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(54) **DISK ARRAY UNIT**

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(57) **ABSTRACT**

A disk array unit connected to a host unit to give information thereto and receive information therefrom. The disk unit includes a plurality of disk units for storing information transmitted from the host unit and a management information recording device, formed by utilizing information storage areas in the disk units, for causing information relating to a logical unit for storing information from the host unit to correspond to information relating to the units. The invention further includes a control unit, when there is no access from the host unit to the logical unit for a predetermined time, for determining the disk units corresponding to the logical unit based on information recorded in the management information recording device and performing power saving of power supply for the disk units.

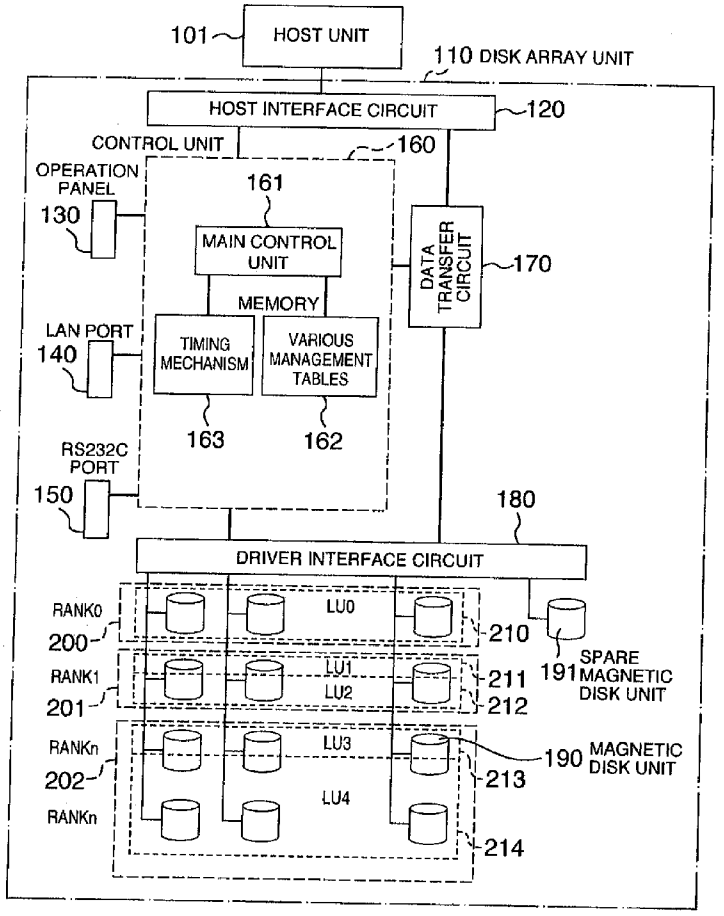


FIG. 1

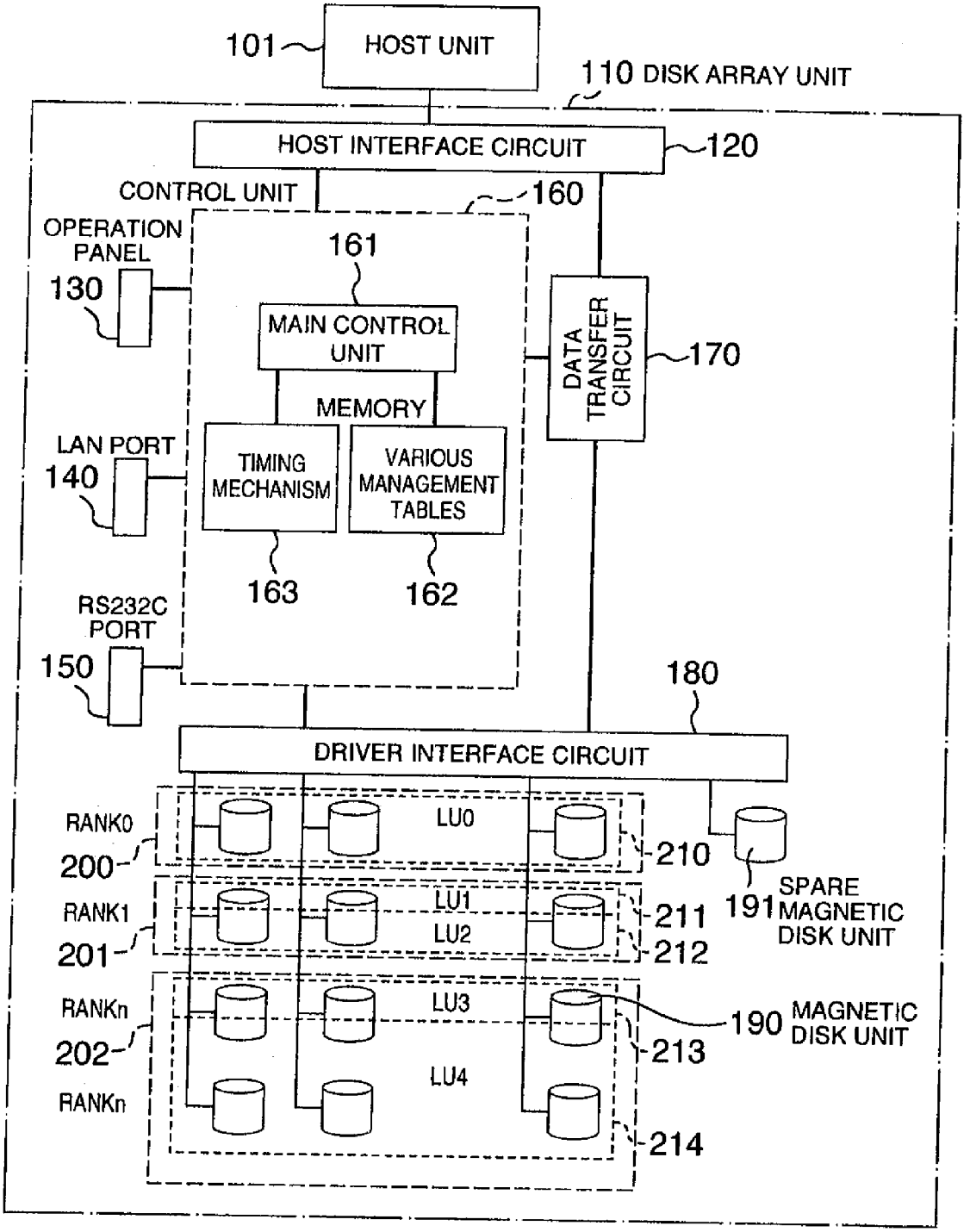

101
HOST UNIT
110 DISK ARRAY UNIT
HOST INTERFACE CIRCUIT
120
CONTROL UNIT
160
OPERATION PANEL
130
161
MAIN CONTROL UNIT
DATA TRANSFER CIRCUIT
170
MEMORY
LAN PORT
140
TIMING MECHANISM
VARIOUS MANAGEMENT TABLES
163
162
RS232C PORT
150
180
DRIVER INTERFACE CIRCUIT
RANK0
200
LU0
210
RANK1
201
LU1
LU2
211
212
191
SPARE MAGNETIC DISK UNIT
RANKn
202
LU3
190
MAGNETIC DISK UNIT
213
LU4
RANKn
214

FIG. 2

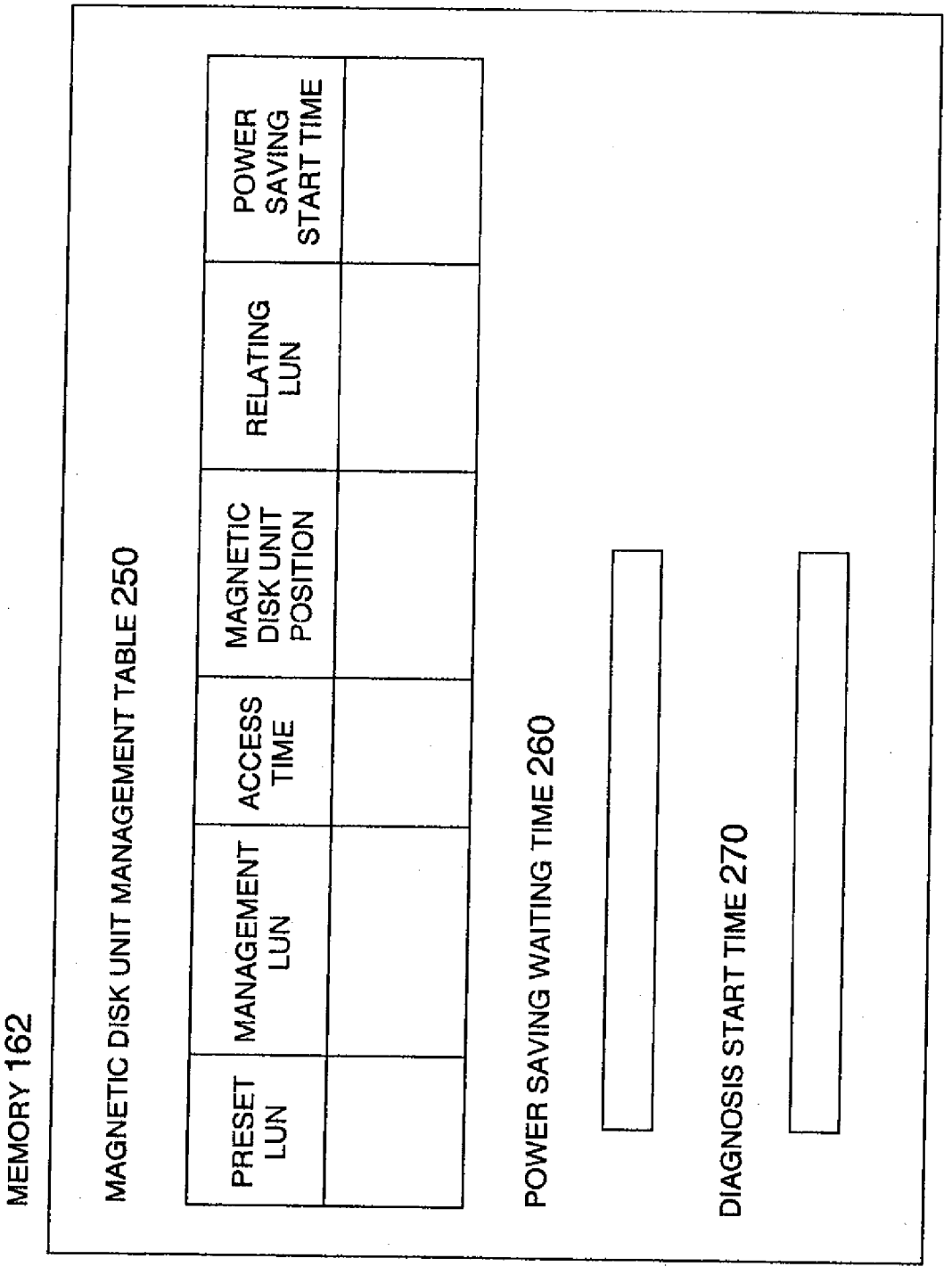

MEMORY 162
MAGNETIC DISK UNIT MANAGEMENT TABLE 250
PRESET LUN
MANAGEMENT LUN
ACCESS TIME
MAGNETIC DISK UNIT POSITION
RELATING LUN
POWER SAVING START TIME
POWER SAVING WAITING TIME 260
DIAGNOSIS START TIME 270

FIG. 3

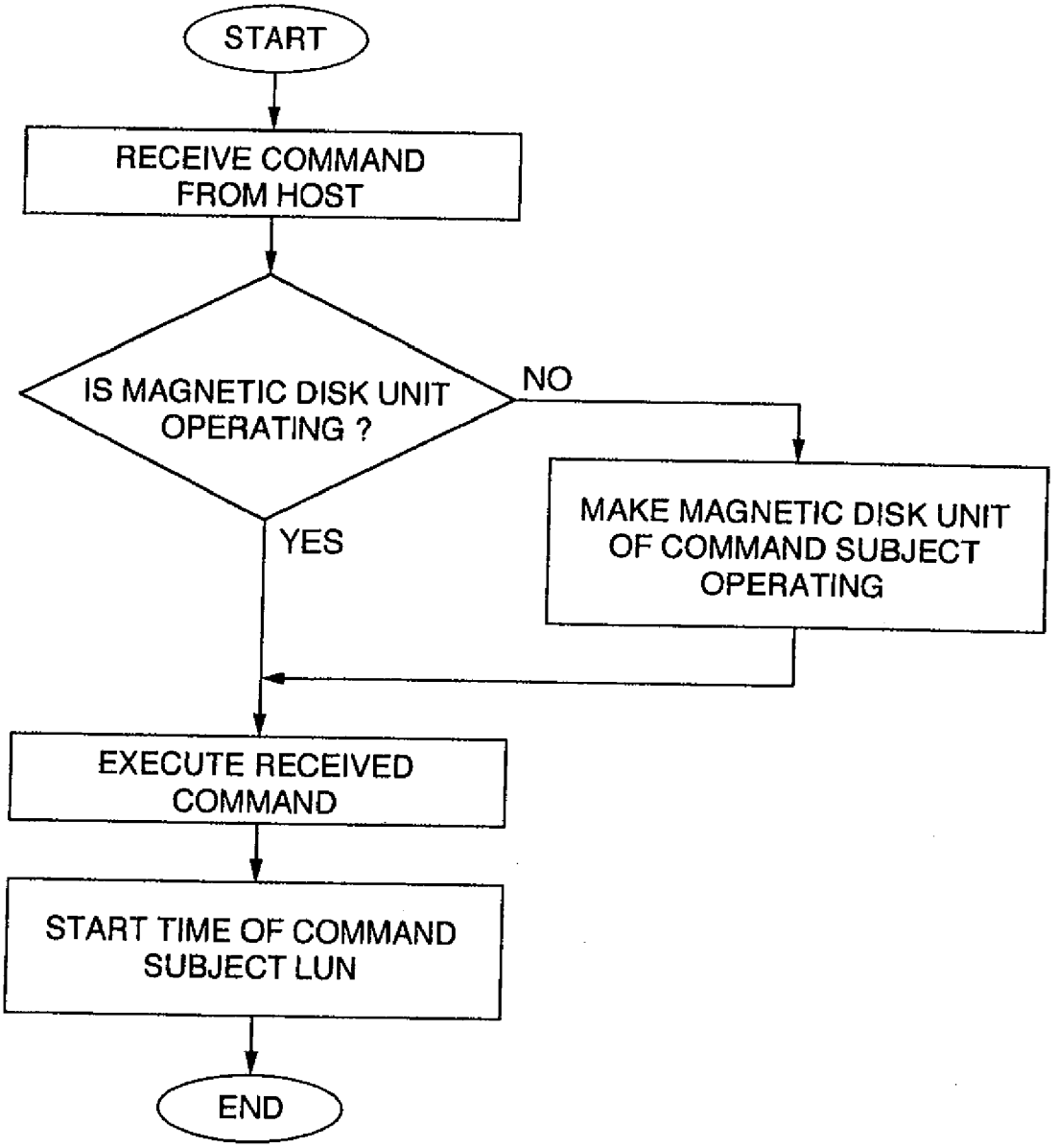

START
RECEIVE COMMAND FROM HOST
IS MAGNETIC DISK UNIT OPERATING ?
NO
YES
MAKE MAGNETIC DISK UNIT OF COMMAND SUBJECT OPERATING
EXECUTE RECEIVED COMMAND
START TIME OF COMMAND SUBJECT LUN
END

FIG. 4

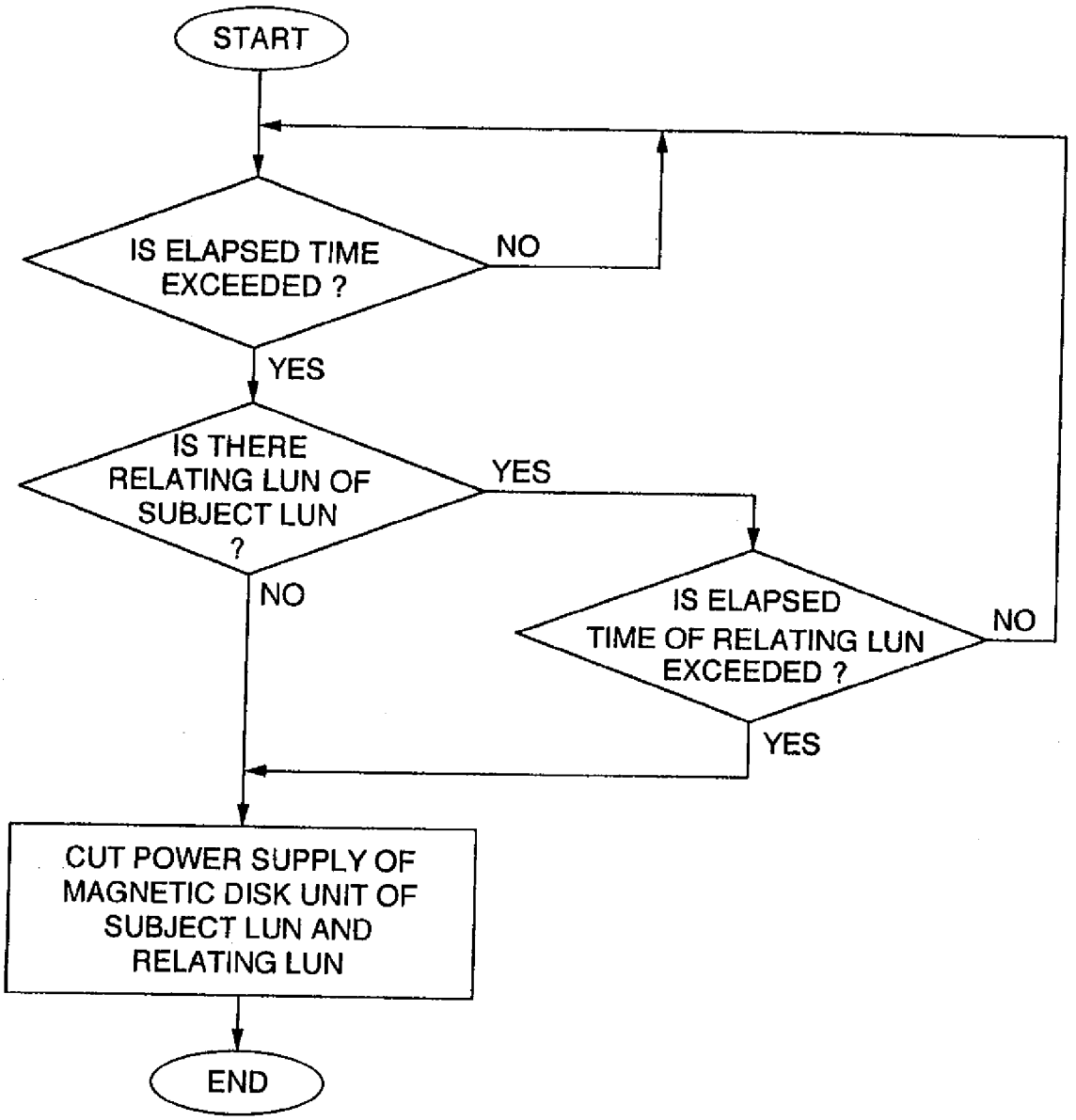
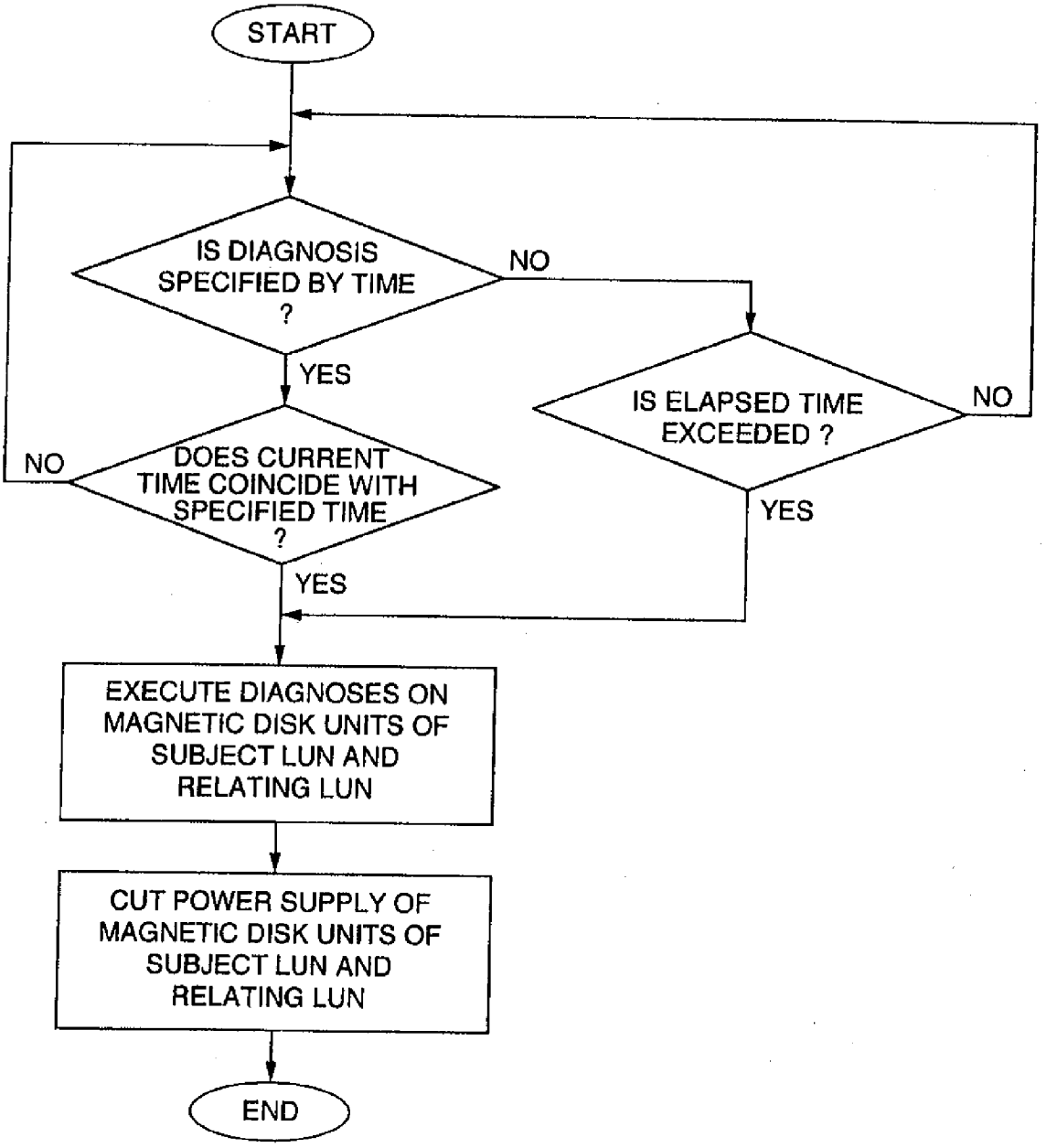

START
IS ELAPSED TIME EXCEEDED ?
NO
YES
IS THERE RELATING LUN OF SUBJECT LUN ?
YES
NO
IS ELAPSED TIME OF RELATING LUN EXCEEDED ?
NO
YES
CUT POWER SUPPLY OF MAGNETIC DISK UNIT OF SUBJECT LUN AND RELATING LUN
END

FIG. 5


START
IS DIAGNOSIS SPECIFIED BY TIME ?
NO
YES
IS ELAPSED TIME EXCEEDED ?
NO
YES
NO
DOES CURRENT TIME COINCIDE WITH SPECIFIED TIME ?
YES
EXECUTE DIAGNOSES ON MAGNETIC DISK UNITS OF SUBJECT LUN AND RELATING LUN
CUT POWER SUPPLY OF MAGNETIC DISK UNITS OF SUBJECT LUN AND RELATING LUN
END

DISK ARRAY UNIT

[0001] The present application is a continuation application of U.S. Ser. No. 11/407,243, filed Apr. 20, 2006, which is a continuation of application Ser. No. 11/182,952, filed Jul. 18, 2005, now U.S. Pat. No. 7,355,806; which is a continuation of application Ser. No. 10/412,388 filed Apr. 14, 2003, now U.S. Pat. No. 6,947,240; which is a continuation of application Ser. No. 09/383,370, filed Aug. 26, 1999, now U.S. Pat. No. 6,583,947, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to power saving of computer apparatuses, peripheral devices, and other electronic apparatuses, and in particular to energy saving of a disk array unit connected to a computer apparatus.

[0003] The disk array unit is a peripheral device of a computer apparatus, and is used as an external storage unit for storing data of the computer. A plurality of magnetic disk units are mounted on the disk array unit. When the disk array unit and a computer system serving as a host unit of the disk array unit are functioning, all of a plurality of magnetic disk units mounted on the disk array unit are typically operating.

[0004] In the specification of the present application, a term "operating" means that a magnetic disk unit is ready to response immediately when control information or data is inputted to the magnetic disk unit from a control unit for a host unit. It is now assumed that the magnetic disk unit is in the so-called sleep mode and a magnetic disk medium is in the still state. When a time required or the magnetic disk medium to be spun up to its ordinary number of revolutions has elapsed, the magnetic disk unit responds. This case is not included in the scope of the term "operating". Furthermore, the term "operating" does not include the case where the magnetic disk unit is in the power saving mode and it responds after the power saving mode has been canceled.

[0005] Furthermore, when viewed from a magnetic disk unit, the term "access" means whether a command intended for itself has been issued or whether information giving and receiving intended for itself has been requested. Typically, it corresponds to that in response to an instruction of information acquisition or storage of a host unit, a signal is issued from an electronic circuit of the host unit side including a drive interface to a magnetic disk unit intended for.

[0006] When an access from a host unit has occurred, the magnetic disk unit to be accessed must be operating so as to be capable of transmitting or receiving control information, the magnetic disk unit to be accessed must be operating. On the other hand, in the case where there is no access from a host unit or a control unit, it is not necessary to keep the magnetic disk unit in the "operating" state.

[0007] For magnetic disk units, there is typically a control method including the steps of throwing the power supply upon receiving access from a host unit, rotating a magnetic recording medium, and answering to the access (transmitting or receiving information), and gradually cutting the power supply of predetermined electronic circuits and a motor for rotating the magnetic recording medium after the answering has been finished. In other words, the magnetic disk unit has various power saving modes built-in, and has a function of selecting a predetermined power saving mode according to mainly the frequency of access from a host unit or a control unit, and automatically shifting into that mode.

[0008] In a conventional disk array unit, mounted magnetic disk units or magnetic disk units so set as to be recognizable from a host unit are controlled so as to become operating in response to start of the disk array unit. After the disk array unit has been started, the above described magnetic disk units mounted thereon remain operating until the power supply of the disk array unit is cut. If such manipulation as to cut the power supply of the disk array unit is conducted, such a sequence as to shift the magnetic disk units from the "operating" state to power supply off-state functions in response to the manipulation, and thereafter the power supply of the disk array unit is cut.

[0009] As for magnetic disk units which have not been so set as to be recognizable from a host unit and magnetic disk units mounted as spares, the power supply is thrown and a magnetic disk unit is made "operating", when a magnetic disk unit is so set as to be recognizable from a host unit or a magnetic disk unit for spare is used. Once a magnetic disk unit is made operating, the power supply is not cut individually until the power supply of the disk array unit is cut. In the case of a magnetic disk unit having an increased number of magnetic disk units, such as a disk array unit having several hundreds magnetic disk units connected, therefore, a power saving measure becomes indispensable.

SUMMARY OF THE INVENTION

[0010] In a disk array unit, it is not necessary to make all magnetic disk units operating, in the case where the number of accesses from the host unit is not many. Therefore, it is considered that power saving is possible by applying the above described control method. However, a time for making a magnetic disk unit "operating" upon receiving an access is required, and the performance of the disk array unit as a whole is significantly degraded. For preventing degradation of the performance, it is necessary to select and execute a power saving mode having a short return time to "operating", use a magnetic disk unit having a short time until spin up, or consider access to a memory for holding data instead of a magnetic disk unit.

[0011] Furthermore, in such a disk array unit that one set of magnetic disk units (physical unit) is not handled as one logical unit, power saving of disk array units cannot be realized by simply diverting the existing power saving mode of magnetic disk units.

[0012] In the case where there has been no access to one set of magnetic disk units (physical unit group) from the host unit or control unit for a predetermined time, one of a plurality of power saving modes is selected and the set of magnetic disk units is brought into the power saving mode. In this power saving mode, a mode for stopping the rotation of a magnetic recording medium is included.

[0013] In the case where one set of magnetic disk units (physical unit group) corresponds to two or more logical units, one of a plurality of power saving modes is selected and the set of magnetic disk units is brought into the selected power saving mode, provided that there has been no access to all of the two or more logical units from the host unit or control unit for a predetermined time.

[0014] In the case where one logical unit is defined for more than one set of magnetic disk units (physical unit group), one of a plurality of power saving modes is selected and the set of magnetic disk units is brought into the selected power saving

mode, provided that there has been no access to all magnetic disk units corresponding to the one logical unit from the host unit or control unit for a predetermined time.

[0015] In order to execute such control, there are provided a means for associating a configuration of magnetic disk units with access from the host unit, a power saving control means for selecting a power saving mode of magnetic disk units recognized by the disk array unit, and a diagnosis means for diagnosing the state of magnetic disk units. Herein, the term "diagnosis" means confirming the operation of a magnetic disk unit to determine whether the magnetic disk unit is in the usable state. For example, an online verify command is executed, and it is determined whether that command causes normal termination.

BRIEF DESCRIPTION OF THE DRAWING

[0016] FIG. **1** is an entire configuration diagram of a disk array unit according to an embodiment of the present invention;

[0017] FIG. **2** is a diagram showing a management table according to an embodiment of the present invention;

[0018] FIG. **3** is a magnetic disk unit power supply throwing operation flow chart according to an embodiment of the present invention;

[0019] FIG. **4** is a magnetic disk unit power supply cutting operation flow chart according to an embodiment of the present invention; and

[0020] FIG. **5** is a magnetic disk unit power supply diagnosis operation flow chart according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Hereafter, embodiments of a disk array unit of the present invention will be described.

[0022] FIG. **1** shows an example of the internal configuration of a disk array unit **110** connected to a host unit **101**.

[0023] The host unit **101** controls information reading and writing, and implements information reading or writing by issuing a command to the disk array unit **110**.

[0024] The disk array unit **110** includes a host interface circuit **120**, a control unit **160**, a data base transfer circuit **170**, a drive interface circuit **180**, magnetic disk units **190**, a spare magnetic disk unit **191**, an operation panel **130**, a LAN control unit **140**, and an RS 232C control unit **150**.

[0025] The control unit **160** is implemented by using a microprocessor and firmware for control. The control unit **160** includes a main control unit **161** and a timing mechanism **163** for managing time. On a memory **162** included in the control unit **160**, various management tables are arranged.

[0026] If small sized magnetic disk units which are general purpose components are used as the magnetic disk units **190** and a spare magnetic disk unit **191**, a great effect of manufacturing cost reduction is brought about. The magnetic disk units **190** are arranged in an array form so as to form a RAID (Redundant Array Inexpensive Disks) configuration (FIG. **1**).

[0027] A RAID group is formed of one column (**200**, **201**) or a plurality of columns (**202**). As for the magnetic disk units **190** forming a RAID group, a concept called RANK is introduced in order to make possible access from the host unit **101**, and a logical unit is set for each RAID group configuration. In each same RANK, the storage area of each magnetic disk unit is divided (area division).

[0028] Typically in the disk array, user data, for example, is divided in data of a suitable size (striping), distributed to magnetic disk units, and stored in them. And it is desirable for the disk array to conduct data storage and access to its own magnetic disk units uniformly. Therefore, the concept called RANK is associated with the configuration including a plurality of logical magnetic disk units. Therefore, one set of magnetic disk units can be associated with a plurality of logical disk units or with less than one logical disk unit.

[0029] Association of RANKs with logical units is determined by setting configuration information of the disk array unit **110**. It is possible to let n RANKs=one logical unit, one RANK=n logical units, or m RANKs=n logical units, In FIG. **1**, LU **0** (**210**, logical unit number **0**) is associated with RANK **0** (**200**), LU **1** (**211**) and LU **2** (**212**) are associated with RANK **1** (**201**), and LU **3** (**213**) and LU **4** (**214**) are associated with RANK n (**202**).

[0030] When a fault has occurred in the magnetic disk units **190** forming a RAID group, the spare magnetic disk unit **191** is used as a magnetic disk unit for substitution. To be concrete, a diagnosis is executed to detect a fault, and the faulty magnetic disk unit **190** is substituted for the spare magnetic disk unit **191**. In FIG. **1**, only one spare magnetic disk unit is illustrated, but it is not restrictive.

[0031] FIG. **2** shows a structure of various management tables stored on the memory **162**.

[0032] A magnetic disk unit management table **250** manages information of each of preset logical units. The preset logical unit is managed since its number is registered in "preset LUN". In the case of the configuration of the RANK n (**202**), the configuration has a plurality of columns, and consequently "management LUN" is used and a divisional branch number is registered therein for management. Furthermore, time when access to a logical unit from the host unit **101** has been received is registered in "access time". The position of the magnetic disk unit **190** in the preset logical unit is registered in "magnetic disk unit position". In the case where a plurality of logical units have been preset in the same RANK as shown in RANK n (**202**), other logical unit numbers included in the preset plurality of logical units are registered in "relating LUN". The time when the magnetic disk unit **190** has been brought into its power saving mode, or the time when the power supply of the magnetic disk unit **190** has been cut is registered in "power saving start time".

[0033] In "power saving waiting time" **260**, there is registered time to elapse since the last access from the host unit **101** was received until the magnetic disk unit **190** is brought into the power saving mode or its power supply is cut.

[0034] In "diagnosis start time" **270**, there is registered time to elapse since a magnetic disk unit **190** was brought into the power saving mode or the like until diagnosis of the magnetic disk unit **190** is started, or time when diagnosis of a magnetic disk **190** brought into the power saving mode or the like should be executed.

[0035] Hereafter, a power saving method relating to the present invention will be described by referring to flow charts (FIGS. **3**, **4** and **5**).

[0036] The host unit **101** executes an application, and stores necessary information in the disk array unit **110**. The necessary information is taken out or written into the disk array unit by read or write access, and makes a necessary function active.

[0037] When the disk array unit **110** is started, it throws the power supply of necessary magnetic disk units **190** in order to be able to respond to access from the host unit.

[0038] As for the spare magnetic disk unit **191**, typically it is not accessed by the host unit **101**. After the power supply of the spare magnetic disk unit **191** is thrown and it is confirmed that the spare magnetic disk unit **191** functions normally, therefore, the power supply is cut. Instead of cutting the power supply of the spare magnetic disk unit **191**, the spare magnetic disk unit **191** may be kept waiting in the power saving mode.

[0039] After throwing the power supply of the magnetic disk units **190** and confirming normal operation of the magnetic disk units **190**, the disk array unit **110** conducts registration of "preset LUN", "management LUN", "access time (the time when the normality of the magnetic disk units is confirmed)", "magnetic disk unit position", and "relating LUN" (FIG. **2**). In the case where the RANK n (**202**) is formed of a plurality of magnetic disk units **190**, information for dividing a logical unit into respective columns and managing the logical unit as respective columns is registered in the "management LUN". The LU **4** (**214**) is registered in the "management LUN" as LU **4-1** and LU **4-2**.

[0040] In the case where a plurality of logical units are preset in the same RANK as indicated by RANK **1** (**201**), relating LUNs are registered in the "relating LUN". In the "relating LUN" of the LU **1** (**211**), LU **2** (**212**) is registered. In the "relating LUN" of the LU **2** (**212**), LU **1** (**211**) is registered.

[0041] After registering such information, power supply cutting processing shown in FIG. **4** and diagnosis processing shown in FIG. **5** are started. Instead of the power supply cutting processing, processing for the shift to the power saving mode may be conducted. In the case of the power supply cutting processing, the effect of power saving is great. Hereafter, therefore, an embodiment will be described laying stress on the power supply cutting processing. Instead of the power supply cutting, however, selection and execution of the power saving mode may be conducted.

[0042] As for the "access time" and the "power saving start time" (power supply cutting time), they are registered by referring to the timing mechanism **163** included in the control unit **160** for the current time.

[0043] When the disk array unit **110** has received access from the host unit **101**, the power saving start time of magnetic disk units **190** belonging to a logical unit to be accessed is judged by referring to the magnetic disk unit management table **250**. In the case where the power saving start time is not registered, the access is executed in succession. In the case where the power saving start time is registered, the power supply of the magnetic disk unit is in the off state or in the power saving mode. Therefore, the power supply of the magnetic disk units **190** registered in the magnetic disk unit position of the magnetic disk unit management table **250** is thrown or the power saving mode thereof is canceled, the power saving start time is cleared, and then the access is executed. After the access execution has been finished, the access time is updated to the current time.

[0044] In the power supply cutting processing shown in FIG. **4**, the access time of magnetic disk unit management table **250** is monitored by taking a preset logical unit as the unit. As for a logical unit which has ceased to be accessed from the host unit, the time registered in the "access time" is compared with the current time. When the difference has exceeded the "power saving waiting time" **260**, magnetic disk units **190** belonging to the subject logical unit are determined on the basis of the "magnetic disk unit position" of the magnetic disk unit management table **250**, and the power supply of the magnetic disk units **190** registered in the "magnetic disk unit position" is cut or brought into the power saving mode. The time when the power supply has been cut is registered in the "power saving start time" (FIG. **2**).

[0045] In the case where the "power saving waiting time" **260** has been exceeded, it is determined whether power supply should be thrown or cut (whether the mode is the power saving mode) on the basis of the state of the LU **2** (**212**) of the registered "relating LUN". In the case where the LU **2** (**212**) has not exceeded the power saving waiting time, it is judged that the power saving start time of the magnetic disk unit management table **250** is not registered and a magnetic disk unit **190** is being used in the LU **2** (**212**). The power supply of the magnetic disk unit is not cut, or it is not brought into the power saving mode. If the LU **2** (**212**) has exceeded the power saving waiting time, then the "power saving start time" of the magnetic disk unit management table **250** has already been finished in registration, and the LU **2** (**212**) has exceeded the power saving waiting time together with the LU **1** (**211**). Therefore, the power supply of the magnetic disk units **190** in the "magnetic disk unit position" is cut. The time when the power supply has been cut is registered in the "power saving start time".

[0046] In the case where the "power saving waiting time" **260** is exceeded for the LU **4** (**214**), it is determined whether the power supply should be cut on the basis of the "management LUN" in which the LU **4** (**214**) is registered. The LU **4** (**214**) is one logical unit configuration, but it is formed of a plurality of columns of magnetic disk units **190**. Therefore, the LU **4** (**214**) is divisionally managed in the "management LUN". A first column is registered as LU **4-1**, and a second column is registered as LU **4-2**. As for the LU **4-1**, the LU **3** (**213**) is registered in its "relating LUN". In the case where the "power saving start time" of the LU **3** (**213**) is not registered, therefore, the power supply of the magnetic disk units **190** of the first column is not cut, because the magnetic disk units are used in the LU **3** (**213**). As for the LU **4-2**, there are no relating LUs, and consequently the power supply of magnetic disk units **190** of the second column is cut. The time when the power supply has been cut is registered in the "power saving start time". In this way, in the LU **4**, it is made possible to cut the power supply of a part of a group of magnetic disk units forming one logical unit or shift the power supply of the part of the group into the power saving mode.

[0047] In the diagnosis processing of FIG. **5**, the "power saving start time" of the magnetic disk management table **250** is monitored by taking a preset logical unit as the unit. The time registered in the "power saving start time" is compared with the current time. When the difference has exceeded the "diagnosis start time" **270**, magnetic disk units **190** belonging to the subject logical unit are determined from the "magnetic disk unit position" of the magnetic disk unit management table **250**, and diagnosis of the magnetic disk units **190** registered in the "magnetic disk unit position" is executed. After the diagnosis has been finished, the power saving mode is started.

[0048] In the case where a diagnosis is executed, access processing from the host unit **101** is given priority. When

access has been received, the diagnosis is stopped and access is executed. After the access processing has been finished, the diagnosis is resumed.

[0049] As for the diagnosis of the magnetic disk units **190**, time of twenty-four hour clock is registered in the "diagnosis start time" **270**. Instead of referring to the time elapsed since the power supply is cut, when the registered time is reached, the diagnosis is started. Alternatively, the diagnosis may be started on the basis of the time elapsed since the power supply is cut.

[0050] In the case where a diagnosis is executed, access processing from the host unit **101** is given priority. When access has been received, the diagnosis is stopped and access is executed. After the access processing has been finished, the diagnosis is resumed. Diagnoses for magnetic disk units of a logical unit registered in the magnetic disk unit management table **250** are executed simultaneously by taking a logical unit as the unit. In the case where a logical unit is formed of a plurality of columns, diagnosis is executed by taking, as the unit, a "management LUN" of management conducted by taking a column as the unit. Diagnoses of as many magnetic disk units **190** as the number of magnetic disk units in a maximum column configuration are conducted simultaneously. In the case of the configuration of FIG. **1**, diagnoses of five magnetic units including two magnetic disk units which are not illustrated are conducted simultaneously in each RANK. In the case where, for example, four magnetic disk units are mounted on one RANK, diagnoses of the four magnetic disk units are conducted simultaneously. This aims at checking logical magnetic disk units functioning as a disk array of that RANK before use.

[0051] Although it is a special embodiment, the present invention can also be applied to a disk array having only one magnetic disk unit in one RANK. In this case, one set of magnetic disk units is formed of one magnetic disk unit.

[0052] Diagnosis of the spare magnetic disk unit **191** is conducted when a fixed time has elapsed. In the case where time of twenty-four hour clock is registered in the "diagnosis start time" **270**, the diagnosis of the spare magnetic disk unit **191** may be conducted when the registered time has been reached.

[0053] The "power saving start time" **260** and the "diagnosis start time" can be altered from the host command, operation panel **130**, the LAN port **140**, and the RS 232C port. When a directive of alteration has been received, information of the memory **162** is updated. Alteration according to a host command is conducted by a vendor unique command directing alteration of such information. Alteration using the operation panel **130** is conducted by displaying an alteration setting menu of such information and making an operator inputting a value to be altered. Alteration using the LAN port and the RS 232C port is conducted by prescribing a specific interface, burying information to be altered into the interface, and sending information from a device to which the LAN and the RS 232C are connected. The altered information is written into the memory **162** when an alteration directive is given. When writing has been finished, the altered information is made effective.

[0054] The present invention can suppress the power consumption of magnetic disk units mounted on the disk array unit. Furthermore, since the subjects are magnetic disk units which are not accessed from the host unit, it is made possible to save energy while preventing significant performance degradation. Furthermore, by conducting a diagnosis on magnetic disk units cut in the power supply, it is possible to confirm the reliability of magnetic disk units which are often susceptible to power supply cutting.

[0055] To be more concrete, in one magnetic disk unit requiring electric power of 20 W at the time of rotation start, its electronic circuit consumes 5.5 W at the time of read/write, and consumes 3.5 W at the time of read/write idle. A spindle of that magnetic disk unit consumes electric power in the range of 4 to 5 W at the time of idle rotation. If in this case the power saving mode for stopping the function of the electronic circuit is selected, the power consumption of at least 3.5 W is prevented. If the rotation of the spindle is also stopped, power consumption in the range of 4 to 5 W is prevented in addition.

[0056] Actually, power saving is conducted by taking a RANK as the unit. If the electronic circuit of one RANK is in the power saving mode in a disk array having a five column configuration, power consumption of approximately 18 W is prevented, If the rotation of the spindle is also stopped, power consumption in the range of 20 to 25 W is prevented. According to use of the disk array unit, these numerical values increase or decrease. For example, because of a change in access demand between day and night in twenty-four hour continuous running and execution time of the power saving mode consequent thereupon, the power saving effect becomes great.

What is claimed is:

1. A disk array unit connected to a host unit to give information thereto and receive information therefrom, said disk array unit comprising

a plurality of disk units for storing information transmitted from said host unit; and

a management information recording device, formed by utilizing information storage areas in the plurality of disk units, for causing information relating to a logical unit for storing information transmitted from said host unit to correspond to information relating to the plurality of disk units; and

a control unit, when there is no access from said host unit to said logical unit for a predetermined time, for determining said plurality of disk units corresponding to said logical unit based on information recorded in said management information recording device and performing power saving of power supply for said plurality of disk units.

* * * * *