Title of the Invention: Device and method for controlling writing of data

Abstract Title: Device and method for controlling writing of data

Provided are a device and method for controlling writing of data, whereby a target amount of data is written to a tape medium, said target amount being a nominal capacity minus an amount of capacity lost by not backhitching. In the provided tape drive controller (16), when a command processing unit (41) receives a synchronization command, a buffer management unit (42) hands over data from a buffer to a channel I/O unit (43), and a write to a tape finishes, a backhitch determination unit (44) then determines whether the following conditions are fulfilled: information indicating a high-data-rate mode is stored in a mode information storage unit (45); of a nominal capacity, it is possible to write a target amount of data to the tape, said target amount being stored in a target amount storage unit (46); and it is possible to read the written data at a target read-out data rate. An operation signal output unit (48) gives an instruction to backhitch only in the case in which it is determined that the aforementioned conditions are not fulfilled.
[Figure 3]
Start

WRITE LAST DATASET

BACKHITCH DETERMINATION PROCESSING

SWBF CAN BE EXECUTED?

Yes

DETERMINE TO EXECUTE SWBF

START BACKHITCH

No

REPORT COMPLETION OF SYNC COMMAND

STORE DATASET INTO BUFFER

DATASETS ARE SUFFICIENT?

Yes

GIVEN TIME PERIOD PASSES?

Yes

START BACKHITCH

No

WAIT SOME TIME

Yes

START BACKHITCH

No

START WRITING OF DATASETS

STORE Accumulated_Interval AND SpeedX

End
[Figure 6]

Start

ACQUIRE MODE INFORMATION

S501

HIGH DATA RATE MODE IS ON?

No

Yes

ACQUIRE TARGET CAPACITY

S503

ACQUIRE C, T, r, x, n AND L

S504

(C*r - n)*L < T - x?

No

Yes

ACQUIRE Target_Data_Size, Target_Read_Data_Rate,
Read_Data_Rate_with_Speed1, Accumulated_Interval,
Speed_X, AND Speed1

Threshold = Target_Data_Size/Target_Read_Data_Rate
- Target_Data_Size/Read_Data_Rate_with_Speed1
- Accumulated_Interval * Speed_X/Speed1

S505

S506

Threshold > 0?

No

Yes

SET DETERMINATION RESULT TO EXECUTION OF SWDF

S508

S509

SET DETERMINATION RESULT TO EXECUTION OF BACKHITCH

End
Start

WRITE LAST DATASET

BACKHITCH DETERMINATION PROCESSING

SWBF CAN BE EXECUTED?

Yes

DETERMINE TO EXECUTE SWBF

START BACKHITCH

START BACKHITCH

REPORT COMPLETION OF SYNC COMMAND

STORE DATASET INTO BUFFER

DATASETS ARE SUFFICIENT?

No

GIVEN TIME PERIOD PASSES?

No

WAIT SOME TIME

Yes

START BACKHITCH

Dataset INTERVAL IS SHORT?

No

START BACKHITCH

Yes

START WRITING OF DATASETS

End
[Figure 8]

Start

ACQUIRE MODE INFORMATION

S551

HIGH DATA RATE MODE IS ON?

S552

Yes

ACQUIRE TARGET CAPACITY

S553

ACQUIRE C, T, r, x, n AND L

S554

(C*r - n)*L < T - x?

S555

No

Yes

ACQUIRE Tx_Size, Target_Read_Data_Rate, X, AND Read_Data_Rate_with_Speed1

S556

Threshold = Tx_Size/Target_Read_Data_Rate - (Tx_Size + X)/Read_Data_Rate_with_Speed1

S557

Threshold > 0?

S558

No

Yes

SET DETERMINATION RESULT TO EXECUTION OF SWBF

S559

SET DETERMINATION RESULT TO EXECUTION OF BACKHITCH

S560

End
<table>
<thead>
<tr>
<th>READ DATA RATE</th>
<th>TAPE SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>140MB/sec</td>
<td>Speed1</td>
</tr>
<tr>
<td>120MB/sec</td>
<td>Speed2</td>
</tr>
<tr>
<td>100MB/sec</td>
<td>Speed3</td>
</tr>
<tr>
<td>80MB/sec</td>
<td>Speed4</td>
</tr>
<tr>
<td>60MB/sec</td>
<td>Speed5</td>
</tr>
</tbody>
</table>
The present invention relates to an apparatus and method for controlling data writing. In particular, the present invention relates to an apparatus and method for controlling data writing to a tape medium.

A drive to write data to magnetic tapes such as with LTO (Linear Tape Open) format receives synchronization commands from a host (an application program) periodically during write. The synchronization command is a command to force write data accumulated in a tape drive buffer to a tape medium. The reason why the drive receives periodically the synchronize command is for an application program to know (assure) that all data sent to the tape drive is already written to the tape medium and is not left any more in the buffer in the tape drive.

When the tape drive receives a synchronization command, the tape drive buffer becomes empty. Then, the tape drive usually performs "backhitch." The backhitch is a series of operations including stopping the transport of the tape medium once, rewinding the tape medium in a reversed direction, thereafter transporting the tape medium again in the original direction to the target position to restart writing the next data.

This backhitch usually requires approximately two or three seconds. Since the writing of next data starts after
completion of this backhitch, frequent synchronization commands causes considerable degradation in write performance.

To address this problem, there have been heretofore proposed techniques of writing without execution of backhitch (for example, see Patent Literatures 1 to 3).

Patent Literature 1 describes an apparatus including a host I/F unit to store a dataset sent from a host into a buffer memory, as well as to send the dataset to the host, and a medium I/F unit to take out a dataset stored in the buffer memory and to transfer the dataset to a tape, as well as to store a dataset read from a tape into the buffer memory. The apparatus acquires a data rate with the host from the host I/F unit, acquires an error rate in writing to the tape from the medium I/F, determines a tape speed based on the data rate and the error rate, and performs control to transport the tape with the determined speed.

Patent Literature 2 describes a storage apparatus to sequentially write multiple sets of write data to a data recording medium in segment units of a predetermined size. For each of sets of write data, the storage apparatus writes the set of write data to at least one segment of the data recording medium when the set of write data is received in association with a write command to write the set of write data to the data recording medium. In the case where the size of one set of write data is smaller than a prescribed size that is determined in advance, the storage apparatus concatenates the one set of write data and multiple sets of write data written after the
one set of write data, among the multiple sets of write data sequentially written to the data recording medium, and then writes the concatenated sets of write data to a smaller number of segments than the number of segments originally required to write the sets of write data targeted for the concatenation. In addition, according to Patent Literature 2, the storage apparatus performs backhitchless flush of writing write data to a tape recording medium without executing backhitch, and thereby operates with a higher speed than in the case of executing the backhitch.

[C0005]

Patent Literature 3 discloses a helical scan tape recorder including a rotatable scanner, and a transport system for transporting a magnetic tape to a position proximate to the rotatable scanner in a manner so that information can be recorded during a revolution of the scanner. In the helical scan tape recorder, a controller performs, as a pause routine for pausing during a recording operation on the tape, the steps of: determining a tape pause position reference value indicative of a pre-pause last recording position on the tape; recording an erase signal on the tape after the pre-pause last recording position; rewinding the tape; transporting the tape in a forward direction and obtaining a current tape position value; determining when the current tape position value reaches a predetermined value relative to the tape pause position reference value; and at beginning of a next revolution of the scanner, commencing recording of one or more post-pause stripes on the tape.

[Citation List]

[Patent Literature]
[0006]

[Summary of Invention]

[Technical Problem]

[0007]
In the case of resuming writing of a next dataset while transporting the tape medium without execution of backhitch, however, an interval occurs between the dataset lastly written in response to a synchronization command, and the subsequently written dataset, and the capacity is decreased because no data can be written to the portion of the interval. This capacity decrease, if occurs, causes a problem that a data capacity (nominal capacity) which is publicly guaranteed as an amount of data writable to a tape medium is not writable to the tape medium. None of the literatures describes a method for solving such a problem.

[0008]

An objective of the present invention is to enable writing a target capacity of data to a tape medium, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

[Solution to Problem]

[0009]

To achieve the above objective, the present invention
provides an apparatus of controlling writing of data to a tape medium, the apparatus including: a storage unit that stores mode information indicating a mode of the apparatus; and a determination unit that determines to write a target capacity of data to the tape medium when the mode information stored in the storage unit indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

[0010]

Here, the determination unit may determine not to execute backhitch after writing first data to the tape medium until writing second data next to the first data to the tape medium, under one condition that the target capacity of data is expected to be written to the tape medium.

Moreover, the determination unit may determine not to execute backhitch after writing the first data to the tape medium until writing the second data to the tape medium, under one condition that a read data rate from the tape medium is expected to satisfy a target read rate.

In this case, the determination unit may determine that the read data rate from the tape medium will satisfy the target read rate when the sum of a time required to read unit data written to the tape medium with a maximum speed achievable by the apparatus and a time required to skip an area on the tape medium where no data is written because the tape medium is transported without execution of backhitch is shorter than a time required to read the unit data at the target read rate.

Instead, the determination unit may determine that the read data rate from the tape medium will satisfy the target
read rate when a time required to read unit data written to the tape medium and an amount of data corresponding to an area on the tape medium where no data is written because the tape medium is transported without execution of backhitch is shorter than a time required to read the unit data at the target read rate.

In addition, in response to loading of a tape cartridge containing the tape medium, the storage unit may store the mode information indicating the particular mode according to an instruction from an application program configured to write data to the medium.

Instead, in response to loading of a particular tape cartridge containing the tape medium, the storage unit may store the mode information indicating the particular mode.

Further, the present invention also provides an apparatus of controlling data writing to a tape medium, the apparatus including: a storage unit that stores mode information indicating a mode of the apparatus; and a determination unit that determines to write a target capacity of data to the tape medium, without executing backhitch after writing first data to the tape medium until writing second data next to the first data to the tape medium in a case where the mode information stored in the storage unit indicates a particular mode, where the target capacity of data is expected to be written to the tape medium, and where a read data rate from the tape medium is expected to satisfy a target read rate, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of
backhitchless writing.

[0013]

Still further, the present invention also provides a method of controlling writing of data to a tape medium, including the steps of: storing mode information indicating a mode of the apparatus into a memory; and determining to write a target capacity of data to the tape medium when the mode information stored in the memory indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

[0014]

Furthermore, the present invention also provides a program causing a computer to function as an apparatus of controlling writing of data to a tape medium, the program causing the computer to function as: a unit to store mode information indicating a mode of the apparatus into a memory; and a unit to determine to write a target capacity of data to the tape medium when the mode information stored in the memory indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

[Advantageous Effect of Invention]

[0015]

The present invention enables writing of a target capacity of data to a tape medium, the target capacity calculated by a nominal capacity minus a data capacity lost due to execution of backhitchless writing.

[Brief Description of Drawings]

[0016]
[Fig. 1] Fig. 1 is a block diagram illustrating a configuration of a tape drive to which an embodiment of the present invention is applied.

[Fig. 2] Fig. 2 is a diagram for explaining interval-based control as a kind of control for a read data rate according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is a diagram for explaining transaction-size-based control as a kind of control for the read data rate according to the embodiment of the present invention.

[Fig. 4] Fig. 4 is a block diagram illustrating a functional configuration example of a controller according to the embodiment of the present invention.

[Fig. 5] Fig. 5 is a diagram illustrating a first operation example of the controller according to the embodiment of the present invention.

[Fig. 6] Fig. 6 is a diagram illustrating a first operation example of a backhitch determination unit of the controller according to the embodiment of the present invention.

[Fig. 7] Fig. 7 is a diagram illustrating a second operation example of the controller according to the embodiment of the present invention.

[Fig. 8] Fig. 8 is a diagram illustrating a second operation example of the backhitch determination unit of the controller according to the embodiment of the present invention.

[Fig. 9] Fig. 9 is a diagram illustrating correspondence between the read data rate and a tape speed.

[Description of Embodiment]

Hereinafter, an embodiment of the present invention will
be described in detail with reference to the accompanying drawings.

Fig. 1 is a diagram illustrating a configuration example of a tape drive 10 to which the embodiment of the present invention is applied. This tape drive 10 includes a host interface (hereinafter, referred to as "host I/F") 11, a buffer 12, a channel 13, a head 14, and a motor 15. In addition, the tape drive 10 includes a controller 16, a head position control system 17, and a motor driver 18. Moreover, Fig. 1 also illustrates a tape cartridge 20, because the tape cartridge 20 is loadable in the tape drive 10 by being inserted thereinto. This tape cartridge 20 includes a tape 23 wound around reels 21 and 22. With rotations of the reels 21 and 22, the tape 23 is transported in a longitudinal direction, i.e., in a direction from the reel 21 to the reel 22 or a direction from the reel 22 to the reel 21. Note that, a magnetic tape is illustrated as the tape 23, but any tape medium other than the magnetic tape is usable.

Here, the host I/F 11 communicates with a host 29 that is an example of an upper level apparatus from the tape drive 10. For example, the host I/F 11 receives a command to write data to the tape 23, a command to read data from the tape 23, a command to transport the tape 23 to position a target location, and a command (a synchronization command) to forcibly write data stored in the buffer 12 to the tape 23. Here, SCSI is illustrated as a communication protocol standard used by the host I/F 11. In the case of SCSI, the first command corresponds to a Write command, the second command corresponds to a Locate command or a Space command, the third command corresponds to
a Read command, and the fourth command corresponds to a WriteFM non-immediate command. In addition, the host I/F 11 returns to the host 30 a reply indicating a success or failure of processing in response to any of these commands.

The buffer 12 is a memory in which data to be written to the tape 23 and data read from the tape 23 are accumulated. For example, the buffer 12 is formed of a DRAM (Dynamic Random Access Memory). In addition, the buffer 12 includes multiple buffer segments, and each of the buffer segments stores a dataset that is a unit of data to be written to and read from the tape 23. The channel 13 is a data path to send data from the head 14 to the tape 23, and to receive data read from the tape 23 to the head 14.

The head 14 writes data to the tape 23 or reads data from the tape 23 while the tape 23 is moving in the longitudinal direction.

The motor 15 rotates the reels 21 and 22. Incidentally, although Fig. 1 illustrates one rectangle for the motor 15, it is preferable to provide two motors 15 in total for the reels 21 and 22, respectively, on a one-to-one basis.

Meanwhile, the controller 16 controls the whole of the tape drive 10. For example, the controller 16 controls data write to the tape medium and data read from the tape 23 in accordance with commands received by the host I/F 11. In addition, the controller 16 controls the head position control system 17 and the motor driver 18.

The head position control system 17 is a system to track desired one or more wraps. Here, the term wrap means a group
of tracks on the tape 23. When the wrap needs to be switched to another one, the head 14 also needs to be switched electrically. Thus, the head position control system 17 controls such a switching operation.

The motor driver 18 drives the motor 15. If the two motors 15 are used as described above, two motor drivers 18 are provided as well.

[0021]

In the embodiment of the present invention, even when receiving a synchronization command, the tape drive 10 having the above configuration continuously transports the tape 23 without executing backhitch, and writes next data to the same wrap. This method of writing data to the same wrap without executing backhitch is referred to as SWBF (Same Wrap Backhitchless Flush) or Skip Sync, and is called SWBF in the following description.

For this method, the embodiment of the present invention prepares "a high data rate mode" (one example of a specific mode) supposed to write a target capacity that is smaller than a nominal capacity, instead of aiming to write the nominal capacity. Here, the target capacity means a capacity obtained by subtracting a preset margin for SWBF. In a tape cartridge 20 having a nominal capacity of 1.5 TB, for example, the target capacity is 1.0 TB if the margin of the tape 23 is set to 0.5 TB. In this case, the high data rate mode aims to write 1.0 TB or more of data.

[0022]

Implementation of this high data rate mode requires the following technical mechanisms. The first mechanism is capacity control. In this control, whether or not to execute
backhitch is determined in order to write data of the preset target capacity or more.

The second mechanism is control for a read data rate. In this control, whether or not to execute backhitch is determined in consideration of the read data rate.

The third mechanism is control for the high data rate mode. In this control, a timing when the tape drive 10 is switched to the high data rate mode is determined.

[0023]

Hereinafter, these controls will be described one by one.

<Capacity Control>

The tape drive 10 has a predetermined target capacity of the tape cartridge 20 in addition to the nominal capacity thereof.

Then, upon receipt of a synchronization command, the tape drive 10 judges whether the following formula 1 holds (is TRUE) or does not hold (is FALSE).

If it is judged as TRUE as a result, the tape drive 10 determines that there is a margin large enough to write the target capacity of data to the tape 23, and waits for transmission of next data from the host 31 without executing backhitch. Then, if next data is prepared within a specified time, the tape drive 10 resumes writing data. If the next data is not ready within the specified time, the tape drive 10 executes backhitch, and when the next data is prepared, writes the next data to the tape 23 at a location immediately after the data lastly written.

On the other hand, if it is judged as FALSE, the tape drive 10 executes backhitch as usual, and waits for transmission of next data from the host 30.
(Formula 1) \((C \times r - n) \times L < T - x\)

Here, variables are defined as follows.

- \(C\) denotes the total number of datasets for the case of a nominal capacity of 1.5 TB. When the dataset size is 2.4 MB, for example, \(C = 1.5TB / 2.4MB = 625000\). \(T\) denotes an effective tape length and is a value calculated by the total tape length minus a length of an end warning area. Here, the end warning area is located near an end of the tape 23, and is an area for returning a warning called "Early Warning" to the host 30 so that all the data stored in the buffer 12 can be written to the tape 22 before the end thereof.
- \(r\) denotes an SWBF margin ratio, and is a value obtained by dividing the length of the margin for SWBF by \(T\). When the target capacity is 1.0 TB and the nominal capacity is 1.5 TB, for example, \(r = 2/3\).
- \(x\) denotes a final dataset location, that is, a physical location of a dataset lastly written \((0 < x < T)\).
- \(n\) denotes a final dataset number, that is the number of the dataset lastly written.
- \(L\) denotes a dataset length. Here, a dataset is rewritten if a writing error occurs. \(L\) is a dataset length without consideration of such rewriting of the dataset.

By judging to execute backhitch by use of the above formula 1, the data derive 10 can aim to write the target capacity of data or more to the tape 23, and can reduce the occurrence frequency of backhitch executed in response to synchronization commands.
Control for Read Data Rate

Frequent execution of SWBF may significantly decrease a data rate in reading datasets from the tape 23 due to widening of intervals between the datasets written to the tape 23. Here, consider the case where synchronization commands are received in units of 24 MB, and where SWBF is executed for each synchronization command if the formula 1 is true, for example. In this case, if one dataset is of 2.4 MB, 10 datasets are collectively written to the tape 23, then SWBF is executed, and then a next dataset is written with a dataset interval spaced out. Here, the dataset interval between the 10 datasets collectively written is very short, but the dataset interval spaced out when SWBF is executed is very long (for example, 3 m).

In general, the maximum data rate in reading described in the specifications of the tape drive 10 is determined by a line density/a maximum tape speed. The line density is a dataset size/a dataset length, and is determined without consideration of the dataset interval on the tape 23 generated by SWBF. If the maximum tape speed is 5.987 m/sec for the tape drive 10 capable of usually reading with 140 MB/sec, the read data rate in the above case is 35 MB/sec as a result of calculations as described below:

\[
\text{SWBF overhead} = \frac{3[\text{m}]}{5.987[\text{m/sec}]} = 0.501[\text{sec}];
\]

\[
\text{read time of 10 datasets} = \frac{10 \times 2.4[\text{MB}]}{140[\text{MB/sec}]} = 0.171[\text{sec}]; \text{ and}
\]

\[
\text{average read time} = \frac{\text{data amount of read target data}}{(\text{SWBF overhead} + \text{read time of 10 datasets})} = \]
10×2.4[MB]/(0.501[sec]+0.171[sec]) = 35[MB/sec].

[0029]

Here, it cannot be denied that there are users who are concerned about a significant degradation of read performance, no matter how write performance is increased.

For this reason, the embodiment of the present invention judges to execute SWBF in data writing, in consideration of a tolerable level of degradation in the read performance.

Such control methods for the read data rate are roughly classified into two control methods.

[0030]

The first method is an interval-based control method. The distance between datasets can be controlled by control of an interval that is a wait time for preparation of next data. In this way, the number of datasets within a certain length can be controlled and thereby the read data rate can be controlled.

Specifically, Threshold derived by using the following formula 2 is controlled to control the read data rate. In the tape drive 10 followed by LTO format, the maximum dataset distance is 4 m. If the read data rate is not taken into consideration, the tape drive 10 may continue to wait for preparation of next data until 4 m of the tape passes after the above formula 1 is judged as TRUE. However, the tape drive 10 controls the read data rate by controlling the wait time for the preparation of the next data to control by use of the following formula. To be more specific, the tape drive 10 executes SWBF if Threshold in the formula 2 is larger than 0, and does not execute SWBF if Threshold is equal to or smaller than 0.
(Formula 2) Threshold = 
\[ \frac{\text{Target}_\text{Data}_\text{Size}}{\text{Target}_\text{Read}_\text{Data}_\text{Rate}} - \frac{\text{Target}_\text{Data}_\text{Size}}{\text{Read}_\text{Data}_\text{Rate}_\text{with}_\text{Speed1}} - \text{Accumulated}_\text{Interval} \times \frac{\text{Speed}_\text{X}}{\text{Speed1}}. \]

Here, the variables are defined as follows. 

- \( \text{Target}_\text{Data}_\text{Size} \): denotes a size of unit data for performance measurement. 
- \( \text{Target}_\text{Read}_\text{Data}_\text{Rate} \): denotes a read data rate to be achieved. 
- \( \text{Read}_\text{Data}_\text{Rate}_\text{with}_\text{Speed1} \): denotes a read data rate in the case where the tape 22 is transported with the maximum speed. In other words, the tape drive 10 is supposed to provide higher \( \text{Read}_\text{Data}_\text{Rate}_\text{with}_\text{Speed1} \) than \( \text{Target}_\text{Read}_\text{Data}_\text{Rate} \) per unit data. 
- \( \text{Accumulated}_\text{Interval} \): denotes a time generated by SWBF during writing of data of \( \text{Target}_\text{Data}_\text{Size} \), and specifically denotes a cumulative total of times, each generated after completion of writing in response to a synchronization command until start of writing next data, during the writing of the data of \( \text{Target}_\text{Data}_\text{Size} \). 
- \( \text{Speed}_\text{X} \): denotes a tape speed in writing during the execution of SWBF. Since \( \text{Accumulated}_\text{Interval} \) is a time measured during data writing, a time required for skip reading with speed1 is obtained by converting \( \text{Accumulated}_\text{Interval} \) by use of \( \text{Speed}_\text{X} \) of the tape speed at the above data writing. 

For example, assume that 
\[
\text{Target}_\text{Data}_\text{Size} := 100 \text{ MB}, \\
\text{Target}_\text{Read}_\text{Data}_\text{Rate} := 100 \text{ MB/sec}, \\
\text{Read}_\text{Data}_\text{Rate}_\text{with}_\text{Speed1} := 142 \text{ MB/sec}, \\
\text{Speed}_\text{X} := \text{Speed1}
\]
= 5.987 m/sec, a transaction size (an amount of data written to the tape 23 in response to a single synchronization command) is 10 MB, and every interval between transactions (each transaction is data writing to the tape 23 in response to a single synchronization command) is 0.1 sec.

When 10MB of data is written in response to a first synchronization command, Threshold is calculated as Threshold = 100/100 - 100/142 - 0 = 0.29 sec. In this case, since Threshold is larger than 0, SWBF is executed.

Then, after 0.1 seconds, 10MB of data is written in response to a second synchronization command. At this time, Threshold is calculated as Threshold = 100/100 - 100/142 - 0.1 = 0.19 sec. Also in this case, Threshold is larger than 0 and SWBF is executed.

Then, when 10MB of data is written in response to a third synchronization command after 0.1 seconds, Threshold is calculated as Threshold = 100/100 - 100/142 - 0.2 = 0.09 sec. In this case, Threshold is larger than 0 and SWBF is executed as well.

Further, when 10 MB of data is written in response to a fourth synchronization command after 0.1 seconds, Threshold is calculated as Threshold = 100/100 - 100/142 - 0.3 = -0.91 sec. In this case, since Threshold is equal to or smaller than 0, SWBF is not executed.

[0033]

In other words, when a time after the execution of SWBF until the completion of preparation of next data is short constantly, SWBF is executed because the read data rate is not influenced much even though synchronization commands are frequently received.
However, if a time after the execution of SWBF until the completion of preparation of next data is long, the wait time for preparation of next data is made short in the next execution of SWBF. In this way, the target value of the read data rate is controlled.

(0034)

This interval-based control method will be described with reference to the following drawing.

Fig. 2 is a diagram illustrating a portion of the tape 23 to which the unit data for performance measurement is written.

In the drawing, four areas where datasets are written are illustrated by diagonal hatching. The data sizes written to the respective areas are called D1, D2, D3, and D4, respectively, from the left side. In other words, Target_Data_Size = D1 + D2 + D3 + D4. Then, a time required to read these datasets at the read data rate Read_Data_Rate_with_Speed1 that is the maximum speed achievable by the tape drive 10 is

\[
\frac{D1}{\text{Read\_Data\_Rate\_with\_Speed1}} + \frac{D2}{\text{Read\_Data\_Rate\_with\_Speed1}} + \frac{D3}{\text{Read\_Data\_Rate\_with\_Speed1}} + \frac{D4}{\text{Read\_Data\_Rate\_with\_Speed1}}.
\]

In addition, three areas where no data is written due to execution of SWBF are present between these datasets. Times required to skip these areas with the maximum tape speed achievable by the tape drive 10 (the tape speed corresponding to the maximum read data rate) are called Interval1, Interval2 and Interval3, respectively. In other words, Accumulated_Interval_X/Speed1 = Interval1 + Interval2 + Interval3.
In the above case, by reading data with the maximum tape speed, the datasets can be read for a time specified by \( \frac{\text{Target\_Data\_Size}}{\text{Read\_Data\_Rate\_with\_Speed1}} + \frac{\text{Accumulated\_Interval}}{\text{Speed\_X}}/\text{Speed1} \). Therefore, if this time is shorter than \( \frac{\text{Target\_Data\_Size}}{\text{Target\_Read\_Data\_Rate}} \), it can be concluded that the unit data can be read at the target read data rate.

[0035]

The second method is a transaction-size-based control method.

In this control, SWBF is not executed if a transaction size is small or if the size of accumulated data is small. In this way, the number of datasets within a certain length can be controlled and thereby the read data rate can be controlled.

Specifically, Threshold derived from the following formula 3 is controlled to control the read data rate. To be more specific, the tape drive 10 executes SWBF if Threshold in the formula 3 is larger than 0, and does not execute SWBF if Threshold is equal to or smaller than 0.

[0036]

(\text{Formula 3}) \quad \text{Threshold} = \frac{\text{Tx\_Size}}{\text{Target\_Read\_Data\_Rate}} - \frac{(\text{Tx\_Size} + \text{X})}{\text{Read\_Data\_Rate\_with\_Speed1}}

Here, the variables are defined as follows.

\text{Tx\_Size} denotes a transaction size, that is, an amount of data written to the tape 23 in response to a single synchronization command as described above.

\text{Target\_Read\_Data\_Rate} denotes a read data rate to be achieved.

\text{X} denotes an amount of data readable from a maximum idle transport length after SWBF, and is X =
Read Data Rate with Speed1 = Max Interval / Tape Speed. Here, Max Interval is the maximum idle transport length after SWBF, and is 4 m for the tape drive 10 in conformity with LTO. In addition, Tape Speed denotes a current speed of tape 23.

Read Data Rate with Speed1 denotes a read data rate in the case where the tape 23 is transported with the maximum speed.

[0037]

For example, assume that Target Read Data Rate := 100, Read Data Rate with Speed1 := 142 MB/sec, Max Interval := 4 m, and Tape Speed := 5.987 m/sec.

If the transaction size is 230 MB, Threshold is calculated as Threshold = 230/100 - (230 + 142*4/5.987)/142 = 0.012 sec. In this case, since Threshold is larger than 0, SWBF is executed.

If the transaction size is 220 MB, Threshold is calculated as Threshold = 220/100 - (220 + 142*4/5.987)/142 = -0.017 sec. In this case, since Threshold is equal to or smaller than 0, SWBF is not executed.

[0038]

This transaction-size-based control method will be described with reference to the following drawing.

Fig. 3 is a diagram illustrating a portion of the tape 23 including an area to which data for one transaction is written and an area to which no data is written due to execution of SWBF.

In the drawing, the area to which data is written is shown by diagonal hatching. The data size written to this area, that is, the transaction size is called Tx Size. Then, a time required to read this data at the maximum read data rate
Read_Data_Rate_with_Speed1 achievable by the tape drive 10 is 
Tx_Size/Read_Data_Rate_with_Speed1. In addition, the data 
size writable to the area to which no data is written due to 
exection of SWBF is called X. Then, a time required to read 
this data at the maximum read data rate 
Read_Data_Rate_with_Speed1 achievable by the tape drive 10, 
that is, a time required to skip this area is 
X/Read_Data_Rate_with_Speed1.

In the above case, by data reading with the maximum tape 
speed, the data for one transaction (that is interpretable as 
unit data) can be read for a time specified by (Tx_Size + 
X)/Read_Data_Rate_with_Speed1. Therefore, if this time is 
shorter than Tx_Size/Target_Read_Data_Rate, it can be 
concluded that data for one transaction can be read at the 
target read data rate. 

[0039]

<Control for High Data Rate Mode>

In order to prepare the high data rate mode for the tape 
drive 10, a consideration needs to be taken as to a timing of 
setting the tape drive 10 to the high data rate mode.

The followings methods are possible methods of setting 
the tape drive 10 to the high data rate mode.

In the first method, the tape drive 10 is set to the high 
data rate mode every time an application program loads the tape 
cartridge 20. Specifically, in response to loading of the tape 
cartridge 20, the tape drive 10 is set to the high data rate 
mode according to an instruction from the application program 
configured to write data to the tape 23.

In the second method, the tape drive 10 records, in an 
internal non-volatile memory, that the tape drive 10 is set
in the high data rate mode, and operates in the high data rate mode in a manner transparent to the application program. In this case, the recording that the tape drive 10 is set in the high data rate mode in the non-volatile memory may be performed prior to shipment of the tape drive 10, or may be performed by using a tool or the like at any timing after the shipment of the tape drive 10.

In the third method, when a particular tape cartridge 20 is loaded, the tape drive 10 is set to the high data rate mode.

[0040]

Next, description will be provided for a functional configuration of the controller 16 to implement these operations.

Fig. 4 is a block diagram illustrating a functional configuration example of the controller 16.

As illustrated in the drawing, the controller 16 includes a command processing unit 41, a buffer management unit 42, a channel input-output unit 43, a backhitch determination unit 44, a mode information storage unit 45, a target capacity storage unit 46, a history storage unit 47 and an operation signal output unit 48.

[0041]

Among them, the command processing unit 41 receives commands from the host I/F 11. The commands mentioned herein include, for example, a Write command to store data into the buffer 12, and a synchronization command (a WriteFM command or the like) to write data stored in the buffer 12 to the tape 23.

The buffer management unit 42 prepares data in the buffer
12 in the case where the command processing unit 41 receives a Write command. In addition, in the case where the command processing unit 41 receives a synchronization command, the buffer management unit 42 reads data from the buffer 12, and outputs the data to the channel input-output unit 43. The channel input-output unit 43 outputs data read from the buffer 12 by the buffer management unit 42 to the channel 13 or stores data received from the channel 13 into the buffer 12.

[0042]

The backhitch determination unit 44 determines whether or not to execute backhitch in order to write the target capacity to the tape 23 and to ensure the target read data rate. In the present embodiment, the backhitch determination unit 44 is provided as an example of a determination unit to determine to write a target capacity of data to a tape medium and determine not to execute backhitch.

The mode information storage unit 45 stores mode information indicating whether or not the tape drive 10 is currently set to the high data rate mode. In the present embodiment, the mode information storage unit 45 is provided as an example of a storage unit to store mode information.

The target capacity storage unit 46 stores information of the target capacity that should be written out of the nominal capacity of the tape 23.

The history storage unit 47 stores history information including information such as the size and position of each of datasets written to the tape 23 in the past and a distance between the datasets. Here, the history information may include information (for example, information on error occurrence) other than the above kinds.
The operation signal output unit 48 outputs to the motor driver 18 a signal instructing the motor driver 18 to perform an operation determined by the backhitch determination unit 44.

[0043]

Next, operations of the controller 16 will be described.

Fig. 5 is a flowchart illustrating a first operation example of the controller 16. This first operation example corresponds to the interval-based control method in the control for the read data rate. Here, this operation example is assumed to start during writing of datasets in the buffer 12 to the tape 23 in response to a synchronization command.

In the controller 16 during such writing of the datasets, the buffer management unit 42 reads the last dataset from the buffer 12, and passes the data to the channel input-output unit 43, and the channel input-output unit 43 writes the passed dataset to the tape 23 (step 401).

[0044]

At this time, since the buffer management unit 42 is informed that the last dataset is written to the tape 23, the buffer management unit 42 instructs the backhitch determination unit 44 to determine whether or not to execute backhitch. In response to this, the backhitch determination unit 44 performs backhitch determination processing of determining whether or not to execute backhitch from the standpoints of writing the target capacity to the tape 23 and ensuring the target read data rate (step 402). Note that, the details of the backhitch determination processing will be described later. Then, the determination result in the backhitch determination processing is outputted to the
operation signal output unit 48.

[0045]

In response to this, the operation signal output unit 48 determines whether or not the determination result indicates that SWBF should be executed (backhitch should not be executed) (step 403).

Here, if the determination result indicates that SWBF should be executed, the operation signal output unit 48 determines to execute SWBF (step 404). In other words, the operation signal output unit 48 does not output a signal instructing a start of backhitch to the motor driver 18.

On the other hand, if the determination result does not indicate that SWBF should be executed, that is, if the determination result indicates that backhitch should be executed, the operation signal output unit 48 outputs a signal instructing a start of backhitch to the motor driver 18 (step 405).

[0046]

Upon determination to execute SWBF or start of backhitch as described above, information on that effect is returned to the command processing unit 41, and the command processing unit 41 reports the completion of the synchronization command to the host 30 (step 406).

[0047]

Thereafter, the command processing unit 41 receives the next dataset, and passes the dataset to the buffer management unit 42, and the buffer management unit 42 stores the received data to the buffer 12 (step 407).

Then, the buffer management unit 42 determines whether or not datasets sufficient to start new writing are already
received (step 408). When it is determined that the sufficient datasets are not received yet, the buffer management unit 42 advances to determining whether or not a given time period passes after the completion of step 406 (step 409). When the given time period does not pass yet, the buffer management unit 42 waits for some time (step 410) and then again makes the determination in step 408. When the given time period passes, the buffer management unit 42 passes control to the operation signal output unit 48, and the operation signal output unit 48 outputs a signal instructing start of backhitch to the motor driver 18 (step 412). In contrast, when it is determined in step 408 that the sufficient datasets are received, the buffer management unit 42 determines whether or not the interval between the current location of the head 14 and the location of the end of the dataset lastly written is short (step 411). For example, the determination may be made on whether or not the interval is shorter than a threshold of the dataset interval.

[0048]

Here, in the case where the given time period passes after the completion of step 406, and where the interval between the current location of the head 14 and the location of the end of the dataset lastly written is long after the reception of sufficient datasets, the buffer management unit 42 passes control to the operation signal output unit 48. Then, the operation signal output unit 48 outputs a signal instructing start of backhitch to the motor driver 18 (step 412). Then, the buffer management unit 42 reads the datasets from the buffer 12, and passes the datasets to the channel input-output unit 43, and the channel input-output unit 43 writes the datasets
to the tape 23 (step 413).

On the other hand, if the interval between the current location of the head 14 and the location of the end of the dataset last written is short, backhitch is not executed, but the buffer management unit 42 reads the datasets from the buffer 12, and passes the datasets to the channel input-output unit 43, and the channel input-output unit 43 writes the datasets to the tape 23 (step 413).

Thereafter, the channel input-output unit 43 acquires Accumulated_Interval, which is a cumulative total of dataset intervals generated within a range where unit data (target data) closest to the current write location is written, and Speed_X of the tape speed at the above writing, and stores Accumulated_Interval and Speed_X into the history storage unit 47 (step 414).

Next, the details of the backhitch determination processing in step 402 will be described.

Fig. 6 is a flowchart illustrating a flow of the backhitch determination processing.

Firstly, the backhitch determination unit 44 acquires the mode information stored in the mode information storage unit 45 (step 501). Then, the backhitch determination unit 44 determines whether or not the mode information indicates the high data rate mode (step 502).

When the mode information is determined to indicate the high data rate mode as a result, the backhitch determination unit 44 acquires the target capacity from the target capacity storage unit 46 (step 503). Additionally, the backhitch determination unit 44 acquires a total number of datasets C,
an effective tape length T, an SWBF margin ratio r, a last data size set location x, a last dataset number n, and a dataset length L (step 504). Among them, C, T and L may be acquired from setting information internally retained in advance. Moreover, r may be obtained by dividing the target capacity acquired in step 503 by the nominal capacity. Further, since x and n can be obtained when the last dataset is written in step 401, these values may be acquired as x and n.

Subsequently, the backhitch determination unit 44 determines whether or not the values thus acquired satisfy the conditional expression "(C x r - n) x L < T - x" (step 505).

Here, if the conditional expression is satisfied, the backhitch determination unit 44 acquires Target_Data_Size, Target_Read_Data_Rate, Read_Data_Rate_with_Speed1, Accumulated_Interval, Speed_X, and Speed1 (step 506). Among them, Target_Data_Size, Target_Read_Data_Rate, Read_Data_Rate_with_Speed1, and Speed1 may be acquired from the setting information internally retained in advance. In addition, the values stored in the history storage unit 47 in step 414 may be acquired as Accumulated_Interval and Speed_X.

Then, the backhitch determination unit 44 obtains Threshold by using the formula "Threshold = Target_Data_Size / Target_Read_Data_Rate - Target_Data_Size / Read_Data_Rate_with_Speed1 - Accumulated_Interval * Speed_X / Speed1" (step 507), and determines whether or not Threshold is larger than 0 (step 508).

If Threshold is determined to be larger than 0 as a result, a determination result is set to execution of SWBF (step 509).
On the other hand, in each of the cases where it is determined that the mode information does not indicate the high data rate mode in step 502, the case where it is determined that the conditional expression \((C \times r-n) \times L < T \times k\) is not satisfied in step 505, and the case where Threshold is determined to be equal to or smaller than 0 in step 508, the determination result is set to execution of backhitch (step 510).

Fig. 7 is a flowchart illustrating a second operation example of the controller 16. This second operation example corresponds to the transaction-size-based control method in the foregoing control for the read data rate. Here, this operation example is assumed to start during writing of datasets in the buffer 12 to the tape 23 in response to a synchronization command.

Here, steps 451 to 463 in the second operation example are the same as steps 401 to 413 in the aforementioned first operation example, and the second operation example is different from the aforementioned first operation example in that the second operation example does not include a step of acquiring Accumulated Interval and Speed_X as in step 414.

Next, the details of the backhitch determination processing in step 452 will be described.

Fig. 8 is a flowchart illustrating a flow of the backhitch determination processing.

Since steps 551 to 595 in the flow of the backhitch determination processing are the same as steps 501 to 505 in Fig. 6, the detailed description thereof is omitted herein.
When the conditional expression 
\[(C\times r-n)\times L < T-x\] 
is satisfied in step 555, the backhitch determination unit 44 acquires \(\text{Tx\_Size}, \text{Target\_Read\_Data\_Rate}, \text{X}, \) and \(\text{Read\_Data\_Rate\_with\_Speed1}\) (step 556). Among them, since \(\text{Tx\_Size}\) can be obtained when the last dataset is written in step 451, the value may be acquired as \(\text{Tx\_Size}\). In addition, \(\text{Target\_Read\_Data\_Rate}\) and \(\text{Read\_Data\_Rate\_with\_Speed1}\) may be acquired from the setting information internally retained in advance. Further, since \(X\) is defined as \(\text{Read\_Data\_Rate\_with\_Speed1} \times \text{Max\_Interval}\_\text{Tape\_Speed}\), \(X\) may be calculated by using the values acquired from the setting information internally retained in advance.

[0054]

Then, the backhitch determination unit 44 obtains \(\text{Threshold}\) by using the formula

\[
\text{Threshold} = \frac{\text{Tx\_Size}}{\text{Target\_Read\_Data\_Rate}} - \frac{(\text{Tx\_Size} \times X)}{\text{Read\_Data\_Rate\_with\_Speed1}},
\]

and determines whether or not \(\text{Threshold}\) is larger than 0 (step 559).

If \(\text{Threshold}\) is determined to be larger than 0 as a result, a determination result is set to execution of \(\text{SWBF}\) (step 559).

On the other hand, in each of the case where it is determined that the mode information does not indicate the high data rate mode in step 552, the case where it is determined that the conditional expression 
\[(C\times r-n)\times L < T-x\]

is not satisfied in step 555, and the case where \(\text{Threshold}\) is determined to be equal to or smaller than 0 in step 558, the determination result is set to execution of backhitch (step 560).

[0055]

Here, description will be provided for selection of the
speed of the tape 23.

In the first place, if the speed of the tape 23 is too fast compared with the data rate of the host 30, data transfer cannot be performed efficiently because of occurrence of backhitch. In contrast, if the speed of the tape 23 is too slow compared with the data rate of the host 30, data waiting for writing to the tape 23 are accumulated in the buffer 12, and thereby the practical data rate with the host 30 decreases. For this reason, it is preferable that the data rate of the host 30 and the read data rate from the tape 23 be equal to each other for writing data sent from the host 30 to the tape 23 and for sending data read from the tape 23 to the host 30.

[0056]

Fig. 9 illustrates an example of correspondence between the read data rate from the tape 23 and the tape speed. The tape speed is expressed as "SpeedX" (X = 1, ..., 5) in the drawing, but may be expressed by using specific values (5.987 m/sec for Speed1, for example). Here, in the drawing, "SpeedX" becomes faster as the value of X becomes smaller.

Under the above condition, consider a case where the data rate of the host 30 is 100 MB/sec, for example. In this case, Speed3 that is the tape speed corresponding to the read data rate of 100 MB/sec is usually considered suitable to transport the tape 23. In the present embodiment, however, intervals are generated between datasets. For this reason, there is a possibility that the read data rate of 100 MB/sec cannot be ensured even if the tape 23 is transported with Speed3. Thus, it is preferable to ensure the read data rate of 100 MB/sec by transporting the tape 23 with Speed2 or Speed1. Which one of Speed1 and Speed2 is more suitable as the tape speed can
be determined by using a technique similar to that in Patent Literature 1. To be more specific, which tape speed is the most suitable can be determined with a technique similar to that of Patent Literature 1 by interpreting a decrease in the recording density in writing due to SWBF as a decrease in the recording density due to occurrence of errors.

[0057]

The description of the present embodiment is completed hereinabove.

As described above, in the present embodiment, prepared is the high data rate mode in which a target capacity of data is written to a tape medium, the target capacity calculated by the nominal capacity minus a data capacity lost due to execution of backhitchless writing. Use of this mode enables the target capacity of data out of the nominal capacity to be written to the tape medium.

[0058]

Note that, although the backhitch is performed prior to a change in the speed of the tape 23 in the present embodiment, an embodiment may be configured to change the speed of the tape 23 without performing backhitch.

[0059]

Here, the present invention may be entirely implemented by hardware, or may be entirely implemented by software. Instead, the present invention may be implemented by both of hardware and software. The present invention may also be implemented as a computer, a data processing system, and a computer program. This computer program can be stored in a computer-readable medium, and be provided. Here, a medium considered usable as the above medium is an electric, magnetic,
optical, electromagnetic, infrared or semiconductor system (apparatus or device), or a propagation medium. In addition, examples of the computer-readable medium include a semiconductor, a solid state storage device, a magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disc, and an optical disc. Examples of the optical disc at the present time include a compact disc read-only memory (CD-ROM), a compact disc read/write (CD-R/W) and a DVD.

[0060]

The embodiments have been described by using the embodiment hereinabove. The technical scope of the present invention, however, is not limited to the foregoing embodiments. It is apparent to those skilled in the art to modify the foregoing embodiment variously or to employ an alternative embodiment without deviating from the spirit and scope of the present invention.

[Reference Signs List]

[0061]

10  tape drive
11  host I/F
12  buffer
13  channel
14  head
15  motor
16  controller
17  head position control system
18  motor driver
Claims

1. An apparatus of controlling writing of data to a tape medium, comprising:
   a storage unit that stores mode information indicating a mode of the apparatus; and
   a determination unit that determines to write a target capacity of data to the tape medium when the mode information stored in the storage unit indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

2. The apparatus according to claim 1, wherein
   under one condition that the target capacity of data is expected to be written to the tape medium, the determination unit determines not to execute backhitch after writing first data to the tape medium until writing second data next to the first data to the tape medium.

3. The apparatus according to claim 2, wherein
   under one condition that a read data rate from the tape medium is expected to satisfy a target read rate, the determination unit determines not to execute backhitch after writing the first data to the tape medium until writing the second data to the tape medium.

4. The apparatus according to claim 3, wherein
   the determination unit determines that the read data rate from the tape medium will satisfy the target read rate when the sum of a time required to read unit data written to the
tape medium with a maximum speed achievable by the apparatus and a time required to skip an area on the tape medium where no data is written because the tape medium is transported without execution of backhitch is shorter than a time required to read the unit data at the target read rate.

5. The apparatus according to claim 3, wherein

the determination unit determines that the read data rate from the tape medium will satisfy the target read rate when a time required to read unit data written to the tape medium and an amount of data corresponding to an area on the tape medium where no data is written because the tape medium is transported without execution of backhitch is shorter than a time required to read the unit data at the target read rate.

6. The apparatus according to claim 1, wherein

in response to loading of a tape cartridge containing the tape medium, the storage unit stores the mode information indicating the particular mode according to an instruction from an application program configured to write data to the medium.

7. The apparatus according to claim 1, wherein

in response to loading of a particular tape cartridge containing the tape medium, the storage unit stores the mode information indicating the particular mode.

8. An apparatus of controlling data writing to a tape medium, comprising:

a storage unit that stores mode information indicating
a mode of the apparatus; and

determination unit that determines to write a target capacity of data to the tape medium, without executing backhitch after writing first data to the tape medium until writing second data next to the first data to the tape medium in a case where the mode information stored in the storage unit indicates a particular mode, where the target capacity of data is expected to be written to the tape medium, and where a read data rate from the tape medium is expected to satisfy a target read rate, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

9. A method of controlling writing of data to a tape medium, comprising the steps of:

storing mode information indicating a mode of the apparatus into a memory; and

determining to write a target capacity of data to the tape medium when the mode information stored in the memory indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.

10. A program causing a computer to function as an apparatus of controlling writing of data to a tape medium, the program causing the computer to function as:

a unit to store mode information indicating a mode of the apparatus into a memory; and

a unit to determine to write a target capacity of data to the tape medium when the mode information stored in the
memory indicates a particular mode, the target capacity calculated by a nominal capacity of the tape medium minus a data capacity lost due to execution of backhitchless writing.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
G11B20/10(2006.01)i, G11B15/087(2006.01)i, G11B15/20(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
G11B20/10, G11B15/087, G11B15/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shihan Koho 1922-1996 Jitsuyo Shihan Toroku Koho 1996-2010
Kokai Jitsuyo Shihan Koho 1971-2010 Toroku Jitsuyo Shihan Koho 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>JP 62-49434 A (Oki Electric Industry Co., Ltd.), 04 March 1987 (04.03.1987),</td>
<td>1,2,8-10, 6</td>
</tr>
<tr>
<td></td>
<td>page 5, upper left part, line 13 to page 6, upper right part, line 3; fig. 1 to 6</td>
<td>3,5</td>
</tr>
<tr>
<td>Y</td>
<td>JP 11-239318 A (Sony Corp.), 31 August 1999 (31.08.1999), paragraphs [0463] to</td>
<td>6,7</td>
</tr>
<tr>
<td>A</td>
<td>[0479]; fig. 25, 26 (Family: none)</td>
<td>3-5</td>
</tr>
<tr>
<td></td>
<td>JP 6-202814 A (Hitachi, Ltd.), 22 July 1994 (22.07.1994), paragraphs [0039] to</td>
<td>1-10</td>
</tr>
<tr>
<td></td>
<td>[0040]; fig. 1, 5 (Family: none)</td>
<td></td>
</tr>
</tbody>
</table>

[X] Further documents are listed in the continuation of Box C.  [ ] See patent family annex.

* Special categories of cited documents:
   "A" document defining the general state of the art which is not considered to be of particular relevance
   "E" earlier application or patent but published on or after the international filing date
   "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
   "O" document referring to an oral disclosure, use, exhibition or other means
   "P" document published prior to the international filing date but later than the priority date claimed
   "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
   "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
   "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
   "&" document member of the same patent family

Date of the actual completion of the international search
07 October, 2010 (07.10.10)

Date of mailing of the international search report
19 October, 2010 (19.10.10)

Name and mailing address of the ISA/
Japanese Patent Office
Authorized officer

Facsimile No.
Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)
INTERNATIONAL SEARCH REPORT

Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The inventions in claims 1, 9, 10 have no special technical feature in the light of the contents disclosed in JP 62-49434 A (Oki Electric Industry Co., Ltd.), 4 March 1987 (04.03.1987), page 5, upper left column, line 13 - page 6, upper right column, line 3, fig. 1 - 6.  (continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>
The inventions in claims 1, 9, 10 relate to a device provided with a determination unit which does not perform back hitch according to modes of the device.

The inventions in claims 2, 8 relates to such a technique that the quantity of date to be written is made to be the condition under which back hitch is not performed, and the inventions in claims 3 - 5 relate to such a technique that the speed of reading data written into a tape medium is made to be the condition under which back hitch is not performed.

The inventions in claims 6, 7 relate to such a technique that the mode of the device is set in accordance with loading of a tape cartridge.