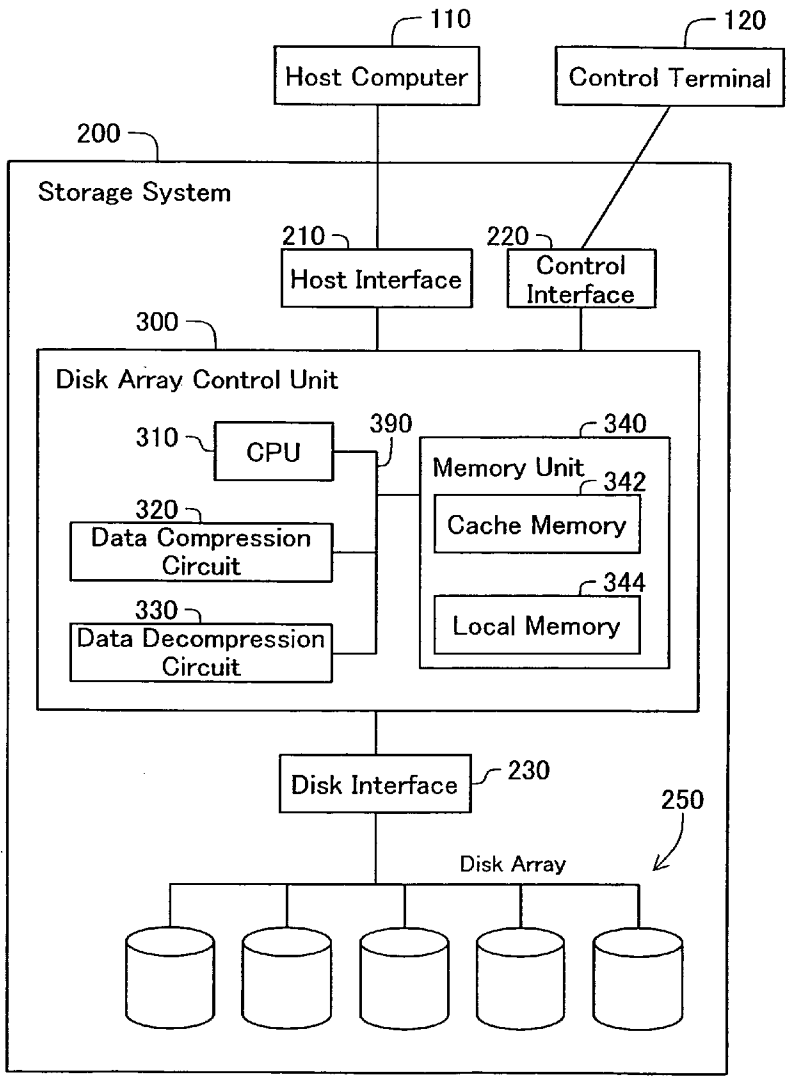


Fig.1

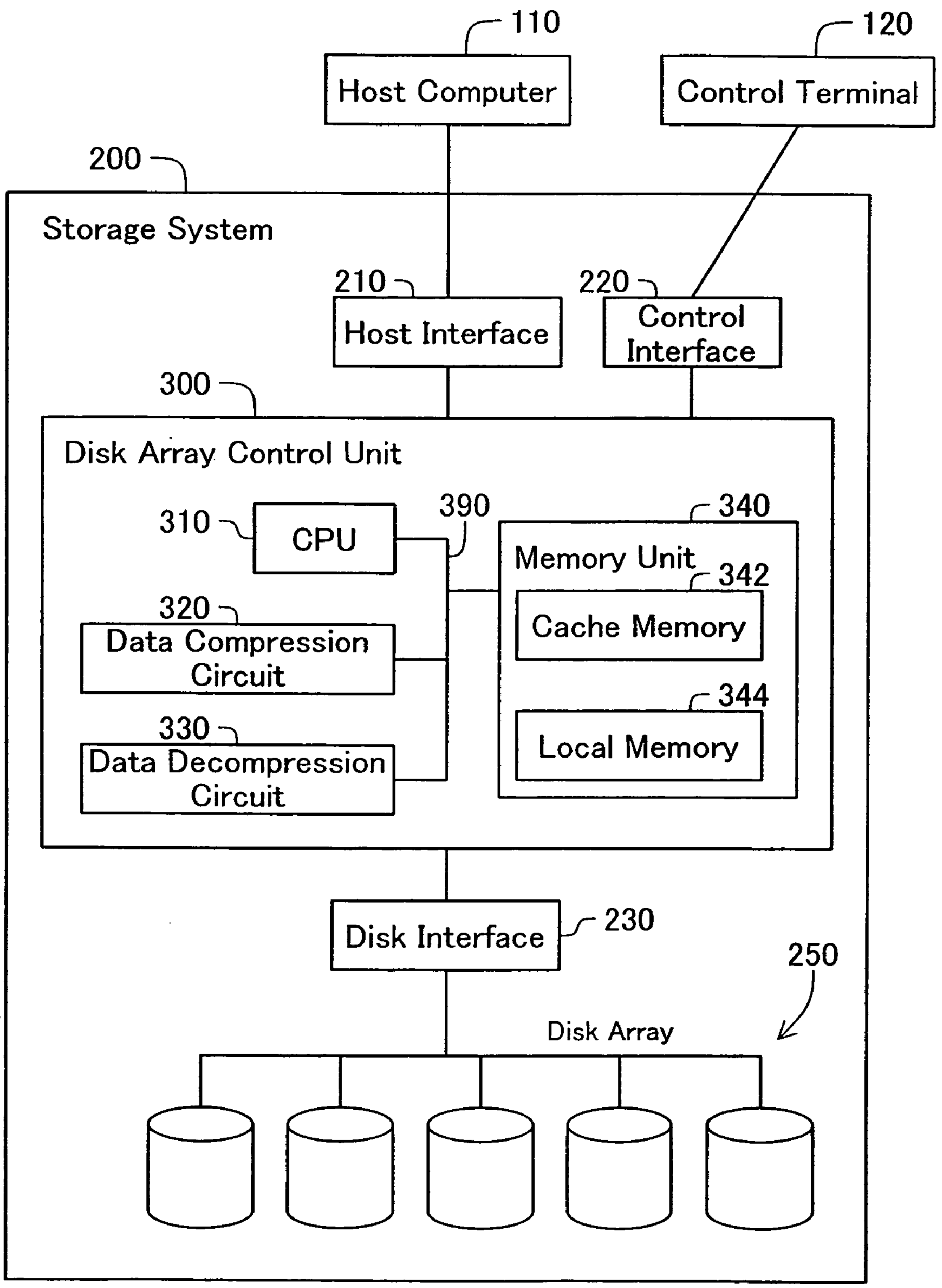

110
Host Computer
120
Control Terminal
200
Storage System
210
Host Interface
220
Control Interface
300
Disk Array Control Unit
310
CPU
390
340
Memory Unit
342
Cache Memory
320
Data Compression Circuit
344
Local Memory
330
Data Decompression Circuit
Disk Interface
230
250
Disk Array

Fig.2

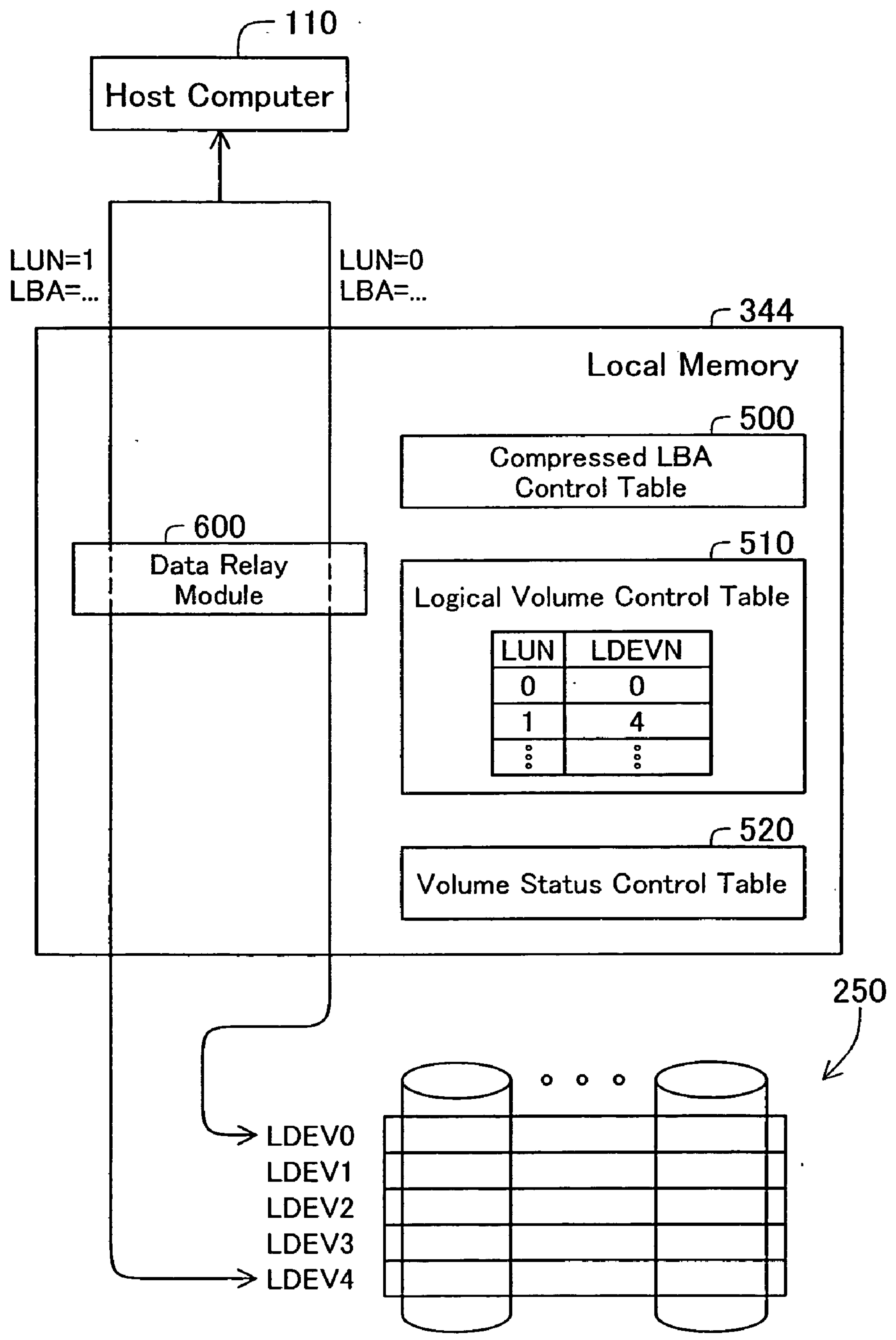
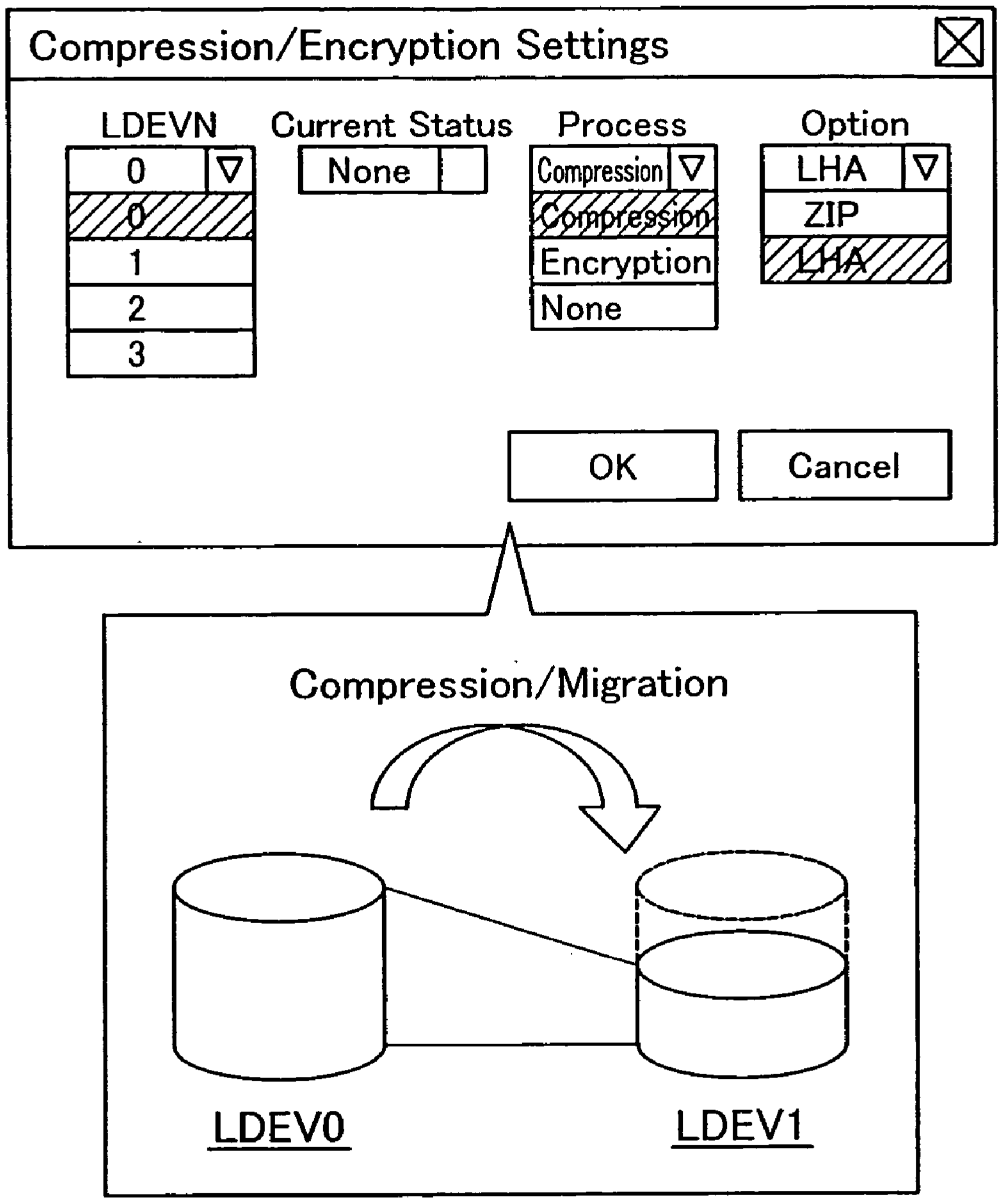

110
Host Computer
LUN=1
LBA=...
LUN=0
LBA=...
344
Local Memory
500
Compressed LBA Control Table
600
Data Relay Module
510
Logical Volume Control Table
LUN | LDEVN
0 | 0
1 | 4
520
Volume Status Control Table
250
LDEV0
LDEV1
LDEV2
LDEV3
LDEV4

Fig.3



Compression/Encryption Settings

LDEVN	Current Status	Process	Option
0	None	Compression	LHA

Fig.4

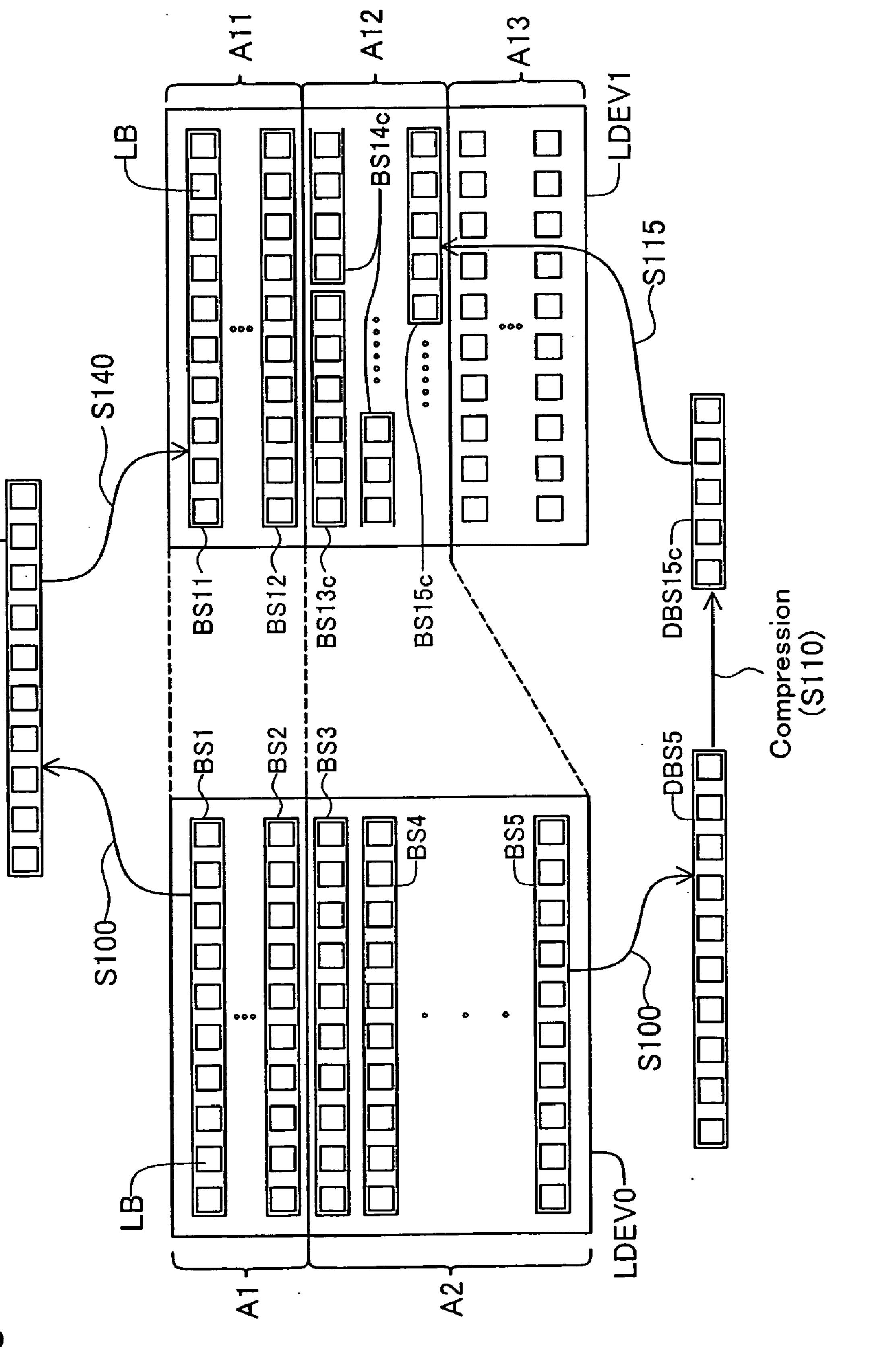

A11
A12
A13
LB
LDEV1
BS14c
S115
S140
DBS1
BS11
BS12
BS13c
BS15c
DBS15c
Compression (S110)
DBS5
BS1
BS2
BS3
BS4
BS5
S100
S100
LB
LDEV0
A1
A2

Fig.5

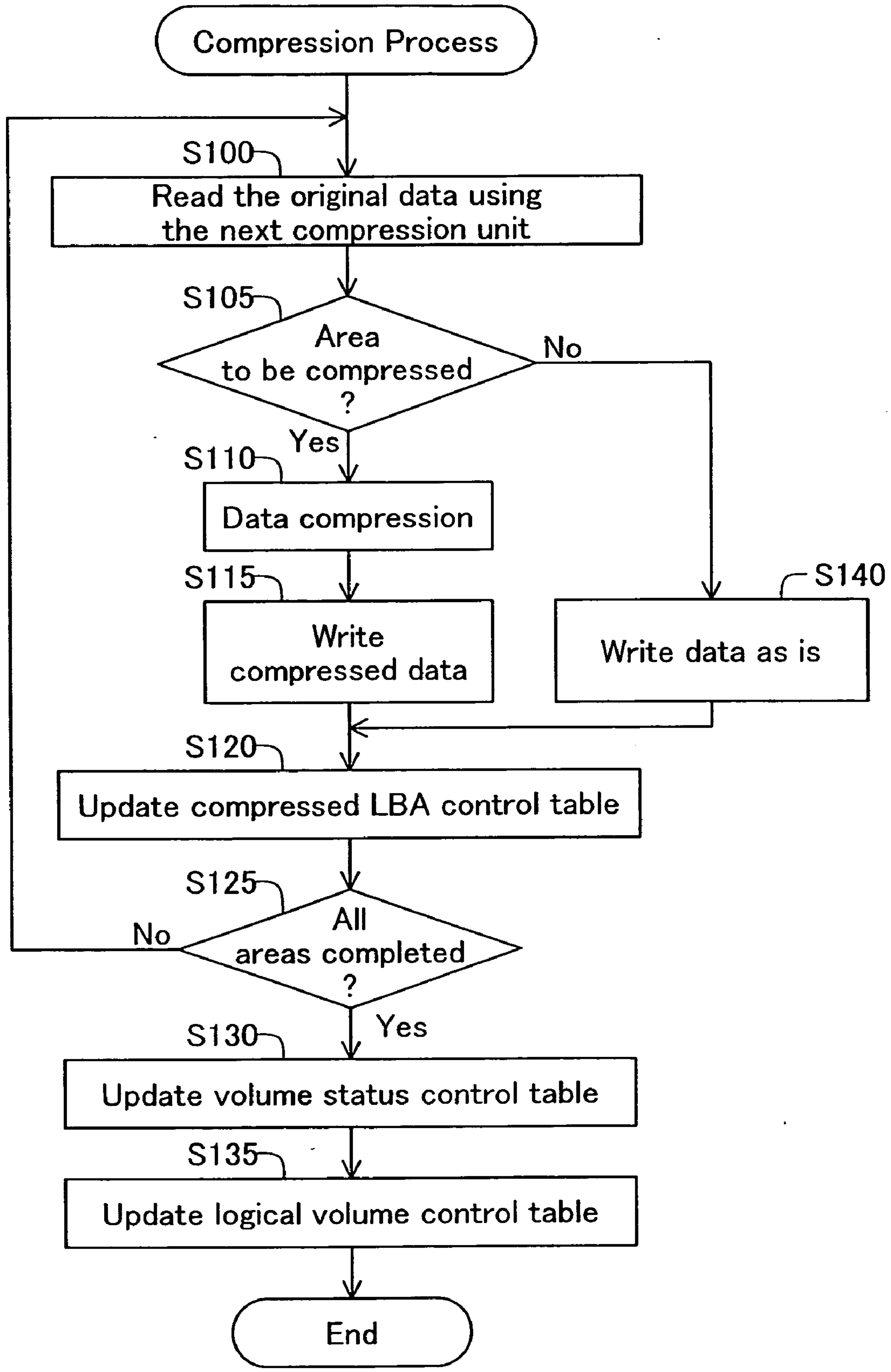

Compression Process
S100
Read the original data using the next compression unit
S105
Area to be compressed ?
No
Yes
S110
Data compression
S115
Write compressed data
S140
Write data as is
S120
Update compressed LBA control table
S125
All areas completed ?
No
Yes
S130
Update volume status control table
S135
Update logical volume control table
End

Fig.6(A)

Compressed LBA Control Table 500

	Pre-migration (Pre-compression)		Post-migration (Post-compression)			
	Starting LBA	Size	Starting LBA	Size	Compressed (C) Non-compressed (N)	
BS1	0000	10	0000	10	N	BS11
	⋮	⋮	⋮	⋮	⋮	
BS2	3000	10	3000	10	N	BS12
BS3	3010	10	3010	06	C	BS13c
BS4	3020	10	3016	07	C	BS14c
	⋮	⋮	⋮	⋮	⋮	
BS5	7990	10	5808	05	C	BS15c

Fig.6(B)

Volume Status Control Table 520

LDEVN	Compression	Encryption	Algorithm
0	Disabled	Disabled	–
1	Enabled	Disabled	LHA
2	Enabled	Disabled	ZIP
3	Disabled	Enabled	DES
⋮	⋮	⋮	⋮

Fig.6(C)

Logical Volume Control Table 510

LUN	LDEVN
0	$\cancel{0} \rightarrow 1$
1	4
⋮	⋮

Fig.7

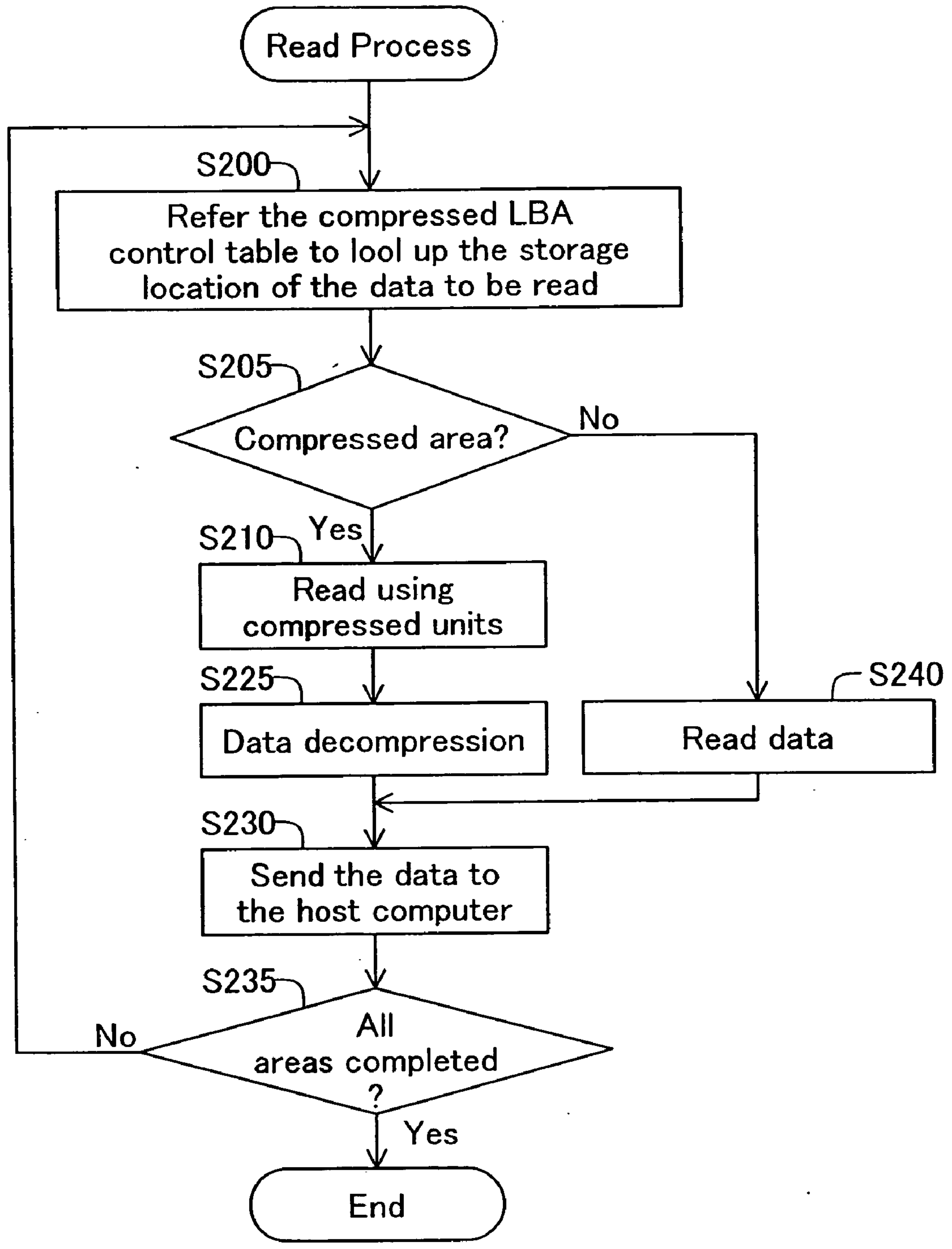

Read Process
S200
Refer the compressed LBA control table to lool up the storage location of the data to be read
S205
Compressed area?
No
Yes
S210
Read using compressed units
S225
Data decompression
S240
Read data
S230
Send the data to the host computer
S235
All areas completed ?
No
Yes
End

Fig.8

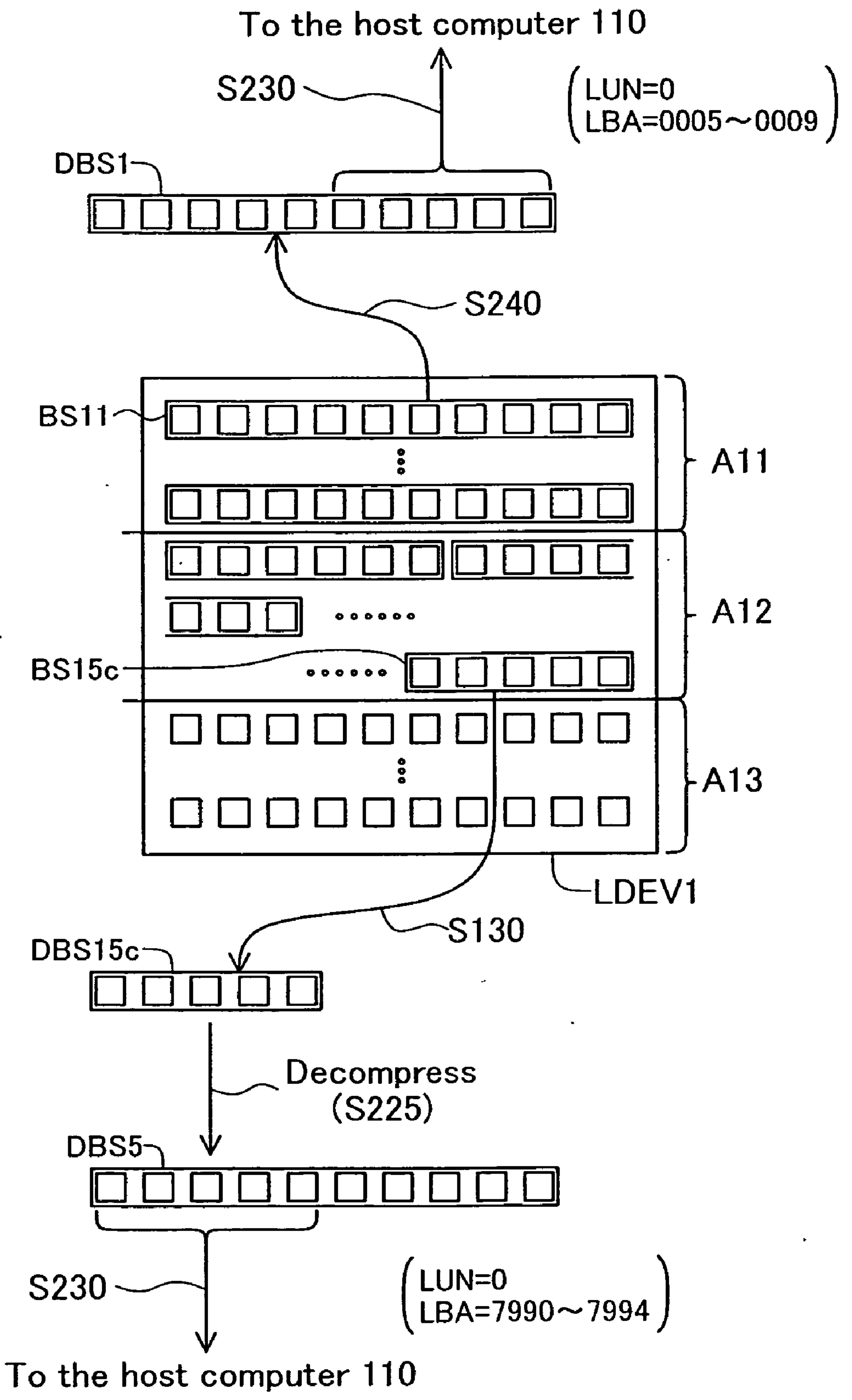

To the host computer 110
S230
LUN=0
LBA=0005～0009
DBS1
S240
BS11
A11
A12
BS15c
A13
LDEV1
S130
DBS15c
Decompress
(S225)
DBS5
S230
LUN=0
LBA=7990～7994
To the host computer 110

Fig.9

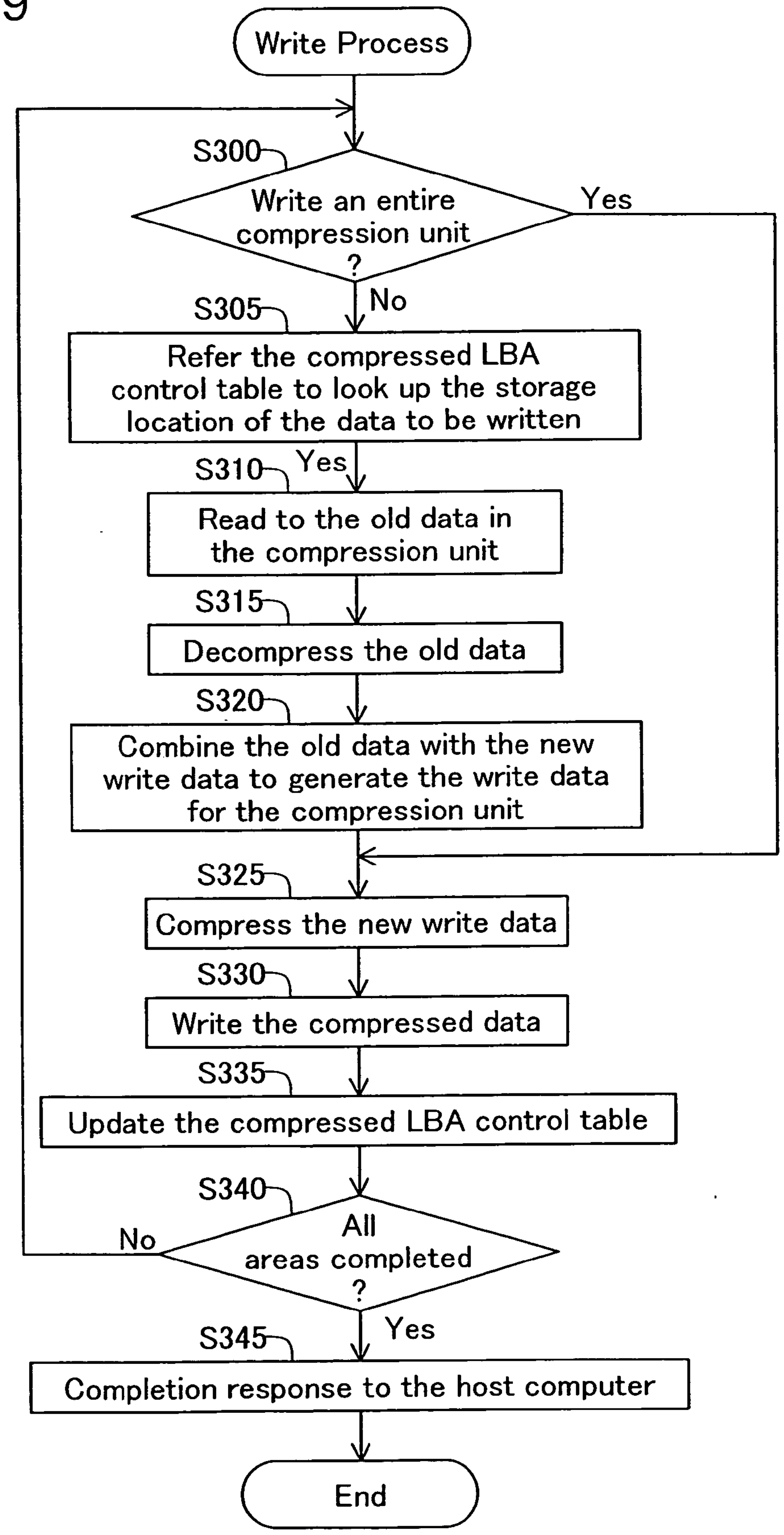

Write Process
S300
Write an entire compression unit ?
Yes
No
S305
Refer the compressed LBA control table to look up the storage location of the data to be written
S310
Yes
Read to the old data in the compression unit
S315
Decompress the old data
S320
Combine the old data with the new write data to generate the write data for the compression unit
S325
Compress the new write data
S330
Write the compressed data
S335
Update the compressed LBA control table
S340
All areas completed ?
No
Yes
S345
Completion response to the host computer
End

Fig.10

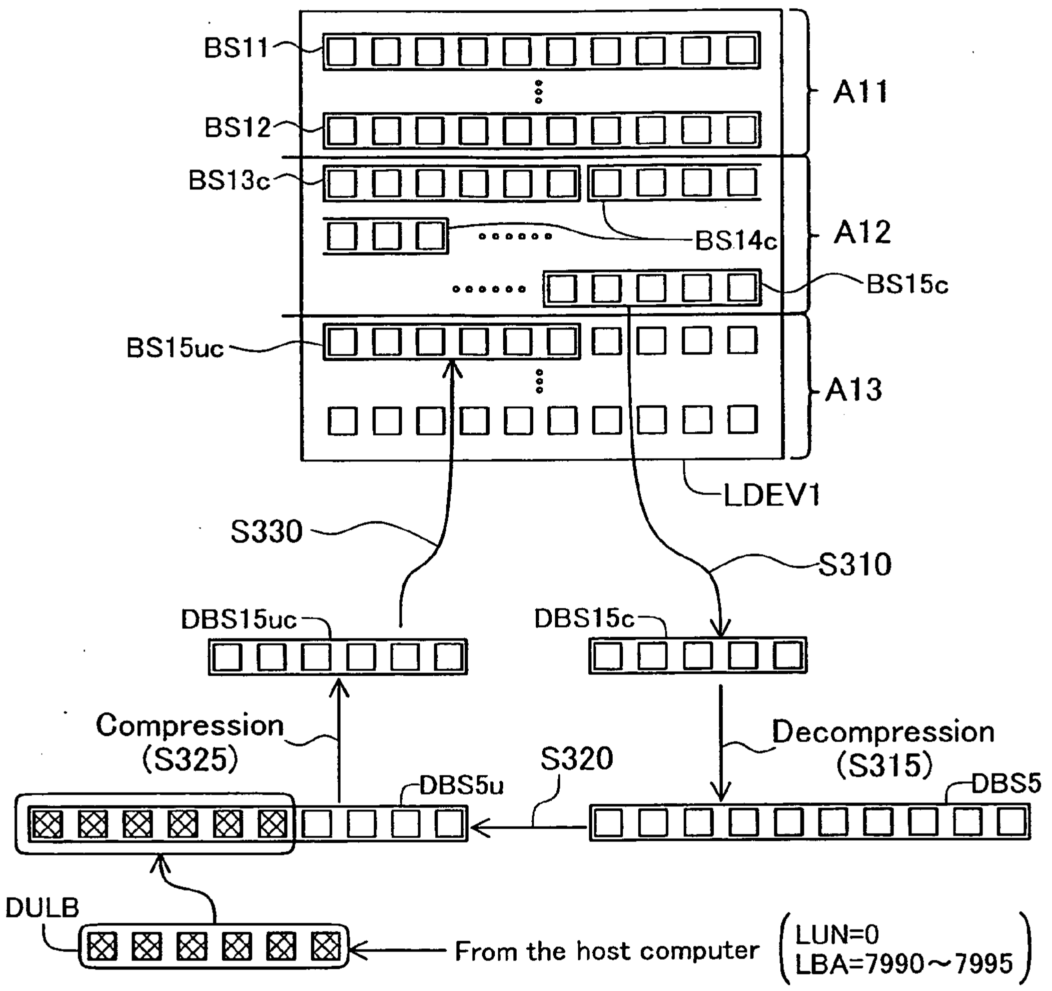


Fig.11

Compressed LBA Control Table 500

	Pre-migration (Pre-compression)		Post-migration (Post-compression)			
	Starting LBA	Size	Starting LBA	Size	Compressed (C) Non-compressed (N)	
BS1	0000	10	0000	10	N	BS11
	⋮	⋮	⋮	⋮	⋮	
BS2	3000	10	3000	10	N	BS12
BS3	3010	10	3010	06	C	BS13c
BS4	3020	10	3016	07	C	BS14c
	⋮	⋮	⋮	⋮	⋮	
BS5	7990	10	5813	06	C	BS15uc

Fig.12

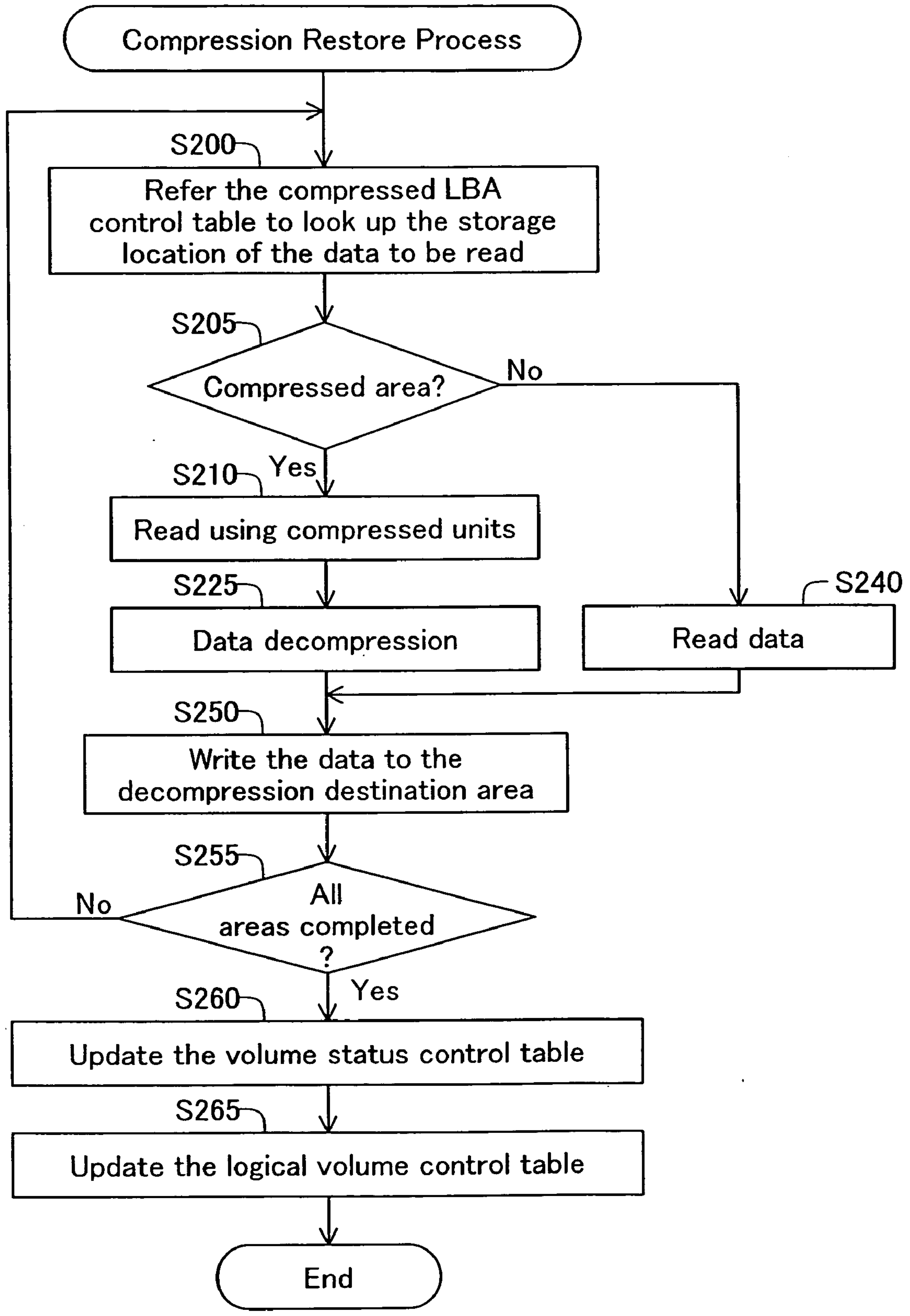

Compression Restore Process
S200
Refer the compressed LBA control table to look up the storage location of the data to be read
S205
Compressed area?
No
S210
Yes
Read using compressed units
S225
Data decompression
S240
Read data
S250
Write the data to the decompression destination area
S255
All areas completed ?
No
Yes
S260
Update the volume status control table
S265
Update the logical volume control table
End

Fig.13

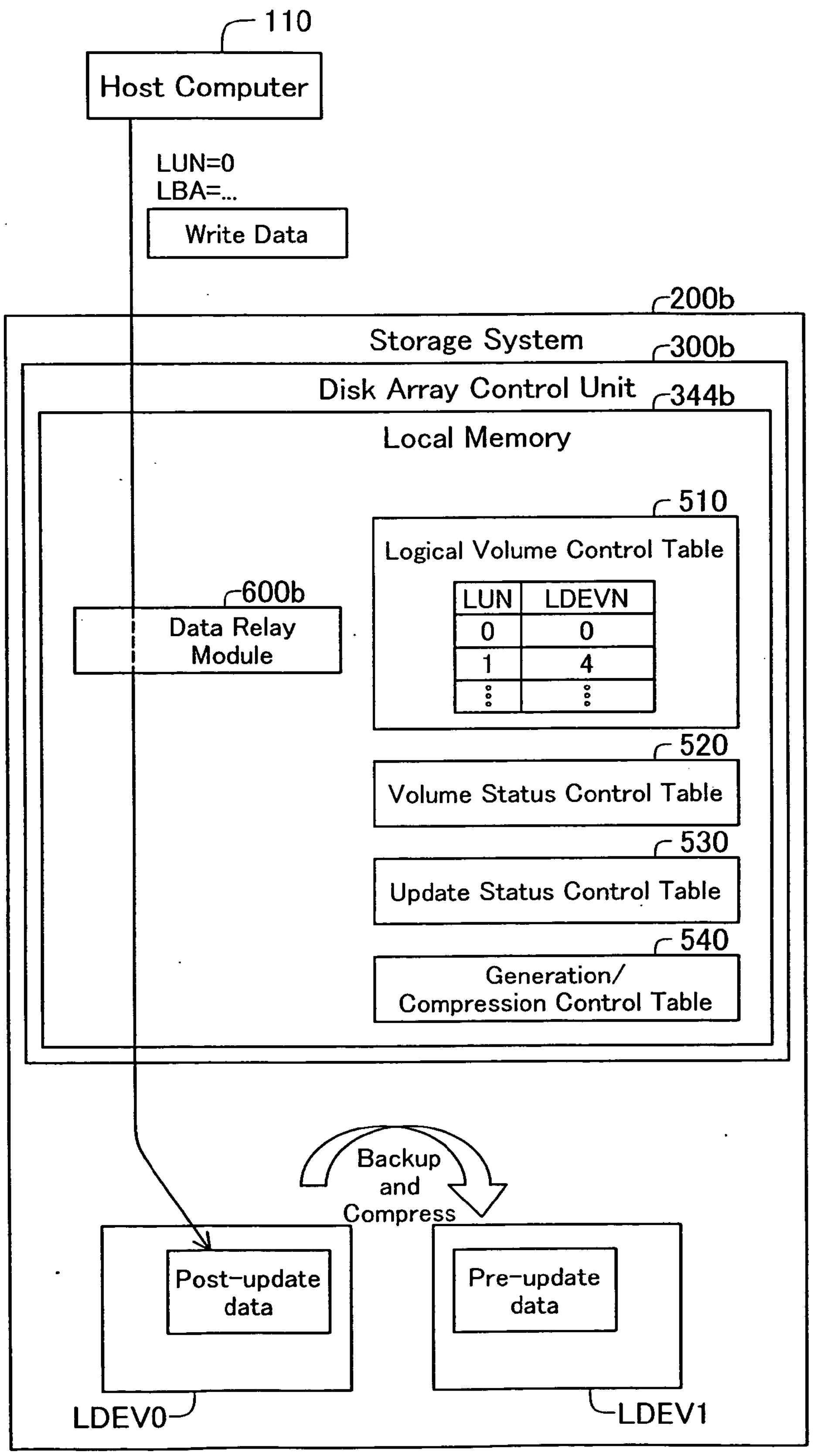
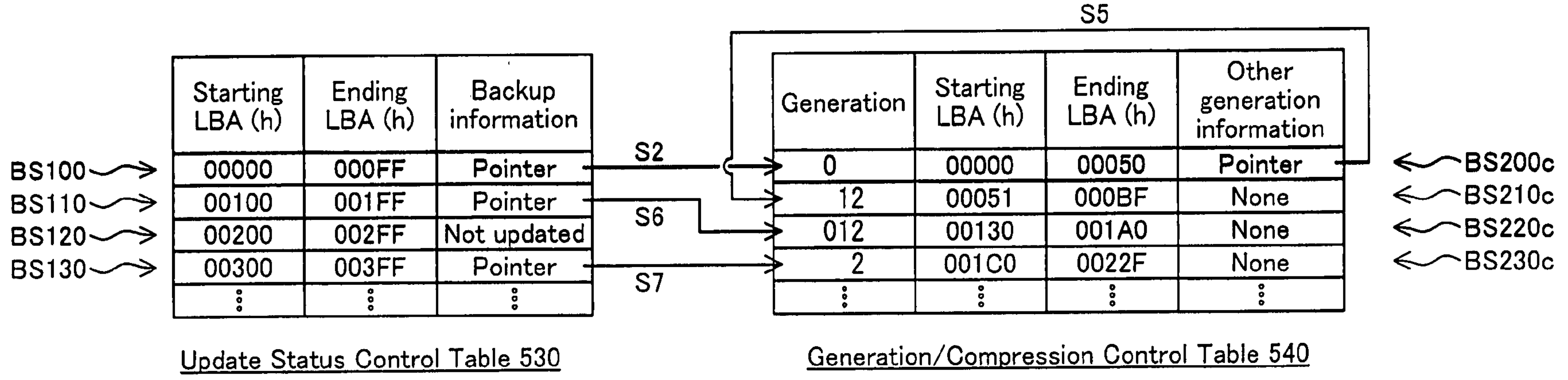

110
Host Computer
LUN=0
LBA=...
Write Data
200b
Storage System
300b
Disk Array Control Unit
344b
Local Memory
510
Logical Volume Control Table
LUN
LDEVN
0
0
1
4
600b
Data Relay Module
520
Volume Status Control Table
530
Update Status Control Table
540
Generation/ Compression Control Table
Backup and Compress
Post-update data
Pre-update data
LDEV0
LDEV1

Fig.14



Starting LBA (h)	Ending LBA (h)	Backup information
00000	000FF	Pointer
00100	001FF	Pointer
00200	002FF	Not updated
00300	003FF	Pointer
⋮	⋮	⋮

Update Status Control Table 530

Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
0	00000	00050	Pointer
12	00051	000BF	None
012	00130	001A0	None
2	001C0	0022F	None
⋮	⋮	⋮	⋮

Generation/Compression Control Table 540

(S1) 0th generation point-in-time copy acquisition instruction

(S2) Normal data "00000 (00000 through00050)(h)" update

(S3) First-generation point-in-time copy acquisition instruction

(S4) Second-generation point-in-time copy acquisition instruction

(S5) Normal data "00000 (00000 through00040)(h)" update

(S6) Normal data "00100 (00100 through00120)(h)" update

(S7) Second-generation data "00300 (00300 through00310)(h)" update

Fig.15

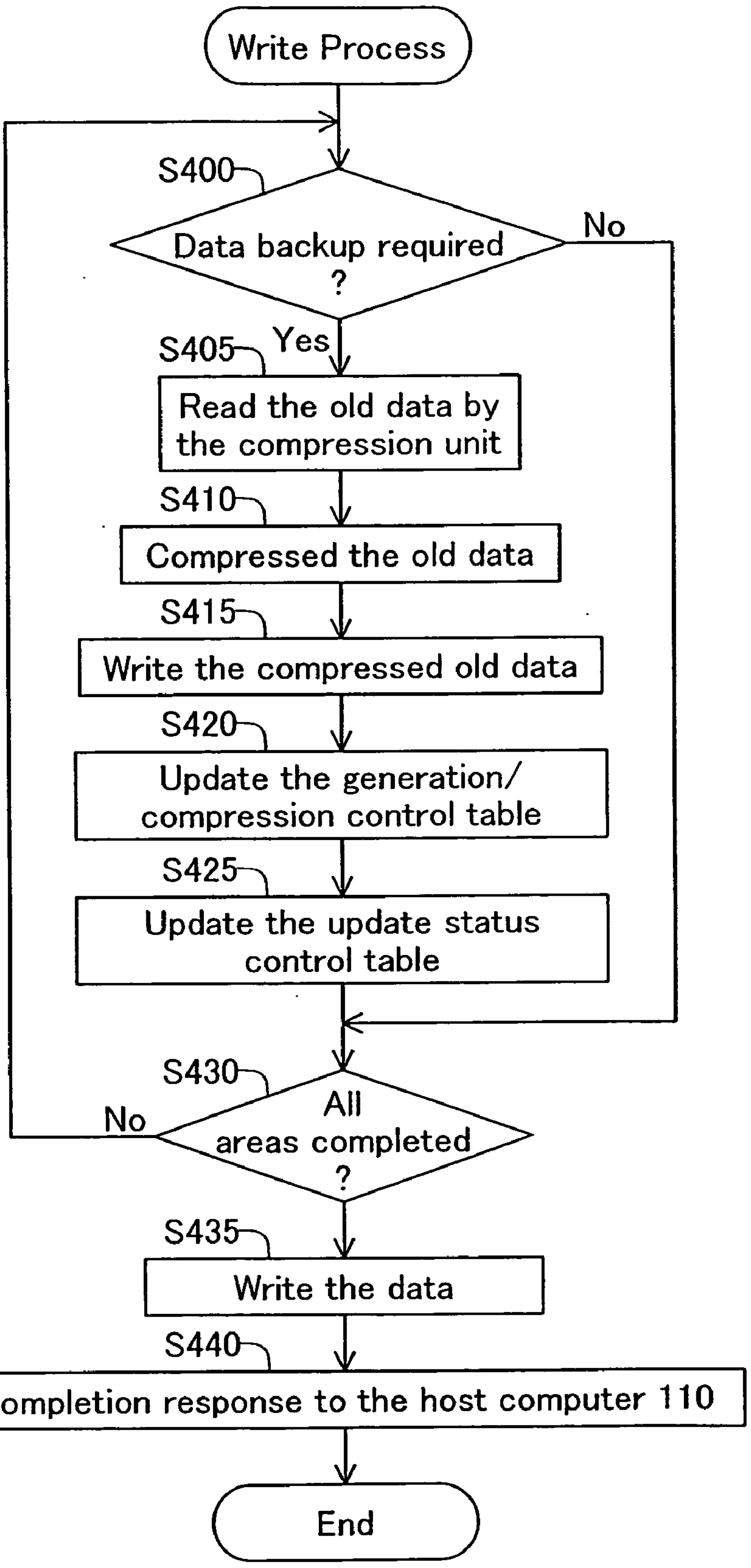

Write Process
S400
Data backup required ?
No
Yes
S405
Read the old data by the compression unit
S410
Compressed the old data
S415
Write the compressed old data
S420
Update the generation/ compression control table
S425
Update the update status control table
S430
All areas completed ?
No
S435
Write the data
S440
Completion response to the host computer 110
End

Fig.16

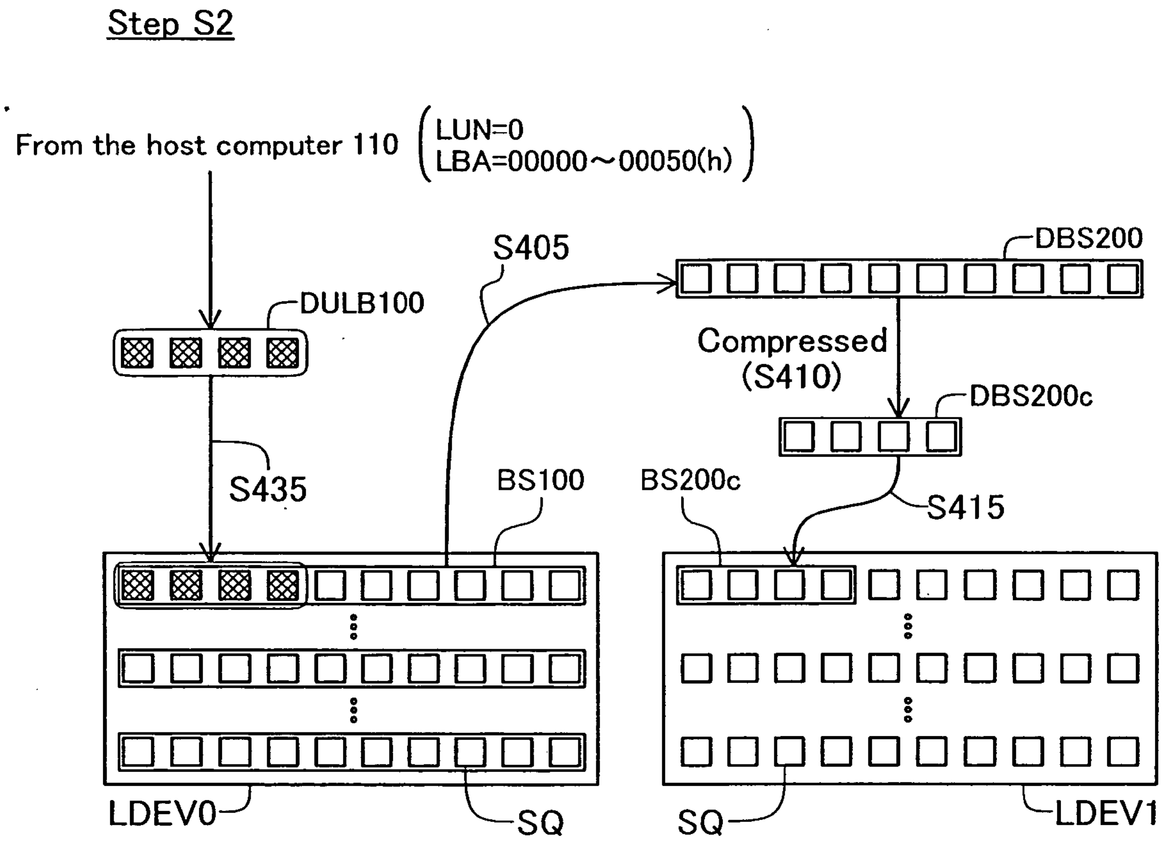
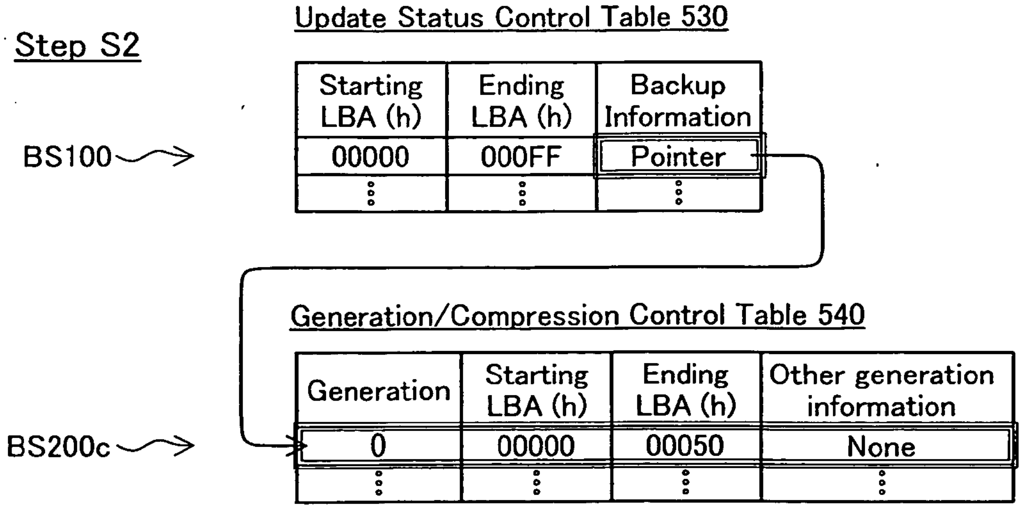


Fig.17


Step S2
BS100
BS200c

Update Status Control Table 530

Starting LBA (h)	Ending LBA (h)	Backup Information
00000	000FF	Pointer
⋮	⋮	⋮

Generation/Compression Control Table 540

Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
0	00000	00050	None
⋮	⋮	⋮	⋮

Fig.18

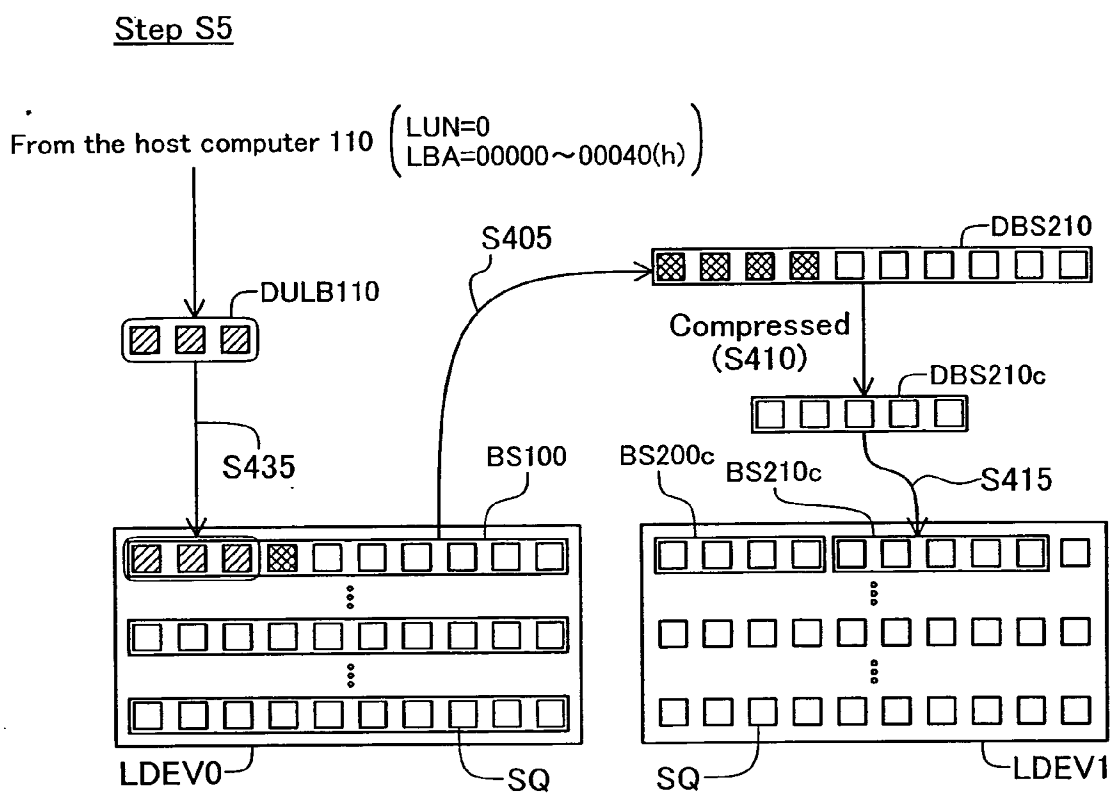
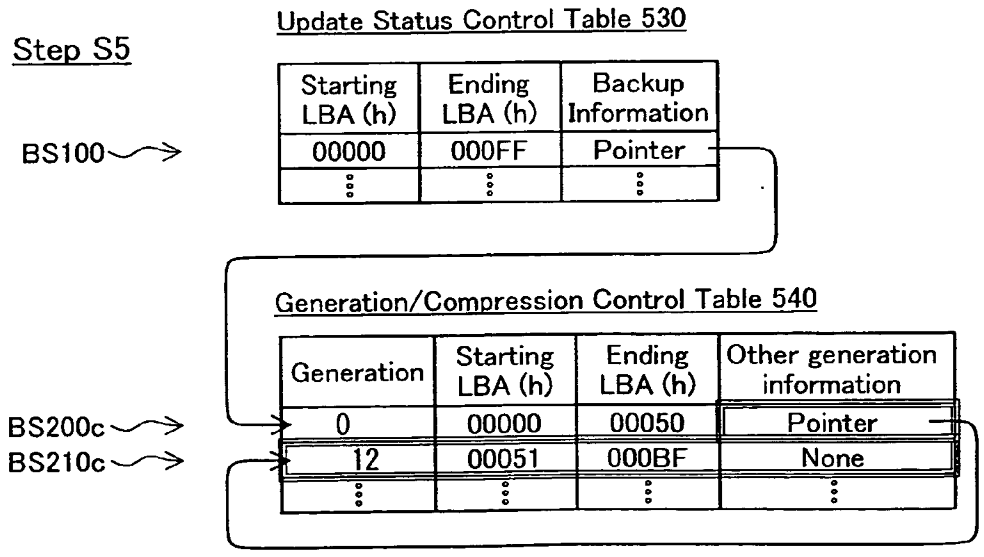


Fig.19


Step S5
BS100
BS200c
BS210c

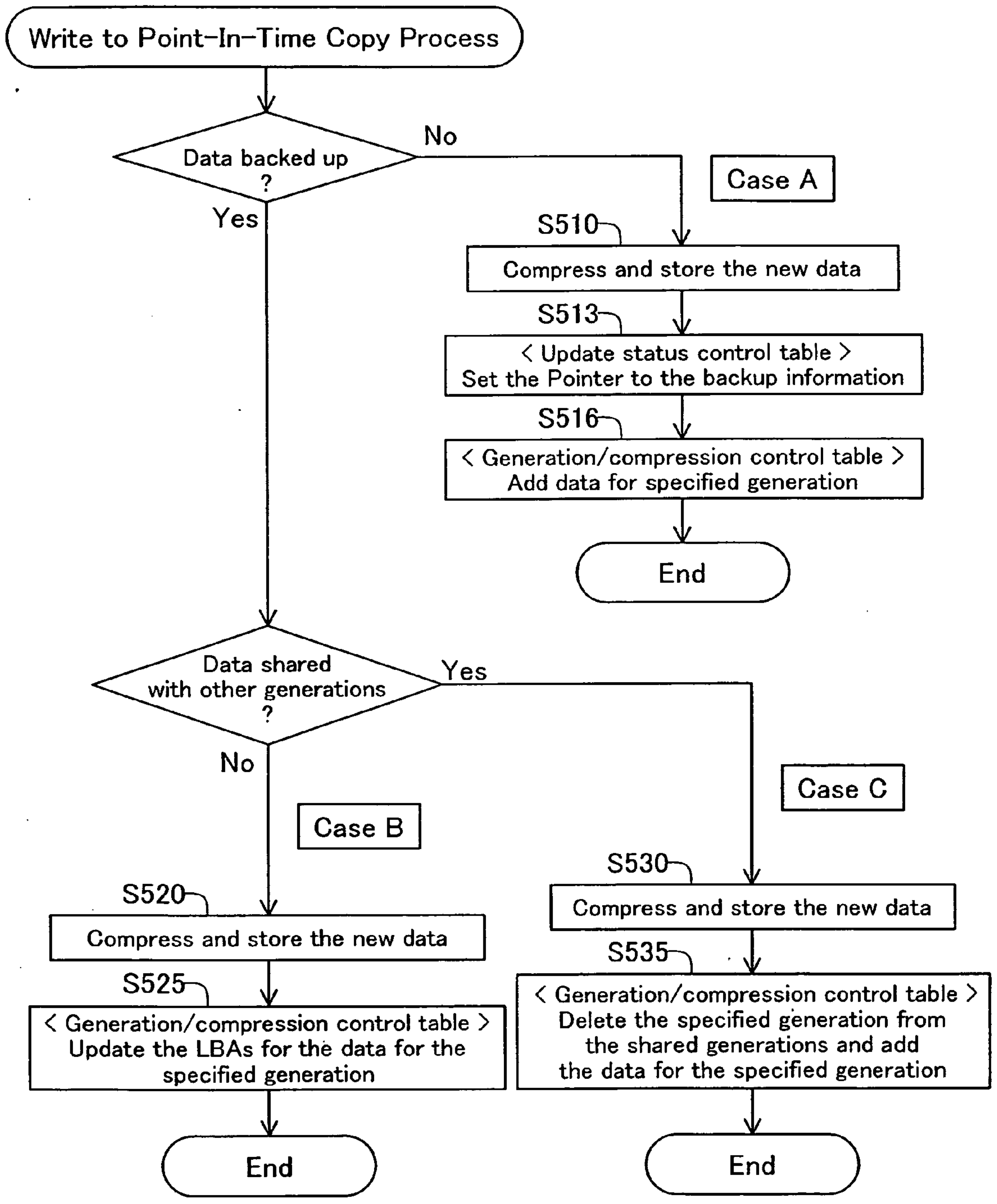
Update Status Control Table 530

Starting LBA (h)	Ending LBA (h)	Backup Information
00000	000FF	Pointer
⋮	⋮	⋮

Generation/Compression Control Table 540

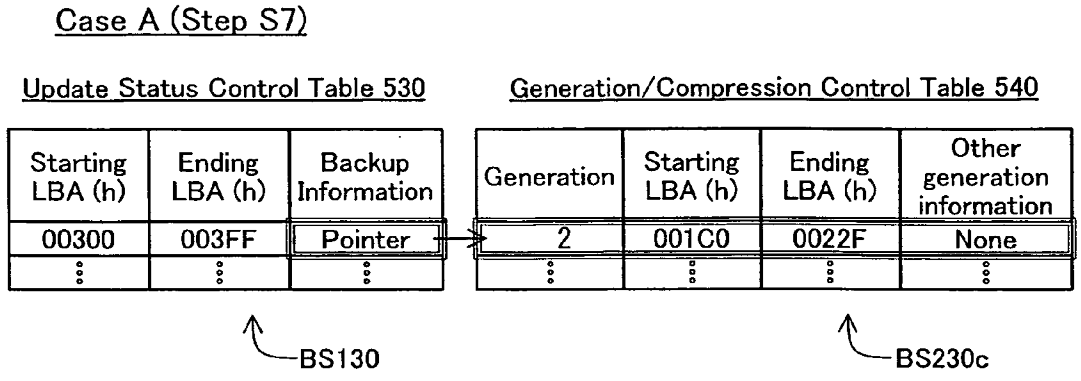
Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
0	00000	00050	Pointer
12	00051	000BF	None
⋮	⋮	⋮	⋮

Fig.20



Write to Point-In-Time Copy Process
Data backed up ?
No
Yes
Case A
S510
Compress and store the new data
S513
< Update status control table > Set the Pointer to the backup information
S516
< Generation/compression control table > Add data for specified generation
End
Data shared with other generations ?
Yes
No
Case B
Case C
S520
Compress and store the new data
S525
< Generation/compression control table > Update the LBAs for the data for the specified generation
End
S530
Compress and store the new data
S535
< Generation/compression control table > Delete the specified generation from the shared generations and add the data for the specified generation
End

Fig.21


Case A (Step S7)
Update Status Control Table 530
Generation/Compression Control Table 540
BS130
BS230c

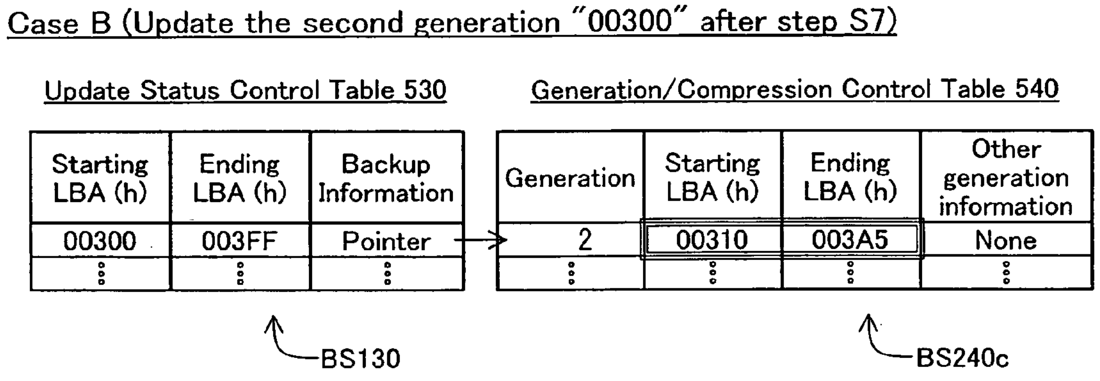
Update Status Control Table 530

Starting LBA (h)	Ending LBA (h)	Backup Information
00300	003FF	Pointer
⋮	⋮	⋮

Generation/Compression Control Table 540

Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
2	001C0	0022F	None
⋮	⋮	⋮	⋮

Fig.22


Case B (Update the second generation "00300" after step S7)
Update Status Control Table 530
Generation/Compression Control Table 540
BS130
BS240c

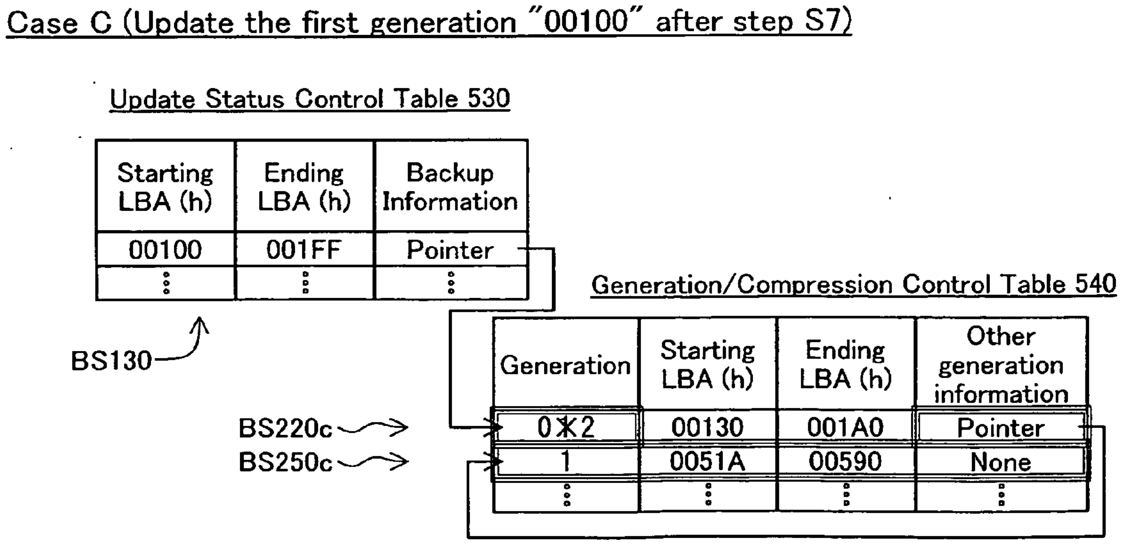
Update Status Control Table 530

Starting LBA (h)	Ending LBA (h)	Backup Information
00300	003FF	Pointer
⋮	⋮	⋮

Generation/Compression Control Table 540

Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
2	00310	003A5	None
⋮	⋮	⋮	⋮

Fig.23


Case C (Update the first generation "00100" after step S7)
Update Status Control Table 530
Generation/Compression Control Table 540
BS130
BS220c
BS250c

Update Status Control Table 530

Starting LBA (h)	Ending LBA (h)	Backup Information
00100	001FF	Pointer
⋮	⋮	⋮

Generation/Compression Control Table 540

Generation	Starting LBA (h)	Ending LBA (h)	Other generation information
0＊2	00130	001A0	Pointer
1	0051A	00590	None
⋮	⋮	⋮	⋮

Fig.24

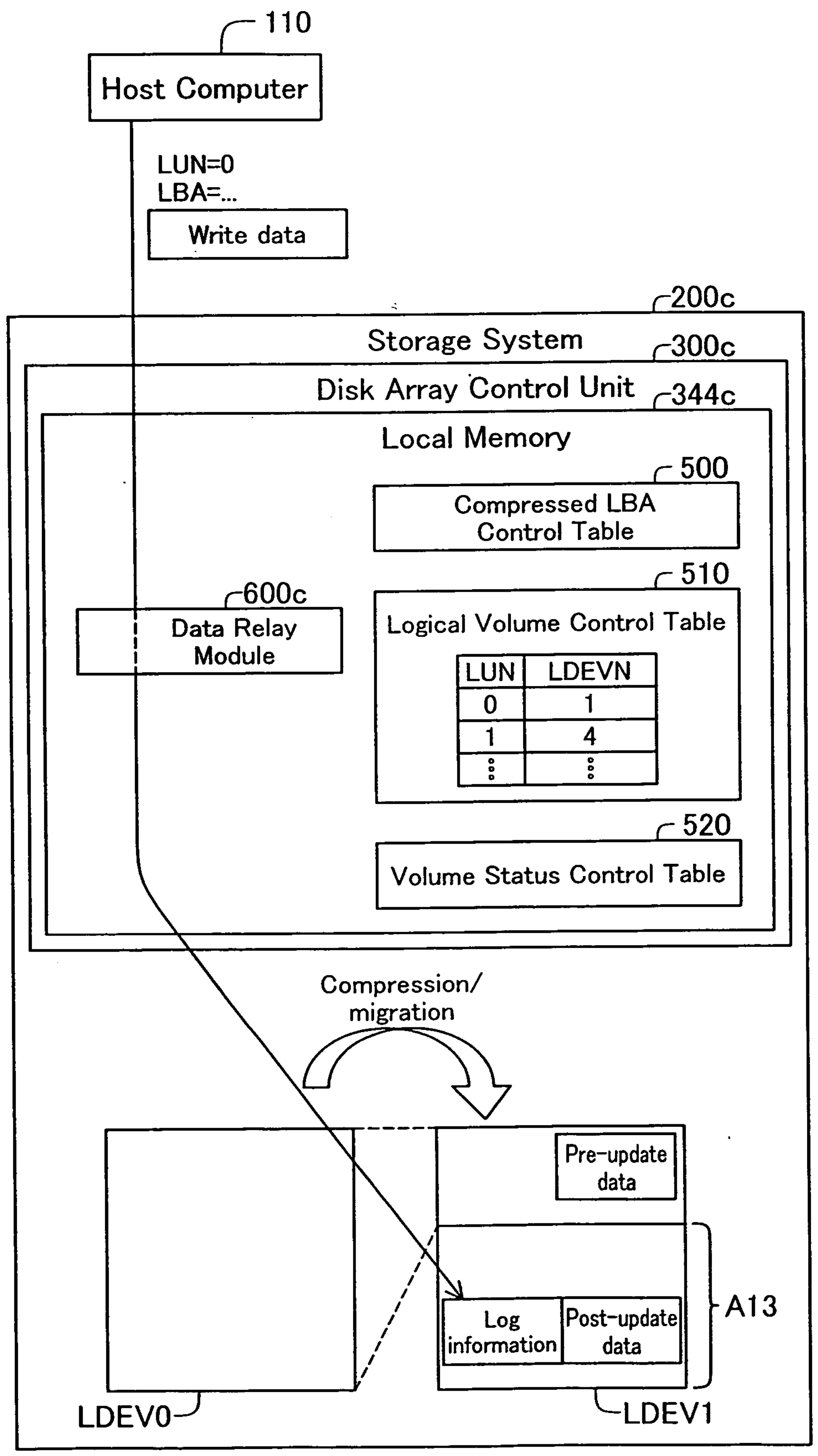
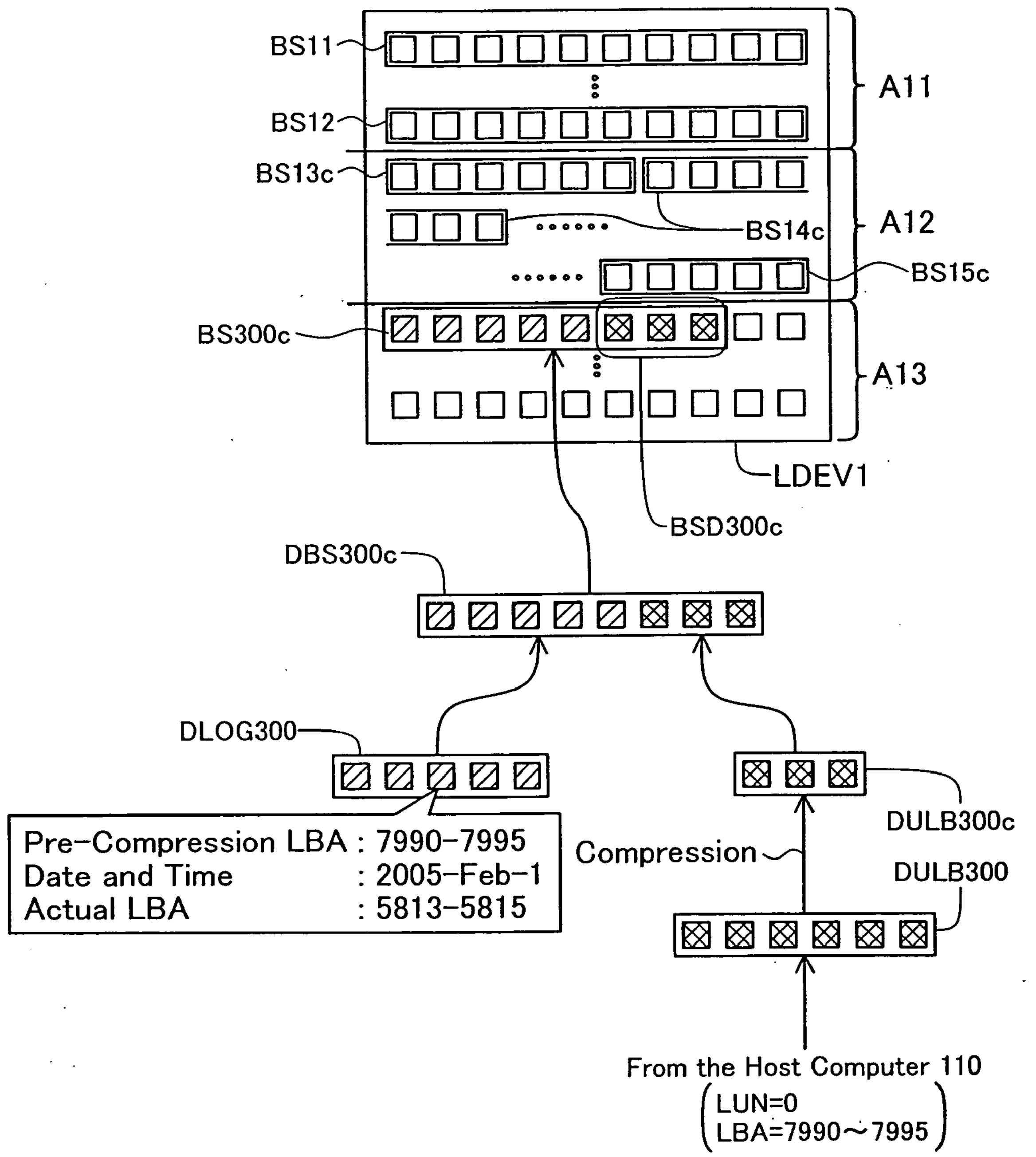

110
Host Computer
LUN=0
LBA=...
Write data
200c
Storage System
300c
Disk Array Control Unit
344c
Local Memory
500
Compressed LBA Control Table
510
Logical Volume Control Table
LUN
LDEVN
0
1
1
4
600c
Data Relay Module
520
Volume Status Control Table
Compression/ migration
Pre-update data
Log information
Post-update data
A13
LDEV0
LDEV1

Fig.25


BS11
BS12
A11
BS13c
BS14c
A12
BS15c
BS300c
A13
LDEV1
BSD300c
DBS300c
DLOG300
DULB300c
Compression
DULB300
Pre-Compression LBA : 7990-7995
Date and Time : 2005-Feb-1
Actual LBA : 5813-5815
From the Host Computer 110
LUN=0
LBA=7990～7995

STORAGE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the priority based on Japanese Patent Application No. 2005-74375 filed on Mar. 16, 2005, the disclosure of which is hereby incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to storage systems that provide data storage areas to host computers.

[0004] 2. Description of the Related Art

[0005] In recent years storage systems that provide data storage areas to host computers have become more common. When this type of storage system is used, the host computer does not merely store the application data to the storage system. But rather the host computer additionally performs a variety of data processes. For example, the host computer additionally performs compressing the data, storing the compressed data to the storage system, and controlling the compressed data. In another example, the host computer performs storing backup data to the storage system, and controlling the backup data that has been stored. (See, for example, U.S. Pat. No. 5,649,152, U.S. Pat. No. 5,555,389, and JP7-72981A.)

[0006] However, sometimes performing these processes increases the load on the host computer. In particular, when compressing data files for storage or controlling the locations of the compressed data, the increase in the overhead on the host computer has been remarkable.

[0007] Note that this type of problem is not limited to cases wherein data compression processes are performed, but rather the problem is the same in cases wherein, for example, data encryption processes are performed, or when data processes are performed when the size of the data itself is changed.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide a technology to reduce the overhead on the host computer through the use of a storage system that stores data after data processing that changes the size of the data.

[0009] In an aspect of the present invention, there is provided a storage system for providing a storage area that stores data to a host computer. The storage system has a data storage unit having a storage area for storing data, and a control unit configured to control data transfer between the host computer and the storage area. The control unit performs: receiving data from and sending data to the host computer according to a logical storage location expressed in units of first blocks of a specific size, the logical storage location being specified by the host computer; and storing data to and reading data from the storage area in units of second blocks of a specific size. And the control unit has a conversion storage mode for performing a data conversion process on data of interest for each first block set in the data-of interest to generate a second block set corresponding to each first block set, and storing the second block set in the storage area, the data conversion process changing size of the data of interest, the first block set including N first blocks where N is an integer greater than or equal to 1, the second block set including one or more second blocks. And wherein the storage system further has a correspondence relationship memory unit configured to store a block correspondence relationship that indicates correspondence relationship between a plurality of the first block sets and a plurality of the second block sets. When the control unit has received a data read request for a specific first block from the host computer, the control unit executes: referencing the block correspondence relationship to identify a second block set to be read associated with a particular first block set that includes the requested first block; reading out the second block set to be read; performing a reverse conversion process of the data conversion process on the readout second block set; and sending data of the requested first block to the host computer.

[0010] Given this storage system, the correspondence relationship memory unit stores the block correspondence relationships that indicate the correspondence relationships of the block sets before and after the data conversion processing, and the control unit, in response to a read request from the host computer, references the block correspondence relationships to read out the data from after the conversion processing from the storage area, and performs the reverse conversion process for the data that has been read out, and sends the requested data to the host computer, using the data that has been obtained, thus making it possible to reduce the load on the host computer through the use of a storage system that stores the data after the data processing that changes the size of the data itself has been performed.

[0011] Note that the present invention may be implemented in a variety of forms; for example, embodied in the form of a method and a device that provide a storage area, embodied in the form of a computer program for executing the functions of such method and device, embodied in the form of a recording medium on which is recorded this computer program, or embodied in a form of a data signal embodied in a carrier wave that includes this computer programs.

[0012] These and other objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a drawing of the structure of a storage system as a first embodiment according to the present invention;

[0014] **FIG. 2** is a schematic diagram showing the internal structure of a local memory **344**;

[0015] **FIG. 3** is a figure showing one example of a set up screen displayed on a control terminal **120**;

[0016] **FIG. 4** is a drawing showing the overview of the compression/migration process;

[0017] **FIG. 5** is a flowchart showing the procedures for the compression/migration process;

[0018] FIGS. **6**(A)-**6**(C) are drawings showing one example of tables **500**, **510**, and **520**;

[0019] **FIG. 7** is a flowchart showing the procedures for the data read process for the storage system **200**;

[0020] **FIG. 8** is a drawing showing an overview of the read process;

[0021] **FIG. 9** is a flow chart showing the procedures for the data write process for the storage system **200**;

[0022] **FIG. 10** is a drawing showing an overview of the write process;

[0023] **FIG. 11** is a drawing showing one example of the post-update compressed LBA control table **500**;

[0024] **FIG. 12** is a flowchart showing the procedures for the compression restore process;

[0025] **FIG. 13** is a drawing showing the structure of the storage system **200***b* in a second embodiment;

[0026] **FIG. 14** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540**;

[0027] **FIG. 15** is a flowchart showing the procedures for the data write process;

[0028] **FIG. 16** is a drawing showing an overview of the write process in Step S**2**;

[0029] **FIG. 17** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in the write process in Step S**2**;

[0030] **FIG. 18** is a drawing showing an overview of the write process in Step S**5**;

[0031] **FIG. 19** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in the write process in Step S**5**;

[0032] **FIG. 20** is a flowchart showing the procedures for the write process for data to past generation;

[0033] **FIG. 21** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case A;

[0034] **FIG. 22** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case B;

[0035] **FIG. 23** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case C;

[0036] **FIG. 24** is a drawing showing the structure of a storage system **200***c* in a third embodiment; and

[0037] **FIG. 25** is a drawing showing an overview of the write process in the third embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0038] Next, embodiments of the present invention will be explained based on examples in the following sequence:

A. First embodiment

B. Second embodiment

C. Third embodiment

D. Variants

A. First Embodiment

A1. Structure of the Device

[0039] **FIG. 1** is a drawing showing the structure of a storage system as a first embodiment according to the present invention. This storage system **200** has a host interface **210**, a control interface **220**, a disk interface **230**, a disk array control unit **300** connected to each of the interfaces **210**, **220**, and **230**, and a disk array **250** that is connected to the disk interface **230**. The disk array **250** has a plurality of disk devices.

[0040] The host interface **210** is connected to a host computer **110**. This host computer **110** uses the data storage area provided by the storage system **200**, and achieves specific functions. As functions of the host computer **110**, there are, for example, functions as a file server to provide data files to a client device (not shown), and functions as a database server to control a variety of data.

[0041] The control interface **220** is connected to a control terminal **120**. An administrator (operator) of the storage system **200** can control operational settings of the storage system **200** by operating this control terminal **120**.

[0042] The disk array control unit **300** has a CPU **310**, a data compression circuit **320**, a data decompression circuit **330**, and a memory unit **340**. All of the structural elements are connected to each other through a bus **390**. Moreover, the memory unit **340** has a cache memory **342** and a local memory **344**. The cache memory **342** stores, temporarily, the data that is sent between the disk array **250** and the host computer **110**. Moreover, the local memory **344** stores the data and programs used when the CPU **310** performs a variety of data processes (described below).

[0043] **FIG. 2** is a schematic diagram showing the internal structure of the local memory **344**. The local memory **344** has a compressed LBA control table **500**, a logical volume control table **310**, a volume status control table **520**, and a data relay module **600**. The data relay module **600** has a function that relays data transmissions between the host computer **110** and the disk array **250** (described in detail below). The functions of the data relay module **600** are achieved by a computer program executed by the CPU **310** (**FIG. 1**).

[0044] Moreover, the data relay module **600** configures a RAID (Redundant Array of Inexpensive Disks) system that uses the disk array **250**. In **FIG. 2**, the data relay module **600** forms five logical volumes LDEV**0** through LDEV**4** by configuring a RAID system.

[0045] Here a logical volume is a data storage area that includes a plurality of logical blocks. A logical block is the smallest unit for data transmission to or from the logical volume. In the first embodiment, the data sizes in the logical blocks are identical for each of the logical volumes LDEV**0** through LDEV**4**. A logical block within one logical volume is identified by a unique logical block address (hereinafter termed "LBA") for each of the logical blocks. In the first embodiment, serial numbers, starting with "0" are used for the LBAs. The data relay module **600** specifies a logical block to be accessed by using the LBA. In the below, a logical volume may be referred to as a "logical device," or simple a "volume." Moreover, a logical block may be referred to simply as a "block." Moreover, the data relay module **600**, in order to identify each of the logical volumes, assigns a unique number (hereinafter termed the "LDEVN") to each of the logical volumes (logical devices). In **FIG. 2**, each of the five logical volumes are assigned numbers 0 through 4, respectively.

[**0046**] Moreover, the data relay module **600** selectively causes the logical volumes to be used by the host computer **110**. In **FIG. 2**, the data relay module **600** provides two logical volumes LDEV**0** and LDEV**4** to the host computer **110**. The logical volumes that can be used by the host computer **110** in this way are termed the "logical units." The data relay module **600** assigns a unique logical unit number (hereinafter termed "LUN") to each of the logical units. In the example shown in **FIG. 2**, the 0th logical volume LDVE**0** is assigned "No. 0," and the fourth logical volume LDEV**4** is assigned "No. 1." This type of correspondence relationship between the LUNs and the LDEVNs is stored in the logical volume control table **510**.

[**0047**] In the first embodiment, the minimum unit for data transfer between the host computer **110** and the data relay module **600** is the logical block, which is the same as the minimum unit (the logical block) for data transfer between the data relay module **600** and the logical volume. The host computer **110** requests data transfer to/from a logical unit by specifying the LUN and the LBA. The data relay module **600** relays the data transfer for a logical volume according to a request from the host computer **110**. However, as will be explained below, in the first embodiment, the data to be stored in multiple logical blocks is gathered together, compressed, and stored in smaller logical blocks. Consequently, there are cases wherein the LBA specified by the host computer **110** will be different from the LBA of the actual logical block that is used in the data transfer. In this way, the correspondence relationship between the specified LBA and the actual LBA is stored in the compressed LBA control table **500** (explained in detail below). The LBA specified by the host computer **110** is called the "specified LBA."

A2. Compression Process

[**0048**] **FIG. 3** is an explanatory figure showing one example of a setup screen displayed on a control terminal **120**. This setup screen is a setup screen for performing the compression/migration of the logical volume. "Compression/migration" refers to the process for compressing the data that has been stored on a logical volume, and then re-storing. In the first embodiment, all of the data for a first logical volume is compressed, and migrated to another logical volume. The operator, by operating the setup screen shown in **FIG. 3**, is able to select the logical volume that will be processed (the migration origin), the contents to be processed, and the processing algorithm. In **FIG. 3**, the "0th logical volume LDEV**0**" is selected. "Compression" is selected as the process to be performed at the time of migration, and "LHA" is selected as the algorithm for the compression process. "Encryption" may also be selected instead of "compression" as the process to be performed at the time migration, and described below. "ZIP" can also be selected instead of "LHA" as the algorithm for the compression process. When the operator activates the "OK" button, the disk array control unit **300** (**FIG. 1**) commences the compression/migration process. Note that the data relay module **600** selects automatically an empty logical volume to be the logical volume for the migration destination. In **FIG. 3**, the first logical volume LDEV**1** is selected as the migration destination. Note also that this selection may be made by the operator.

[**0049**] **FIG. 4** is a diagram showing an overview of the compression/migration process. **FIG. 4** shows the 0th logical volume LDEV**0** and the first logical volume LDEV**1**. Each of these logical volumes LDEV**0** and LDEV**1** has a plurality of logical blocks LB.

[**0050**] The 0th logical volume LDEV**0** is partitioned into a non-compressed area A**1** and a compressed area A**2**. These partitions are set up in advance. Moreover, the correspondence relationship between each of the logical blocks and each area is stored in advance in the local memory **344**. For example, when a file system is structured in a logical volume, the logical volume may be partitioned into a data area, wherein data files are stored, and a control area, wherein information for controlling the data files (such as the correspondence relationships between the file names and the LBAs) is stored. In such a case, the control area is set up in the non-compressed area A**1**, and the data area is set up in the compressed area A**2**. Typically the part of the area wherein is stored data that is accessed relatively frequently should be used as the non-compressed area A**1**, and the part of the area wherein is stored data that is accessed relatively infrequently should be used as the compressed area A**2**. Additionally, all areas of a logical volume may be used as compressed areas. Note that the operator may set up such areas.

[**0051**] **FIG. 5** is a flow chart showing the procedures for the compression/migration process. The data relay module **600** (**FIG. 2**) migrates data, in compression units, sequentially from the front (from the side wherein the LBA is the lowest). In the first embodiment, the compression unit is a block set comprising ten logical blocks with sequential LBAs. The logical volume LDEV**0** is partitioned into multiple block sets.

[**0052**] First the procedures will be explained for the case wherein data is migrated within the non-compressed area A**1**. In Step S**100**, the data relay module **600** reads out the data from one block set within the migration origin logical volume LDEV**0**. In the example shown at the top of **FIG. 4**, the data relay module **600** reads out the data DBS**1** from the first block set BS**1** within the non-compressed area A**1**.

[**0053**] In the next Step S**105**, the data relay module **600** determines whether or not the read origin block set is within the compressed area A**2**. In the example at the top of **FIG. 4**, the first block set BS**1** is in the non-compressed area A**1**. Consequently, the data relay module **600** moves to Step S**140**. In Step S**140**, the data relay module **600** stores as is the data that has been read out, storing this data to the migration destination logical volume LDEV**1**. Here the "stores as is" means that the contents of the data are stored without modification. At this time, the data relay module **600** selects the migration destination logical blocks sequentially from the front (from the side wherein the LBA is the lowest). In **FIG. 4**, the data DBS**1** is stored to the first block set BS**11**. Each block set BS**1** and BS**11** has the same number of logical blocks.

[**0054**] In the next step, S**120**, the data relay module **600** updates the compressed LBA control table **500**. **FIG. 6** (A) is a figure showing an example of the compressed LBA control table **500**. The compressed LBA control table **500** stores the correspondence relationships between the pairs of block sets before and after migration, and information regarding whether or not compression was performed at the time of migration. In the example in **FIG. 6** (A), the block set is specified by a combination of the starting LBA and the size (number of blocks). The data relay module **600** stores in the compressed LBA control table **500** the correspondence relationship between the first block set BS**1** prior to migration and the first block set BS**11** after migration. In **FIG. 6** (A), the starting LBA for the first block set BS**1** is "0000," and the size is "10." The starting LBA is "0000" for the block set BS**11** after migration as well, and the size is also "10."

[**0055**] Note that the information stored in the compressed LBA control table **500** is not limited to combinations of starting LBAs and sizes, but rather can also use any given information that can be used for specifying the block set. For example, combinations of the starting LBAs and the ending LBAs may be used instead.

[**0056**] In the next step, S**125**, the data relay module **600** determines whether or not migration has been completed for all of the data. If not completed, then the data relay module **600** returns to Step S**100**.

[**0057**] Next, the procedure will be explained for the case when data is migrated within the compressed area A**2**. In the example at the bottom of **FIG. 4**, the data relay module **600** reads out the data DBS**5** from the 5th block set BS**5** in the compressed area A**2** (Step S**100**).

[**0058**] Once Step S**100** has been completed, the data relay module **600** moves to Step S**105**. Because the 5th block set BS**5** is within the compressed area A**2**, the data relay module **600** moves to Step S**110**.

[**0059**] In Step S**110**, the data relay module **600** compresses the read out data in the data compression circuit **320** (**FIG. 1**). At this time, the algorithm set in the set up screen in **FIG. 3** is used. In **FIG. 4**, the data compression circuit **320** generates the data DBS**15***c* through compressing the data DBS**5**. The size of the data DBS**15***c* after compression is five blocks.

[**0060**] In the next step, S**115**, the data relay module **600** stores the post-compression data into the migration destination logical volume LDEV**1**. At this time, the data relay module **600** selects the migration destination blocks sequentially from the front (the side wherein the LBA is the smallest). In **FIG. 4**, the data DBS**15***c* is stored in the 5th block set BS**15***c*. The size of this block set BS**15***c* is five blocks.

[**0061**] In the next step, S**120**, the data relay module **600** stores into the compressed LBA control table **500** the correspondence relationship between the pre-migration and post-migration block sets BS**5** and BS**15***c*. In **FIG. 6** (A), the starting LBA for the pre-migration 5th block set BS**5** is "7990," and the size is "10." For the post-migration 5th block set BS**15***c*, the starting LBA is "5808," and the size is "5."

[**0062**] The same migration process is performed for the other block sets as well. In **FIG. 4**, the second block set BS**2** is migrated to the second block set BS**12**, and the third block set BS**3**, after compression, is migrated to the third block set BS**13***c*, and the 4th block set BS**4**, after compression, is migrated to the 4th block set BS**14***c*. Note that although, in **FIG. 5**, the series of processes from Step S**100** to Step S**125** are performed for each individual block set, but instead, this series of processes can be performed for each plurality of block sets.

[**0063**] Once the migration has been completed in this way for all of the data, then, in the next step, S**130**, the data relay module **600** updates the volume status control table **520**. **FIG. 6** (B) is a diagram showing an example of a volume status control table **520**. The volume status control table **520** stores the correspondence relationships of the LDEVNs, whether or not the data is compressed, whether or not the data is encrypted, and the algorithm used. The data relay module **600** stores, as information regarding the migration destination logical volume LDEV**1**, "Compression: enabled, ""Encryption: disabled," and "Algorithm: LHA."

[**0064**] In the next step, S**135**, the data relay module **600** updates the logical volume control table **510**. **FIG. 6** (C) is a drawing showing an example of a logical volume control table **510**. The data relay module **600** updates the LDEVN corresponding to the 0th logical unit LU**0** from "0" to "1."

[**0065**] Once the processes described above have been completed, then the disk array control unit **300** terminates the compression/migration process. The result is that a non-compressed area A**11**, a compressed area A**12** and an open area A**13** are formed in the migration destination logical volume LDEV**1**.

A3. Read Process

[**0066**] **FIG. 7** is a flowchart showing the procedures for the process for reading data from the storage system **200**. As described above, a LUN and a LBA are specified by the host computer **110** to the storage system **200** to request that the data be read. The explanation below will assume that the first logical volume LDEV**1** (LUN=0) has been specified.

[**0067**] **FIG. 8** is a drawing showing an overview of the read process. In **FIG. 8**, the top shows the case of reading data from the non-compressed area A**11**, and the bottom shows the case of reading data from the compressed area A**12**.

[**0068**] The procedure in the case of reading data from the non-compressed area A**11** will be explained first. In Step S**200** (**FIG. 7**) the data relay module **600** looks up from the compressed LBA control table **500** (**FIG. 6** (A)) the combination of pre-migration block set and post-migration block set that includes the specified logical block. In the example at the top of **FIG. 8**, the specified LBAs are "0005" through "0009." In this case, a combination of the first block set BS**1** and the first block set BS**11** is looked up.

[**0069**] In the next step, S**205**, the data relay module **600** determines whether or not the looked up block set has been subjected to a compression process. This determination is performed by referencing the compressed LBA control table **500**. In the example at the top of **FIG. 8**, the decision is "no."

[**0070**] In the next step, S**240**, the data relay module **600** reads the data from the post-migration block set looked up in Step S**200**, within the first logical volume LDEV**1**. In the example at the top of **FIG. 8**, the data DBS**1** is read from the first block set BS**11**.

[0071] In the next step, S**230**, the data relay module **600** obtains, from the data that has been read, the data associated with the specified LBA, and transfers this data to the host computer **110**. In the example at the top of **FIG. 8**, from the 10 blocks worth of data included in data DBS**1**, the 5th through 9th blocks are the data for the logical blocks for "LBA=0005" through "LBA=0009."

[0072] In the next step, S**235**, the data relay module **600** determines whether or not the transfer of data has been completed for all of the specified LBAs. If not complete, then the data relay module **600** returns to the Step S**200**, and iterates the series of steps from S**200** through S**230** for the specified LBAs for which data transfer has not yet been completed. This series of processes is performed for each individual block set. However, this series of processes may be performed for each plurality of block sets instead.

[0073] The procedures will be explained next for the case wherein data is read from the compressed area A**12**. The bottom part of **FIG. 8** shows the case wherein the specified LBAs are "7990" through "7994." In this case, the data relay module **600** looks up the combination of the 5th block set BS**5** and the 5th block set BS**15***c* in Step **200**. (**FIG. 6** (A))

[0074] Once Step S**200** has been completed, the data relay module **600** moves to the next step, S**205**. In the example at the bottom of **FIG. 8**, the decision is "yes."

[0075] In the next step, S**210**, the data relay module **600** reads the data from the post-migration block set specified in Step S**200**. In the example at the bottom of **FIG. 8**, data DBS**15***c* is read from the 5th block set BS**15***c* associated with the 5th block set BS**5**.

[0076] Note that the pre-migration 5th block set BS**5** that includes the specified LBAs corresponds to the "first block set" in the present invention. Moreover, the post-migration 5th block set BS**15***c* corresponds to the "second block set" in the present invention. Moreover, the LUN, pre-compression starting LBA, and pre-compression size, as a whole, correspond to information indicating the "first block set logical storage location" in the present invention. In addition, the LDEVN, the post-compression starting LBA, and post-compression size, as a whole, correspond to the information indicating the "second block set physical storage location" in the present invention.

[0077] In the next step, S**225**, the data relay module **600** decompresses, in the data decompression circuit **330** (**FIG. 1**), the data that has been read. This decompression process is the reverse conversion process of the compression process that had been performed by the data compression circuit **320**. The data decompression circuit **330** references the volume status control table **520** (**FIG. 6** (B)) to select a decompression process with the appropriate algorithm. In the example at the bottom of **FIG. 8**, the data decompression circuit **330** produces data DBS**5** through decompressing the data DBS**15***c*.

[0078] In the next step, S**230**, the data relay module **600** obtains, from this data that has been generated, the data associated with the specified LBAs, and transfers this data to the host computer **110**. In the example at the bottom of **FIG. 8**, of the 10 blocks of data included in the data DBS**5**, the data for the 0th to 4th blocks are the data for each block from "LBA=7990" through "LBA=7994."

[0079] When all of the data for the specified LBAs has been transferred in this way, the disk array control unit **300** terminates the data read process.

[0080] In the read process, described above, the storage system **200** has a compressed LBA control table **500**, and the data relay module **600** reads and decompresses the data by referencing this compressed LBA control table **500**, and sends to the host computer **110** the data for the requested logical blocks. Consequently, even when data is compressed and stored in the storage system **200**, the host computer **110** controls neither the decompression process nor the compressed data, and can read data through the specification of the pre-compression LBA.

A4. Write Process:

[0081] **FIG. 9** is a flow chart showing the procedures for the process of writing data to the storage system **200**. As with the read process, the host computer **110** specifies the LUN and the LBA to the storage system **200** in order to request that data be written. The explanation below will assume that the first logical volume LDEV**1** (LUN=0) is specified.

[0082] **FIG. 10** is a drawing showing an overview of the write process. **FIG. 10** shows an overview of the process in the case of writing data to the compressed area A**12**. First, in Step S**300** (**FIG. 9**), the data relay module **600** determines whether or not the specified LBAs include all of the logical blocks in a single compressed unit (block set). This decision is made by referencing the compressed LBA control table **500** (**FIG. 6** (A)). **FIG. 10** shows the case where the specified LBAs are from "7990" through "7995." The specified blocks are the logical blocks for only a portion (6 logical blocks) of the 5th block set BS**5**. As a result, in this case, the data relay module **600** decides "no."

[0083] Note that the specified LBAs may contain blocks from a plurality of compressed unit (block sets). In such a case, the data relay module **600** performs the series of processes, for each block set, following Step S**300** (explained below).

[0084] In each Step S**305**, the data relay module **600** references the compressed LBA control table **500** (**FIG. 6** (A)) to look up the combination of pre-migration block set and post-migration block set that includes the specified logical blocks. This process is the same as the process in Step S**200** in **FIG. 7**. In **FIG. 10**, the combination of the 5th block set BS**5** and the 5th block set BS**15***c* is looked up.

[0085] In the next step, S**310**, the data relay module **600** reads the data from the post-migration block set looked up in Step S**305**. In **FIG. 10**, the data DBS**15***c* is read from the 5th block set BS**15***c*.

[0086] In the next step S**315**, the data relay module **600** decompresses, in data decompression circuit **330** (**FIG. 1**), the data that has been read. This process is the same as in Step S**225** in **FIG. 7**. In **FIG. 10**, the data compression circuit **330** generates the data DBS**5** through decompressing the data DBS**15***c*. The data that is generated in this way is used as the pre-update data for the block set to be updated.

[0087] In the next step S**320**, the data relay module **600** overwrites the pre-update data with the data for which the host computer **110** has requested writing, thereby generating the data to be written to the compressed unit. In **FIG. 10**, the data relay module **600** generates the post-update data DBS**5***u* by overwriting the data in the 0th through 5th block of the pre-update data DBS**5** with the update data DULB obtained from the host computer **110**.

[**0088**] In the next step S**325**, the data relay module **600** compresses the post-update data in the data compression circuit **320** (**FIG. 1**). This process is the same as the process in Step S**110** in **FIG. 5**. In **FIG. 10**, the data compression circuit **320** generates the post-compression data DBS**15***uc* by compressing the post-update data DBS**5***u*. The size of this new post-compression data DBS**15***uc* is six blocks.

[**0089**] Note that the processes in Steps S**305** through S**320** are omitted if updating the data in all of the blocks in a single compressed unit (block set). In this case, the single-block set worth of data requested to be written is compressed as post-update data.

[**0090**] In the next step, S**330**, the data relay module **600** stores the post-compression data to an open area A**13** of the first logical volume LDEV**1**. In this case, the data relay module **600** selects the storage destination logical blocks sequentially from the front (the side where the LBA is the smallest). In **FIG. 10**, the data DBS**15***uc* is stored in the 5th block set BS**15***uc*.

[**0091**] In this step S**330**, the data relay module **600** selects a logical block in an unused area of the open area A**13**. Any given method may be used for the method of discriminating between the used area and the unused area of the open area A**13**. For example, a method can be employed, in which the data relay module **600** stores in the local memory **344** an LBA that indicates the boundary between the used area and the unused area, and performs referencing and updating the LBA as appropriate.

[**0092**] In the next step, S**335**, the data relay module **600** updates the compressed LBA control table **500**. **FIG. 11** is a drawing showing an example of a post-update compressed LBA control table **500**. The data relay module **600** updates the information for the post-migration block set associated with the 5th block set BS**5**, doing so from the old 5th block set BS**15***c* to the new 5th block set BS**15***uc*. In **FIG. 11**, the starting LBA is "5813," and the size is "6." When, after this, the data relay module **600** receives a read request for the 5th block set BS**5**, the data is read from the new 5th block set BS**15***uc*. After this point, the data in the old 5th block set BS**15***c* is not used.

[**0093**] In the next step, S**340**, the data relay module **600** determines whether or not the write process has been completed for all of the specified LBAs. If not complete, the data relay module **600** returns to Step S**300**, and repeats the series of processes from Step S**300** through Step S**335** for those specified LBAs for which the writing has not been completed. This series of processes is repeated for each individual block set. But instead, this series of processes may be performed for each plurality of block sets.

[**0094**] Once writing has been completed for the data for all of the specified LBAs in this way, then in the next step, S**345**, the data relay module **600** sends to the host computer **110** a notification that the writing of the data has been completed.

[**0095**] In the write processes described above, the data relay module **600** compresses and stores data when the data relay module **600** has received a data write request from the host computer **110**, and also write, to the compressed LBA control table **500**, a new correspondence relationship between the pre-compression and post-compressing (pre-migration and post-migration) block sets. Consequently, even when the storage system **200** compresses and stores the data, the host computer **110** can write the data through specifying the pre-compression LBAs without performing the compression process and without controlling the compressed data.

[**0096**] Moreover, when there is not a request to update all of the blocks in the pre-compression block set that includes the specified LBAs, the data relay module **600** overwrite the pre-update data within the block set with the requested data to perform the compression process using the block set as the unit. This makes it possible to prevent the control of the post-compression data from becoming excessively complex.

[**0097**] Note that the post-update post-compression data may be stored in a logical volume that is different from the logical volume in which the pre-update post-compression data was stored. Doing so makes it possible to write the post-update data to a logical volume that has a recording area larger than the open area A**13**, and makes it possible to accommodate the updating of large amounts of data. In such a case, the LDEVN that includes the post-migration block set may be added to the correspondence relationships for the pre-compression and post-compression (pre-migration and post-migration) block sets in the compressed LBA control **500** (**FIG. 6** (A)).

[**0098**] Moreover, if the post-update compressed data is smaller than the pre-update compressed data, then the post-update compressed data may be stored in the logical block wherein the pre-update compressed data had been stored. Doing so makes it possible to increase the efficiency with which the logical blocks are used.

A5. Compression Restore Process

[**0099**] **FIG. 12** is a flowchart for the procedures for the compression restore processes. The "compression restore processes" are the processes that decompress and re-store the compressed data stored in a logical volume. In the first embodiment, a single logical volume's worth of data is migrated to another logical volume while decompressing. The compression restore process is performed by the disk array control unit **300** following instructions from the control terminal **120** (**FIG. 1**). In the below, the explanation will be of migrating a first logical volume LDEV**1** to a second logical volume LDEV**2**. Note that, for the decompression destination (the migration destination) logical volume, the data relay module **600** automatically selects from among the open logical volumes. Note that this selection may instead be done by an operator.

[**0100**] The disk array control unit **300** reads out data for each block set and further decompresses the read-out data as appropriate, in the same manner as the read process shown in **FIG. 7**. However, there are three differences from the read process in **FIG. 7**. The first difference is that a single logical volume's worth of data is read, instead of the data specified by the host computer **110**. The second difference is that a process is performed (in Step S**250**) to write to the decompression-destination (migration-destination) logical volume instead of a process to transfer the read-out data to the host computer **11** (**FIG. 7**: Step S**230**). The third difference is that, when the migration has been completed, the volume status control table **520** (**FIG. 6** (B)) and the logical volume control table **510** (**FIG. 6** (C)) are updated (in Steps S**260** and S**265**).

[**0101**] The processes from Steps S**200** through S**250** are the same as the read processes in **FIG. 7**.

[**0102**] In Step **250**, the data relay module **600** stores the read data in the decompression-destination (migration-destination) logical volume. In the first embodiment, the data relay module **600** selects the decompression-destination logical blocks so that the decompression-destination logical block LBA is the same as the pre-compression logical block LBA.

[**0103**] In the next step, S**255**, the data relay module **600** determines whether or not data migration has been completed for all of the pre-compression LBAs. If not complete, then the data relay module **600** returns to Step S**200**, and repeats the processes in the series of steps from S**200** through S**250** for the block sets for which data transfer is not complete. This series of processes is performed for each single block set. However, this series of processes may be performed for each plurality of block sets.

[**0104**] After the data transfer has been completed, then in the next step, S**260**, the data relay module **600** updates the information regarding the decompression-destination logical volume in the volume status control table **520** (**FIG. 6** (B)). For example, "Compression: Disabled,""Encryption: Disabled," and "Algorithm: None," are set for the decompression-destination second logical volume LDEV**2**.

[**0105**] In the next step, S**265**, the data relay module **600** switches the LDEVN in the logical volume control table **510**. For example, the data relay module **600** changes the LDEVN corresponding to the 0th logical unit LU**0** from "1" to "2." Note that the switching of the LDEVN may be performed with timing according to an instruction from the control terminal **120**.

[**0106**] After this, when the data relay module **600** receives a data transfer request (such as a read request or a write request) for the 0th logical unit LU**0**, the data transfer is performed regarding the new second logical volume LDEV**2**. At this time, the specified LBA (the pre-compression LBA) is used as is for the LBA for the logical volume.

[**0107**] In the compression restore process described above, the disk array control unit **300** performs the data decompression without placing an additional load on the host computer **110**. Moreover, the data relay module **600** selects logical blocks for storing the post-decompression data so that the pre-compression LBAs are the same as the decompression-destination LBAs. Consequently, even when the storage system **200** has decompressed the compressed data, the host computer **110** is able to perform data transfer requests through specifying the pre-compression LBAs, without having to control the decompression process or the decompressed data.

[**0108**] Note that it is not necessary for the LBAs for the decompression-destination logical blocks to match the LBAs of the pre-compression logical blocks. In this case, the correspondence relationships between the pre-compression LBAs and the post-decompression LBAs should be stored in the storage system **200**. Doing so makes it possible to have appropriate data transfer, through referencing these types of correspondence relationships when the data relay module **600** receives a data transfer request.

[**0109**] Given the first embodiment, explained above, the disk array control unit **300** (**FIG. 1**) performs the compression/migration process independently from the host computer **110**, making it possible to economize the storage area without putting an additional load on the host computer **110**.

[**0110**] Moreover, in the first embodiment, the logical volume data is split between multiple block sets and compressed. Consequently, when compared to the case wherein the entire logical volume is compressed as a single data, it is possible for the speed of the data transfer process on partial areas of the logical volume to prevent excessive delays.

[**0111**] Furthermore, in the first embodiment, the storage system **200** not only stores control data regarding the correspondence relationships of the pre-compression and post-compression block sets (the compressed LBA control table **500**, the logical volume control table **510**, and the volume status control table **520**), but also performs data compression and decompression, and updating of control data, independently from the host computer **110**. Consequently, it is possible to perform the data compression and decompression without placing an additional load on the host computer **110**.

[**0112**] In particular, in the first embodiment, the storage system **200** has a compressed LBA control table **500** that stores the correspondence relationship between the LBA specified by the host computer **110** (the pre-compression LBA) and the actual LBA (the post-compression LBA). As a result, the disk array control unit **300** is able to receive a data transfer request that specified the pre-compression LBA from the host computer **110** in a consistent manner regardless of the data compression status (i.e., regardless of whether or not the data is compressed, and regardless of whether or not there have been changes in the LBAs in the blocks wherein the data is stored). In other words, the disk array control unit **300** can hide the data compression status from the host computer **110**. This makes it possible for the host computer **110** to request a data transfer using a specific pre-compression LBA without having to control the data compression status.

[**0113**] In addition, even when the data that is stored in the storage system **200** is shared by a plurality of host computers, each computer is able to perform data transfer requests using the shared pre-compression LBA regardless of the data compression status. In this way, the storage system **200** in the first embodiment makes it possible to provide storage areas without constraining the host computers, regardless of the data compression status. This ability to operate without constraints on the host computers will be termed "host transparent," below.

[**0114**] Note that in the first embodiment, the compressed LBA control table **500** and the logical volume control table **510**, as a whole, correspond to the "block correspondence relationships" in the present invention.

B. Second Embodiment

[**0115**] **FIG. 13** is a drawing showing the structure of a storage system **200***b* in a second embodiment. The differences from the storage system **200** shown in **FIG. 1** are in that the data relay module **600***b* not only stores a data update history, but also performs generation control of the update history. Moreover, the local memory **344***b* stores an update status control table **530** and a generation/compression control table **540** instead of the compressed LBA control table **500**. These tables **530** and **540** are used in generation control. The other structures are the same as in the storage system **200** of **FIG. 1** and **FIG. 2**. Note that in **FIG. 13**, only the local memory **344***b* of the disk array control unit **300***b* is shown as a structural element of the storage system **200***b*, and the other structural elements are omitted in the drawings.

[0116] In the second embodiment, the 0th logical unit LU**0** is assigned as corresponding to the 0th logical volume LDEV**0** (**FIG. 13**: Logical volume control table **510**). Moreover, the data of the 0th logical volume LDEV**0** is not compressed. Given this, the data relay module **600***b* uses the specified LBA as is as the LBA corresponding to the 0th logical volume LDEV**0**.

[0117] Moreover, the data relay module **600***b* holds the update history of the data in the 0th logical volume LDEV**0**, and performs generation control on the update history. This makes it possible to provide to the host computer **110** not just the most recent data, but also data for the 0th logical volume LDEV**0** from some point in the past. This data backup for some point in the past is called a "point-in-time copy" or a "snapshot(trademark of Network Appliance, Inc.)."

[0118] The data relay module **600***b* receives an instruction, from the host computer **110**, from the control terminal **120**, etc. to create a "point-in-time copy." In response, the data relay module **600***b* stores backup data to make it possible to provide, later, the data of any given logical block from the point in time at which the instruction was received (hereinafter termed "point in time of the instruction"). At this time, the data relay module **600***b* stores the pre-update data of only those partial areas that are updated after the point in time of the instruction as the backup data. A process that copies only the updated part (the modified part) is known as "copy-on-write." Note that the data relay module **600***b* stores the backup data into a first logical volume LDEV**1** that is different from the origin 0th logical volume LDEV**0**. At this time, the backup data is compressed and stored (as will be described in detail below).

B1. Write Process (Update Process):

[0119] **FIG. 14** is a drawing showing an update status control table **530** and a generation/compression control table **540**. These tables **530** and **540** are examples showing the case wherein data updating is performed following the procedures in Steps **S1** through S7 shown at the bottom of **FIG. 14**.

[0120] The update status control table **530** stores the correspondence relationships between the block sets in the 0th logical volume LDEV**0** and whether or not there is backup data. In the second embodiment, the data relay module **600***b* partitions the 0th logical volume LDEV**0** into a plurality of block sets. Furthermore, the data relay module **600***b* performs storing and generation controlling of the update history by using the block set as the processing unit. In **FIG. 14**, the processing unit is the block set comprising 100 (hexadecimal) logical blocks with continuous LBAs. In the update status control table **530**, the block sets are identified by a combination of starting LBAs and ending LBAs. In **FIG. 14**, four block sets BS**100** through BS**130** are shown for illustration. On the other hand, a pointer that references information (described in detail below) that indicates the backup status of the pre-update data is used as the backup information. Pointers are not set up for block sets wherein the data has not been updated.

[0121] Note that the symbol "(h)" that is added to the LBA indicates that the LBA is written in hexadecimal notation. In the below, LBAs with the additional symbol "(h)" will indicate that the LBAs are written in hexadecimal notation, where LBAs without the additional symbol are written in decimal notation.

[0122] On the other hand, the generation/compression control table **540** stores the backup status of the pre-update data. Specifically, this table stores the correspondence relationships between the block sets that store the pre-update data, the generation numbers of the pre-update data, and the pointers that reference the information for pre-update data of other generations. The pointers that reference the information for other generations reference one other correspondence relationship in the generation/compression control table **540**. Moreover, the "pointer" in the update status control table **530**, described above, references one correspondence relationship within this generation/compression control table **540**. The "generation number" will be described below.

[0123] First, in the first step S**1**, the control terminal **120** sends to the disk array control unit **300***b* an instruction to create a point-in-time copy. This type of instruction is sent in response to an operation by the operator. Note that the disk array control unit **300***b* or the control terminal **120** may instead generate the instruction automatically with a timing that is set up in advance, or may generate the instruction automatically following some other set of conditions.

[0124] In the second embodiment, the disk array control unit **300***b* can generate multiple point-in-time copies at different points in time. The point-in-time copy is identified by a unique generation number for each individual point-in-time copy. In the second embodiment, serial numbers, beginning with "0" are used as the generation numbers. In **FIG. 14**, the data relay module **600***b* assigns "0" to the point-in-time copy indicated in Step S**1**. Note that the generation (point in time) corresponds to the "version" in the present invention.

[0125] Next, in Step S**2**, the host computer **110** requests that data be written to the storage system **200***b*. Here the specified LBAs are assumed to be "00000(h)" through "00050(h)."

[0126] **FIG. 15** is a flowchart showing the procedures for the data write process. In the first step, S**400**, the data relay module **600***b* determines whether or not a data backup is necessary. The writing to the block set that includes the specified LBAs (hereinafter termed the "specified block set") is determined to "require backup" when it is the first writing of the specified block set since the most recent specified point in time, or in other words, if no data has been written to the specified block set since the most recent specified point in time. The decision is "backup not required" if the data in the specified block set has already been backed up since the most recent specified point in time. In the write process in Step S2 (**FIG. 14**), the decision is "backup required."

[**0127**] Note that the specified LBAs may include blocks in a plurality of processing units (block sets). In such a case, the data relay module **600***b* performs a series of processes (described below) following Step S400 for each of the block sets.

[**0128**] In the next step, S**405** (**FIG. 15**), the data relay module **600***b* reads out the data from the specified block set within the 0th logical volume LDEV**0**. **FIG. 16** is a drawing showing an overview of the write process in Step S2 (**FIG. 14**). In **FIG. 16**, the data relay module **600***b* reads out the data DBS**200** from the first block set BS**100** including the specified LBAs. Here the data that is read out is pre-update data of the specified block set. Note that in **FIG. 16**, one square symbol SQ does not indicate one block, but rather the number of square symbols SQ provides a rough representation of the number of blocks.

[**0129**] In the next step, S**410** (**FIG. 15**), the data relay module **600***b* compresses, in the data compression circuit **320** (**FIG. 1**) the pre-update data that has been read out. In **FIG. 16**, the data compression circuit **320** generates post-compression pre-update data DBS**200***c* through compressing the pre-update data DBS**200**. The number of blocks in this post-compression data DBS**200***c* is less than the number of blocks in the pre-compression data DBS**200**.

[**0130**] In the next step, S**415**, the data relay module **600***b* stores the post-compression pre-update data into the first logical volume LDEV**1**. In **FIG. 16**, the post-compression pre-update data DBS**200***c* is stored into the first block set BS**200***c*.

[**0131**] In the next step, S**420**, the data relay module **600***b* adds, to the generation/compression control table **540**, information about the block set in which the pre-update data is stored. **FIG. 17** is a drawing showing the update status control table **540** and the generation/compression control table **540** in the write process in Step S2 (**FIG. 14**). Information regarding the first block set BS**200***c* is added to the generation/compression control table **540**. The generation is "0," the starting LBA is "00000(h)," and the ending LBA is "00050(h)," where the other generation information is "none." The fact that the "generation" is "0," is because the pre-update data DBS**200***c* is the 0th generation data.

[**0132**] In the next step, S**425**, the data relay module **600***b* updates the backup information for the update status control table **530**. According to **FIG. 17**, a pointer is added to the backup information for the first block set BS**100**. This pointer is data that references information regarding the first block set BS**200***c* in the generation/compression control table **540**.

[**0133**] In the next step, S**430**, the data relay module **600***b* determines whether or not the data backup process has been completed for all of the specified LBAs. If not complete, the data relay module **600***b* returns to Step S**400**, and repeats the procedures from Step S**400** through Step S**425** for the specified LBAs that have not been completed. Note that the data relay module **600***b* omits the processes from Steps S**405** through S**425**, not backing up the data, for block sets for which the decision is "backup not required" in Step S**400**.

[**0134**] In the next step, S**435**, the data relay module **600***b* writes to the logical volume the data requested by the host computer **110**. At this time, the specified LBAs are used as is. According to **FIG. 16**, the data relay module **600***b* writes the new data DUBL**100**, received from the host computer **110**, to the blocks of the specified LBAs (00000 through 00050(h)) of the 0th logical volume LDEV**0**. Note that the process of Step S**435** may be performed, instead, prior to Step S**430** after the completion of the data backup. For example, the writing of data to the block set may be performed each time the block set is backed up.

[**0135**] Once the writing of the data for all of the LBAs has been completed in this way, then, in the next step, S**440**, the data relay module **600***b* sends a notification to the host computer **110** that the data writing has been completed.

[**0136**] After this, in response to a read request from the host computer **110**, the data relay module **600***b* will send the newest data that is stored in the 0th logical volume LDEV**0**.

[**0137**] On the other hand, in response to a read request wherein the generation is specified, the data relay module **600***b* will reference the update status control table **530** and the generation/compression control table **540** to read data from the block set wherein is stored the data associated with the specified generation in order to send the requested data. For example, an explanation will be given regarding the transmission of data for a read request that specifies the 0th generation first block set BS**100**. The data relay module **600***b* first reads out the post-compression pre-update data DBS**200***c* from the 0th generation block set BS**200**. The data that has been read out is then decompressed in the data decompression circuits **330** (**FIG. 1**). At this time, the data decompression circuit **330** generates the pre-compression pre-update data DBS**200**. The data relay module **600***b* uses the pre-update data DBS**200** that has been generated to send the data for the specified LBAs to the host computer **110**. When there is no information regarding the specified generation in the generation/compression control table **540**, the data stored in the 0th logical volume LDEV**0** is sent as is.

[**0138**] Once Step S2 (**FIG. 14**) has been completed, then in the next step, S3, the control terminal **120** sends to the disk array control unit **300***b* a new instruction to generate a point-in-time copy. The generation number of this point-in-time copy will be "1." In the next step, S**4**, the control terminal **120** sends to the disk control unit **300***b* another instruction to create a point-in-time copy. The generation number of this point-in-time copy will be "2.")

[**0139**] In the next step, S5, the host computer **110** performs a data read request on the storage system **200***b*. Here the specified LBAs are "00000 through 00040(h)," where the specified block set is the first block set BS**100**, the same as in Step S1, described above.

[**0140**] **FIG. 18** is a drawing showing an overview of the write process in Step S**5**. The details of the write process are the same as in Step S2 according to **FIG. 16**. However, the data relay module **600***b* stores the pre-update data of the first block set BS**100** into an open second block set BS**210***c* that is different from the earlier block set BS**200***c*. Note that one square symbol SQ does not indicate one block, but rather the number of the square symbols SQ provides a rough representation of the number of blocks.

[**0141**] Specifically, the data relay module **600***b* reads out the pre-update data DBS**210** of the first block set BS**100** in

Step **405** (**FIG. 15**). In Step S**410**, the data compression circuit **320** (**FIG. 1**) compresses the pre-update data DBS**210** to generate the post-compression pre-update data DBS**210***c*. In Step S**415** the data relay module **600***b* stores the post-compression pre-update data DBS**210***c* into the second block set BS**210***c* of the first logical volume LDEV**1**. In Step S**435**, the data relay module **600***b* writes the new data DULB**110**, received from the host computer **110**, to the blocks of the specified LBAs of the 0th logical volume LDEV**0**. The result is that the two block sets BS**200***c* and BS**210***c* each store different generations of the past data for the first blocks set BS**100**.

[**0142**] **FIG. 19** is a figure showing an example of the update status control table **530** and the generation/compression control table **540** in the write process of Step S**5**. The difference from the example shown in **FIG. 17** is the addition of information regarding the second block set BS**210***c* to the generation/compression control table **540**. Regarding this second block set BS**210***c*, the generation is "1, 2" and the starting LBA is "00051(h)" and the ending LBA is "000BF(h)," and the generation information is "none." Moreover, a pointer to the other generation data of the first block set BS**200***c* is also added. This pointer references information regarding the second block set BS**210***c*.

[**0143**] In the next step, Step S**6** (**FIG. 14**) the host computer **110** performs a data write request on the storage system **200***b*. The data relay module **600***b* performs a write process following the flow chart in **FIG. 15**, in the same manner as in Steps S**2** and S**5**, described above. According to **FIG. 14**, the specified LBAs are "00100 through 00120(h)." The information for the block set in which the pre-update data is stored is added to the generation/compression control table **540** (**FIG. 14**).

B2. Update Process With Specified Generation

[**0144**] In Step S**7**, the host computer **110** performs a data write request on the storage system **200***b*. The difference from Steps S**2**, S**5**, and S**6**, described above, is that the write request is performed specifying a past generation.

[**0145**] **FIG. 20** is a flowchart showing the procedures for the data update process for a past generation. According to **FIG. 20**, the process on the specified block set is performed divided into the three cases, A through C, described below. Note that when the specified LBAs include blocks in a plurality of block sets, this division into cases is performed for each individual block set:

Case A: When data for the specified generation is not backed up.

Case B: When data for the specified generation has been backed up, and the backed up data is not shared with another generation.

Case C: When data for the specified generation has been backed up, and the backed up data is data that is shared with another generation.

B3. Case A

[**0146**] **FIG. 21** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case A. In **FIG. 21**, a part of the content of tables **530** and **540** is shown after Step S**7** in **FIG. 14**.

[**0147**] In Step S**510** (**FIG. 20**), the data relay module **600***b* uses the new data obtained from the host computer **110** to generate compressed data for the specified block set. In this case, the data for all blocks in a single specified block set is obtained in the same way as in the procedures in Steps S**300** through S**325** in **FIG. 9**. After obtaining the data for all of the blocks, the data relay module **600***b* compresses the data in the data compression circuit **310** (**FIG. 1**) and stores (backups) the compressed data in the first logical volume LDEV**1**. According to **FIG. 21**, the post-compression data is stored in block set BS**230***c*. At this time, the original data in the 0th logical volume LDEV**0** is not updated.

[**0148**] In the next step, S**513**, the data relay module **600***b* adds, to the generation/compression control table **540**, data regarding the backup destination block set BS**230***c* in which the new post-compression data has been stored. According to **FIG. 21**, the generation is "2," the starting LBA is "001C0(h)," the ending LBA is "0022F(h)" and the other generation information is "none." The generation is set to the generation specified by the host computer **110**.

[**0149**] In the next step, S**516**, the data generation module **600***b* updates the update status control table **530**. Specifically, a pointer is added to the specified block set backup information. This pointer references information pertaining to the backup destination block set in the generation/compression control table **540**.

[**0150**] Once the processes described above have been completed, the data relay module **600***b* has completed the process of writing to an earlier generation in Case A.

B4. Case B

[**0151**] **FIG. 22** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case B. **FIG. 22** shows an example of the case wherein, following Step S**7** in **FIG. 14**, the host computer **110** performs a write request, for the same specified generation, of the same specified block set, as in Step S**7**.

[**0152**] In Step S**520** (**FIG. 20**) the data relay module **600***b* generates the data for the specified generation using the new data obtained from the host computer **110**, and stores (backs up) the data for the specified generation to the first logical volume LDEV**1**. This process is the same as the process in Step S**510**, described above. However, the data for the blocks that are not specified, within the specified block set, are readout from the backup-destination block set in the first logical volume LDEV**1**, rather than the 0th logical volume LDEV**0**. This backup-destination block set is the block set associated with the specified generation. The data relay module **600***b* obtains the backup-destination block set by referencing the pre-update generation/compression control table **540**.

[**0153**] Moreover, the data relay module **600***b* selects, from the open logical blocks in the first logical volume LDEV**1**, the logical block wherein to store the new post-compression data for the specified generation. According to **FIG. 22**, the block set BS**240***c* is selected. However, if the new post-compression data for the specified generation is smaller than the old (previously backed up) post-compression data for the specified generation, then it is preferable to store the new data for the specified generation to the logical block wherein the old data for the specified generation had been stored.

[0154] In the next step, S**525**, the data relay module **600***b* updates the generation/compression control table **540**. Specifically, the information for the backup-destination block set is replaced with the information for the block set wherein the new post-compression data is stored. According to **FIG. 22**, the starting LBA is updated to "00310(h)," and the ending LBA is updated to "003A5(h)."

[0155] Once the processes described above have been completed, then the data relay module **600***b* has completed the process of writing to a previous generation in Case B.

B5. Case C

[0156] **FIG. 23** is a drawing showing an example of the update status control table **530** and the generation/compression control table **540** in Case C. **FIG. 23** shows an example of the case wherein, following Step S7 in **FIG. 14**, the host computer **110** then performs a write request for the first generation LBA "00100(h)." As is shown in tables **530** and **540** in **FIG. 14**, backups have already been completed for the data for generations 0 through 2, in the block set BS**220***c*, for the block set BS**110**, which includes "00100(h)." According to **FIG. 23**, a host computer **110** requests the writing of new data to only the first generation.

[0157] In Step S**530** (**FIG. 20**), the data relay module **600***b* generates the data for the specified generation using the new data obtained from the host computer **110**, and then stores (backs up) the data for the specified generation to the first volume LDEV**1**. This process is the same as the process in Step S**520**, described above. However, the new data is written to the open logical blocks while maintaining the data in the block set for which the backup has already been completed. According to **FIG. 23**, the new post-compression data is stored to the open block set BS**250***c* while maintaining the data in the block set BS**220***c* for which the backup has already been completed.

[0158] In the next step, S**535**, the data relay module **600***b* updates the generation/compression control table **540**. Specifically, the specified generation is deleted from the information for the block for which the backup has already been completed, and information is added regarding the backup-destination block set wherein the new post-compression data is stored. According to **FIG. 23**, the specified generation (1) is deleted from the generation information for the block set BS**220***c*, and information is added regarding the new block set BS**250***c*. The generation is the same as the specified generation, (1) where the starting LBA is "0051A(h)," and the ending LBA is "00590(h)." Moreover, a pointer is added to the other generation information of the block set for which the backup has been completed. This pointer references information regarding the block set BS**250***c*.

[0159] Once the processes described above have been completed, then the data relay module **600***b* has completed the write process to a past generation in Case C.

[0160] In the second embodiment, described above, the storage system **200***b* stores the post-update data while backing up the pre-update data, so it is possible to provide easily both the most recent data and the data for a specified point in time. Moreover, the disk array control unit **300***b* (**FIG. 13**) performs this backup process independently from the host computer **110**, making it possible to perform the backup without applying a load to the host computer **110**.

[0161] Furthermore, in the second embodiment, the data for the logical volume is divided over a plurality of block sets, and the pre-update data is backed up only for those block sets that are updated. The result is that it is possible to conserve the storage area, when compared to the case wherein the entirety of the logical volume is copied. Moreover, because the pre-update data is compressed and then stored, it is possible to conserve the storage area even further.

[0162] Furthermore, in the second embodiment, the storage system **200***b* not only stores the control data regarding the correspondence relationships between the pre-compression (pre-backup) and post-compression (post-backup) (i.e., the logical volume control table **510**, the volume status control table **520**, the update status control table **530**, and the generation/compression control table **540**), but also performs data compression and decompression, and updating of the control data, independently from the host computer **110**. As a result, it is possible to perform the compression and decompression of the data without applying a load to the host computer **110**.

[0163] In particular, in the second embodiment, the correspondence relationships between the pre-compression and post-compression block sets (the pre-backup and post-backup block sets) are defined by a combination of the update status control table **530** and the generation/compression control table **540**. The result is that the disk array control unit **300***b* is able to receive a data transfer request, from the host computer **110**, specifying pre-compression (pre-backup) LBAs in a consistent manner. Moreover, even when data is shared by a plurality of host computers, the disk array control unit **300***b* is able to receive data transfer requests using shared pre-compression (pre-backup) LBAs. In other words, the storage system **200***b* is "host transparent."

[0164] Furthermore, in the second embodiment, the disk array control unit **300***b* stores the correspondence relationship between the block sets and the generations in the generation/compression control table **540**. Consequently, the disk array control unit **300***b* is able to receive, from the host computer **110**, data transfer requests that specify the generation.

[0165] Furthermore, in the second embodiment, the storage system **200***b* stores the newest data without compression, making it possible to suppress any decrease in processing speed when the newest data is read out.

[0166] Note that in the second embodiment, the logical volume control table **510**, the update status control table **530**, and the generation/compression control table **540**, as a whole, correspond to the "block correspondence relationships" in the present invention.

C. Third Embodiment

[0167] **FIG. 24** is a drawing showing the structure of a storage system **200***c* in a third embodiment. The difference from the storage system **200** shown in **FIG. 1** is that the data relay module **600***c* controls data updating after the compression/migration process by using a log method. The other structures are the same as for the storage system **200** shown in **FIG. 1** and **FIG. 2**. Note that in **FIG. 24**, only the local memory **344***c* of the disk array control unit **300***c* is shown as a structural element of the storage system **200**c, and the other structural elements are omitted from the figure.

[**0168**] The data relay module **600**c performs a compression/migration process. The details of the compression/migration process are the same as in the first embodiment, shown in **FIGS. 3 through 6**.

C1. Write Process

[**0169**] **FIG. 25** is a drawing showing an overview of the write process in the third embodiment. This write process is a process following the compression/migration. Here the specified LBAs are "7990" through "7995."

[**0170**] The data relay module **600**c compresses the new data DULB**300**, obtained from the host computer **110**, in the data compression circuit **320** (**FIG. 1**). The data compression circuit **320** generates the post-compression data DULB**300**c through compressing the new data DULB**300**.

[**0171**] Moreover, the data relay module **600**c generates log information DLOG**300** associated with the post-compression (post-update) data DULB**300**c. This log information DLOG**300** includes the pre-compression LBAs (specified LBAs), the actual LBAs that identify the block set wherein the post-compression data DULB**300**c is stored, and the date and time on which the data was written.

[**0172**] Next the data relay module **600**c stores the log information DLOG**300** and the post-compression data DULB**300**c into an unused area in the open area A**13**. In this way, the log information DLOG**300** is stored in the logical volume in the same manner as is the data. However, as the method of storing the log information, a method is employed, wherein it is possible to distinguish between the block storing the log information DLOG**300** and other blocks. A variety of well-known methods may be used as this type of storage method. For example, a method may be used wherein data that would not be found in other blocks is stored at the beginning block and end block for the log information DLOG**300**.

[**0173**] Note that the log information DLOG**300** and the post-compression data DULB**300**c may be stored in different logical volumes.

[**0174**] Note that According to **FIG. 25**, the data DBS**300**c, together with the log information DLOG**300** and the post-compression data DULB**300**c is stored in the block set BS**300**c. The post-compression data DULB**300**c is stored in the data block set BSD**300**c, within the block set BS**300**c. The actual LBAs for the log information DLOG**300** show the LBAs for this data block set BSD**300**c.

[**0175**] In this way, the data relay module **600**c adds post-update data and log information to the open area A**13** each time a write request is received from the host computer **110**.

[**0176**] Note that the block set identified by the actual LBAs (the post-compression block set) includes the data of each of the blocks in the block set identified by the pre-compression LBAs (the pre-compression block set). Consequently, the post-compression block set can be said to be associated with each of the blocks of the pre-compression LBAs. This point is similar for the other examples of embodiments as well. Moreover, in the third embodiment the number of blocks in the pre-compression block set is a number that varies according to the write request from the host computer **110**.

C2. Read Process

[**0177**] The data relay module **600**c performs data transfers in the same manner as in the first embodiment in **FIGS. 7 and 8**, in response to a read request from the host computer **110**. However, the data relay module **600**c looks up, from the log information in the open area A**13**, the log information containing the specified LBA (hereinafter termed the "specified log information"). After the specified log information is found, the data relay module **600**c reads the data from the block set indicated by the actual LBAs in the specified log information, and decompresses the data that has been read in the data decompression circuit **330** (**FIG. 1**). The data relay module **600**c uses the data that has been generated by the decompression to send the data for the specified LBAs to the host computer **110**.

[**0178**] Note that the data relay module **600**c uses the log information with the most recent write date and time when a plurality of specified log information has been found. Moreover, the data relay module **600**c can receive, from the host computer **110**, read requests specifying a past date and time. In this case, the newest specified log information at the specified date and time is used. In other words, from all of the log information since the specified date and time, the log information that is the newest is looked up. In this way, the "date and time" corresponds to the "a version" in the present invention.

[**0179**] Given the third embodiment, described above, the storage system **200**c stores the post-update data while still leaving the pre-update data behind, thus making it possible to provide easily the newest data and the pre-update data. Moreover, because the post-update data is compressed and stored, it is possible to conserve the storage area.

[**0180**] Furthermore, in the third embodiment, the disk array control unit **300**c not only stores log information regarding the updating and compression of data, but also performs the data compression and decompression independently from the host computer **110**. Consequently, it is possible to perform the data compression and decompression without putting a load on the host computer **110**.

[**0181**] In particular, in the third embodiment, the correspondence relationship between the pre-update and post-update block sets is established by the log information. As a result, the disk array control unit **300**c is able to receive, in a consistent manner, data transfer requests from the host computer **110** specifying the pre-update (pre-compression) LBAs.

[**0182**] Note that in the third embodiment, the compressed LBA control table **500**, the logical volume control table **510**, and the log information, as a whole, corresponds to the "block correspondence relationships" in the present invention. Moreover, the local memory **344**c wherein this information is stored, and the migration-destination logical volume LDEV**1** (or in other words, the disk array **250**), as a whole, correspond to the "correspondence relationship memory unit" in the present invention.

D. Variants

[0183] Note that the present invention is not limited to the examples of embodiments or forms of embodiments described above, but rather can be embodied in a variety of forms in a range that does not deviate from the spirit of the present invention, and, for example, the following alternative forms are also possible.

Variant 1:

[0184] In the compression/migration processes shown in **FIGS. 3 through 6**, the logical volume for the migration destination may be the same as the logical volume for the migration origin. In this case, the post-compression data may overwrite the logical blocks wherein the pre-compression data has been stored.

Variant 2:

[0185] In the first embodiment shown in **FIG. 4** and **FIG. 8**, the reading and writing of data is preformed using the block set as the unit for the non-compressed area **A11** as well; however, the reading and writing may be performed using a single logical block as the unit. This is also true for the other processes and other examples of embodiments as well.

Variant 3:

[0186] In the first embodiment as shown in **FIG. 6**, the size of the unit for the compression process is fixed at "10 blocks." Consequently, it is possible to identify the block set by identifying the starting LBA for a pre-compression block set. Given this, the pre-compression size data may be omitted in the compressed LBA control table **500**. Furthermore, when it comes to the non-compressed area **A1** (or the non-compressed area **A11**), the pre-compression (pre-migration)LBAs and the post-compression (post-migration) LBAs are identical, and so data regarding the non-compressed area **A1** (non-compressed area **A11**) in the compressed LBA control table **500** may be omitted. On the other hand, even in the second embodiment according to **FIG. 14**, the size of the compression processing unit is fixed at "100 (h)" blocks. Consequently, the ending LBA data may be omitted from the update status control table **530**. Note that when it comes to post-compression block set, the size is variable, and so the size data or the ending LBA data should be used, without omission.

[0187] Moreover, in the first embodiment and in the second embodiment, the sizes of the units for the compression processing may be variable. For example, the size of the compression processing unit may vary depending on the location within the storage area.

[0188] Moreover, According to **FIG. 6** (B), the enabling/disabling of compression and the compression algorithm is set for each logical volume; however, any unit desired can be used as a unit for setting up the enabling/disabling of the compression or setting up the compression algorithm. For example, the compression and the algorithm may be set up for each individual logical block, may be set up for each individual RAID group, or the same settings may be used for the storage system as a whole. In any case, a settings memory unit (such as a memory unit **340** or the disk array **250**) should be provided in the storage system, and the details of the settings should be stored in advance for each of the set up units. This is not limited to the case wherein compression processing is performed, but is also true for cases wherein other processes (such as encryption processes) are performed.

Variant 4:

[0189] In the second embodiment, described above, the pre-update data is compressed and backed up (stored); however, the post-update data may be compressed and backed up (stored) instead. In this case, the information about the block set wherein the post-update data has been stored may be stored in the compression control table **540**, in the same manner as according to **FIG. 14**.

Variant 5:

[0190] In the third embodiment, shown in **FIG. 24** and **FIG. 25**, a compression/migration process is performed; however, this process need not be performed. Even in this case, the post-update data may be compressed and stored along with the log information. In this case, the post-update data and the log information may be stored to a logical volume that is different from the logical volume for the original data.

[0191] Furthermore, even in the third embodiment, the compressing and storing of the post-update data may be performed for each block set of a specific size, in the same manner as is done in the second embodiment.

[0192] Furthermore, even in the third embodiment, a point-in-time copy may be saved. For example, only the post-update data immediately prior to the specified point in time may be saved as the post-update data for each pre-compression LBA, while the other post-compression data may be destroyed.

Variant 6:

[0193] In each of the examples of embodiments described above, when data is read to the host computer **110** from the storage system **200**, **200***b*, or **200***c*, the data for the specified LBAs, read out from the logical volume, may be stored temporarily in a cache memory **342**, and then later gathered and sent to the host computer **110**. Similarly, when writing data from the host computer **110** to the storage system **200**, **200***b*, or **200***c*, the data sent from the host computer **110** may be stored temporarily in the cache memory **342**, and then, after a notification of data writing completion has been sent to the host computer **110**, actually be written to the logical volume.

Variant 7:

[0194] In each of the examples of embodiments described above, the LBAs specified by the host computer (i.e., the "specified LBAs"), and the LBAs (hereinafter termed "the physical LBAs") on the logical volume prior to compression (or prior to migration or prior to backup) are identical; however, they need not be identical. In such a case, a settings memory unit (for example, a memory unit **340** or disk array **250**) should be provided in the storage system, and the LBA correspondence relationships between the specified LBAs and the physical LBAs should be stored in the settings memory unit.

[0195] Moreover, in each of the examples of embodiments described above, the sizes of the minimum units for data transfer between the disk array control units **300**, **300***b*, or **300***c* and the host computer **110** (hereinafter termed the "host blocks") is the same as the sizes of the minimum units for data transfer within the logical volumes (hereinafter termed the "volume blocks"). However, the size of the host blocks may be different from the size of the volume blocks. For example, the size of the volume blocks may be set to a value that is smaller than the size of the host blocks (for example, 1/L times the size of the host blocks, where L is an integer equal or greater than 2). Doing so makes it possible to prevent the storage area used in storing data from becoming excessively large when the size of the data is changed by the data conversion process, because a single host block is represented by multiple volume blocks.

[0196] Note that in this case, the structural information that indicates the correspondence relationships between the host blocks and the volume blocks should be stored in the settings memory unit of the storage system. Doing so makes it possible for the disk array control unit to reference the structural information in order to restructure the host blocks from the volume blocks. The correspondence relationships, for example, between the host block LBAs and the LBAs of the volume blocks that structure those host blocks, may be used as structural information.

[0197] Note that this type of LBA correspondence relationship, the structural information, and the tables **500**, **510**, **520**, **530**, and **540**, described above, may be stored in any given memory unit in the storage system. For example, these may be stored in the local memory (for example, the local memory **344** (**FIG. 1**)) or a cache memory (for example, the cache memory **342**), or may be stored in a disk array (for example, the disk array **250**).

Variant 8:

[0198] In each of the examples of embodiments described above, the storage system **200**, **200***b* or **200***c* may provide logical volumes to a plurality of host computers. In such a case, a logical volume control table **510** (**FIG. 6** (C)) should be provided for each host computer. Here data transfer should be prohibited between a host computer and any logical volume not recorded in the logical volume control table **510** used by that host computer. Doing so makes it possible to prevent data transfer with an unintended host computer.

Variant 9:

[0199] Although in each of the examples of embodiments described above, a method that uses the RAID system is used as the method for forming a logical volume; however, other methods may be used instead. For example, the storage area provided by a single disk device may be used as is as a single logical volume.

[0200] Furthermore, the storage area is not limited to that uses a disk device, but any other storage area may be used instead. For example, a storage area that uses semiconductor memory may be used.

Variant 10:

[0201] In each of the examples of embodiments described above, a data compression process is performed; however, the data conversion process may use any given process that converts the size of the data itself. For example, an encryption process may be used instead. As the encryption process, any of a variety of well-known processes, such as DES encryption processing, may be used. Moreover, when using a password-protected encryption process, the password should be specified by the control terminal **120** or by the host computer **110**. Furthermore, both compression processing and encryption processing may be performed.

Variant 11:

[0202] In each of the examples of embodiments described above, a portion of structures embodied in software may be replaced into hardware, and, conversely, a portion of the structure that is embodied in hardware may be replaced by software. For example, the functions of the data compression unit **320** (**FIG. 1**) and the data decompression unit **330** may be embodied in a program.

[0203] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

What is claimed is:

1. A storage system for providing a storage area that stores data to a host computer, comprising:

a data storage unit having a storage area for storing data; and

a control unit configured to control data transfer between the host computer and the storage area, wherein

the control unit performs:

receiving data from and sending data to the host computer according to a logical storage location expressed in units of first blocks of a specific size, the logical storage location being specified by the host computer; and

storing data to and reading data from the storage area in units of second blocks of a specific size, and

the control unit has a conversion storage mode for performing a data conversion process on data of interest for each first block set in the data-of interest to generate a second block set corresponding to each first block set, and storing the second block set in the storage area, the data conversion process changing size of the data of interest, the first block set including N first blocks where N is an integer greater than or equal to 1, the second block set including one or more second blocks, and wherein,

the storage system further comprises:

a correspondence relationship memory unit configured to store a block correspondence relationship that indicates correspondence relationship between a plurality of the first block sets and a plurality of the second block sets, and wherein

when the control unit has received a data read request for a specific first block from the host computer, the control unit executes:

referencing the block correspondence relationship to identify a second block set to be read associated with a particular first block set that includes the requested first block;

reading out the second block set to be read;

performing a reverse conversion process of the data conversion process on the readout second block set; and

sending data of the requested first block to the host computer.

2. A storage system according to claim 1, wherein

the control unit further performs an update process for a first block set to be updated including a specific first block when the control unit has received a data update storage request regarding the specific first block from the host computer, wherein

in the update process, the control unit references the block correspondence relationship to determine whether or not updating has been requested for all of the first blocks included in the first block set to be updated, wherein

when the updating is not requested for all of the first blocks in the first block set to be updated, the control unit performs:

reading a second block set associated with the first block set to be updated,

performing the reverse conversion process on the second block set that has been read,

overwriting the requested first block on the data that is reverse-converted from the second block set, thereby generating an updated first block set,

generating an updated second block set by performing the conversion process on the updated first block set, and

storing the updated second block set in the storage area, and

the control unit writes the correspondence relationship between the first block set to be updated and the updated second block set to the block correspondence relationship.

3. A storage system according to claim 1, wherein:

the storage area is capable of storing a plurality of different-version second block sets, the plurality of different-version second block sets being associated with a common first block set with an identical logical storage location; wherein

the block correspondence relationships include correspondence relationships between a logical storage location of the first block set associated with the plurality of different-version second block sets, and physical storage locations and versions of the plurality of different-version second block sets; wherein

the control unit performs a version readout process when the control unit has received a request for reading data regarding a specific first block and a specific version from the host computer, the version readout process including:

referencing the block correspondence relationship to identify a second block set associated with both a first block set that contains the requested first block and the requested version,

reading out the identified second block set,

performing the reverse conversion process on the identified second block set, and

sending data of the requested first block to the host computer.

4. A storage system according to claim 3, wherein:

the control unit has a non-conversion storage mode for generating a non-converted block set comprising one or more second blocks from a first block set without performing the data conversion process, and storing the non-converted block set in the storage area; wherein

the control unit performs a conversion update process when the control unit has received a data update request regarding a specific first block from the host computer after storing the non-converted block set, the conversion update process including:

(i) storing updated data concerning a particular first block set including the requested first block in the storage area according to a selected one of the conversion storage mode and the non-conversion storage mode; and

(ii) reading out a non-converted block set that is equivalent to the particular first block set before the updating, and performing the data conversion process on the non-converted block set to generate a non-updated second block set, then storing the non-updated second block set to the storage area, and adding in the block correspondence relationship a three-way correspondence relationship between the particular first block set, the non-updated second block set, and a version of the non-updated second block set established according to specific rules.

5. A storage system according to claim 4; wherein

in the conversion update process, the control unit generates a post-update non-converted block set including one or more second blocks without performing the data conversion process on the updated data of the particular first block set, and stores the post-update non-converted block set in the storage area, and

when the control unit has received a data read request without version specification from the host computer, the control unit reads out the post-update non-converted block set and sends requested first block data to the host computer.

6. A storage system according to claim 1; wherein

the storage area is capable of storing a plurality of different-version second block sets, the plurality of different-version second block sets being associated with a common first block with an identical logical storage location, wherein

the block correspondence relationships include correspondence relationships between a logical storage location of a first block set including the first block associated with the plurality of different-version second block sets, and a physical storage location and a version of a different-version second block set, for each of the plurality of different-version second block sets; wherein,

the control unit performs a log update process when the control unit has received a data update request regarding one or more specific first blocks from the host computer, the log update process including:

performing the data conversion process on updated data of a first block set to be updated structured from the requested first blocks thereby generating a updated second block set;

storing the a updated second block set in the storage area; and

adding in the block correspondence relationship a three-way correspondence relationship between the first block set to be updated, the updated second block set, and a version of the updated second block set established according to specific rules, wherein

the control unit performs a version readout process when the control unit has received a data readout request regarding a specific first block and a specific version from the host computer, the version readout process including:

referencing the block correspondence relationship to identify a second block set associated with both a first block set that includes the requested first block and the requested version;

reading out the identified second block set;

performing the reverse conversion process on the second block set that has been read; and

sending data of the requested first block to the host computer.

7. A storage system according to claim 1, wherein

the first block set block number N is a variable value.

8. A storage system according to claims **1**, wherein

the data size of the second block is smaller than the data size of the first block.

9. A method of providing a storage area that stores data to a host computer, the storage area which a storage system has, comprising the steps of:

(A) receiving data and sending data between the host computer and the storage system according to a logical storage location expressed in units of first blocks of a specific size, the logical storage location being specified by the host computer; and

(B) storing data to and reading data from the storage area in units of second blocks of a specific size, and

the step (B) includes the steps of

performing a process of a conversion storage mode for performing a data conversion process on data of interest for each first block set in the data-of interest to generate a second block set corresponding to each first block set, and storing the second block set in the storage area, the data conversion process changing size of the data of interest, the first block set including N first blocks where N is an integer greater than or equal to 1, the second block set including one or more second blocks, and wherein,

the providing method further comprises the step of

(C) generating a block correspondence relationship that indicates correspondence relationship between a plurality of the first block sets and a plurality of the second block sets, and wherein

the step (B) includes the steps of

responsive to a data read request for a specific first block from the host computer:

referencing the block correspondence relationship to identify a second block set to be read associated with a particular first block set that includes the requested first block;

reading out the second block set to be read;

performing a reverse conversion process of the data conversion process on the readout second block set; and

sending data of the requested first block to the host computer.

10. A providing method according to claim 9, wherein

the step (B) includes the step of

performing an update process for a first block set to be updated including a specific first block responsive to a data update storage request regarding the specific first block from the host computer, the update process including:

referencing the block correspondence relationship to determine whether or not updating has been requested for all of the first blocks included in the first block set to be updated;

when the updating is not requested for all of the first blocks in the first block set to be updated:

reading a second block set associated with the first block set to be updated,

performing the reverse conversion process on the second block set that has been read,

overwriting the requested first block on the data that is reverse-converted from the second block set, thereby generating an updated first block set,

generating an updated second block set by performing the conversion process on the updated first block set,

storing the updated second block set in the storage area, and

writing the correspondence relationship between the first block set to be updated and the updated second block set to the block correspondence relationship.

11. A providing method according to claim 9, wherein

the storage area is capable of storing a plurality of different-version second block sets, the plurality of different-version second block sets being associated with a common first block set with an identical logical storage location; wherein

the block correspondence relationships include correspondence relationships between a logical storage location of the first block set associated with the plurality of different-version second block sets, and physical storage locations and versions of the plurality of different-version second block sets; wherein

the step (B) includes the step of performing a version readout process responsive to a request for reading data regarding a specific first block and a specific version from the host computer, the version readout process including:

referencing the block correspondence relationship to identify a second block set associated with both a first block set that contains the requested first block and the requested version,

reading out the identified second block set,

performing the reverse conversion process on the identified second block set, and

sending data of the requested first block to the host computer.

12. A providing method according to claim 11, wherein:

the step (B) includes the steps of

performing a process of a non-conversion storage mode for generating a non-converted block set comprising one or more second blocks from a first block set without performing the data conversion process, and storing the non-converted block set in the storage area; and

performing a conversion update process responsive to a data update request regarding a specific first block from the host computer after storing the non-converted block set, the conversion update process including:

(i) storing updated data concerning a particular first block set including the requested first block in the storage area according to a selected one of the conversion storage mode and the non-conversion storage mode; and

(ii) reading out a non-converted block set that is equivalent to the particular first block set before the updating, and performing the data conversion process on the non-converted block set to generate a non-updated second block set, then storing the non-updated second block set to the storage area, and adding in the block correspondence relationship a three-way correspondence relationship between the particular first block set, the non-updated second block set, and a version of the non-updated second block set established according to specific rules.

13. A providing method according to claim 12, wherein

the conversion update process includes the steps of:

generating a post-update non-converted block set including one or more second blocks without performing the data conversion process on the updated data of the particular first block set; and

storing the post-update non-converted block set in the storage area, and

the step (B) includes the steps of

responsive to a data read request without version specification from the host computer:

reading out the post-update non-converted block set, and

sending requested first block data to the host computer.

14. A providing method according to claim 9, wherein

the storage area is capable of storing a plurality of different-version second block sets, the plurality of different-version second block sets being associated with a common first block with an identical logical storage location, wherein

the block correspondence relationships include correspondence relationships between a logical storage location of a first block set including the first block associated with the plurality of different-version second block sets, and a physical storage location and a version of a different-version second block set, for each of the plurality of different-version second block sets; wherein,

the step (B) includes the step of

performing a log update process responsive to a data update request regarding one or more specific first blocks from the host computer, the log update process including:

performing the data conversion process on updated data of a first block set to be updated structured from the requested first blocks, thereby generating a updated second block set;

storing the a updated second block set in the storage area; and

adding in the block correspondence relationship a three-way correspondence relationship between the first block set to be updated, the updated second block set, and a version of the updated second block set established according to specific rules, wherein

the step (B) includes the step of

performing a version readout process responsive to a data readout request regarding a specific first block and a specific version from the host computer, the version readout process including:

referencing the block correspondence relationship to identify a second block set associated with both a first block set that includes the requested first block and the requested version;

reading out the identified second block set;

performing the reverse conversion process on the second block set that has been read; and

sending data of the requested first block to the host computer.

15. A providing method according to claim 9, wherein

the first block set block number N is a variable value.

16. A providing method according to claim 9, wherein

the data size of the second block is smaller than the data size of the first block.

* * * * *