DESCRIPTION

Image information recording apparatus and image information recording method

TECHNICAL FIELD

The present invention relates to an image information recording apparatus and an image information recording method for recording a video signal on a recording medium such as an optical disk, and more particularly relates to an image information recording apparatus and an image information recording method for performing a trick play reproduction at a constant speed or scale factor.

BACKGROUND ART

As digital storage media have been developed, it has become necessary to record a long-time moving picture in such recording media. In addition, it has also become desirable to transmit a larger amount of moving picture in the fields of communication, broadcasting and the like. In order to accomplish such purposes, high efficiency coding technologies have been examined. In International Organization for Standardization (ISO), standardization activities are now carried on with respect to various methods for coding a moving picture by MPEG (Moving Picture Experts Group) of International Electro-technical Commission (IEC). An international standard for a moving picture includes, for example,

"ISO/IEC 13818".

According to an MPEG coding method, in order to reduce the redundancy in the time-axis direction at first, a motion compensation is performed, thereby obtaining a difference between images, and then, in order to reduce the redundancy in the space-axis direction, a DCT (discrete cosine transform), a quantization and a variable-length coding are performed. In addition, an image unit called "GOP (group of pictures)" composed of a plurality of pictures is provided. In each GOP, a picture to be coded first is intra-picture coded. In the following description, a "picture" is assumed to mean a frame in a frame mode and a field in a field mode in compliance with an MPEG. In this specification, a so-called "frame rate" (i.e., the number of pictures per second) is set at 30. However, it is not limited thereto. For example, in the NTSC (National Television System Committee) standard, it is 29.97, and in the PAL (Phase Alternation Line) standard, it is 25.

(A) and (B) of Figure 11 are diagrams respectively showing the formats of GOPs. In general, each GOP consists of three kinds of coded pictures: an intra-coded picture (which will be simply referred to as an "I picture"); an inter-picture forward predictive-coded picture (which will be simply referred to as a "P picture"); and an inter-picture bidirectionally predictive-coded picture (which will be simply referred to as a "B picture"). An I picture is a picture for performing an intra-picture coding without reference to other pictures; a P picture is a picture for performing an inter-picture coding with reference to an I picture or another P picture temporally

anterior to itself; and a B picture is a picture for performing a predictive coding with reference to I picture(s) or P picture(s) in both directions or temporally anterior and posterior to itself. The inter-picture forward predictive coding and the inter-picture bidirectional predictive coding are called generically as an "inter-picture coding". In the example in Figure 11, the second GOP (i.e., a GOP having a GOP number of 2) is composed of 12 pictures, and P pictures are inserted thereto every two pictures.

In decoding, an I picture can be reproduced without reference to other pictures. A P picture is inter-picture decoded with reference to an I picture or another P picture temporally anterior to itself. Accordingly, in decoding, the I picture or another P picture temporally anterior to itself is required to have been decoded. A B picture is coded using I picture(s) or P picture(s) in both directions or temporally anterior and posterior to itself. Accordingly, in decoding, the B picture cannot be decoded unless the I picture(s) or the P picture(s), which are temporally anterior or posterior to itself and should be used for the prediction, have been decoded. Therefore, a compression coding is performed in the order shown in Figure 11.

The data which have been compression-coded in this way are recorded on a recording medium in the following manner. First, the intra-picture compression-coded data (the I picture data) and the inter-picture compression-coded data (the P picture data or the B picture data) are arranged in a time sequence manner and various kinds of codes are added thereto, thereby inte-

grating them into one data. Then, the data is divided into a plurality of sectors, each of which has a constant capacity. An address is provided for each of the divided sectors, and the sectors are recorded on the recording medium.

In the case of reproducing image information which has been recorded on the recording medium by the above-described method, the reproduction is carried on while identifying the addresses of the respective sectors. In a high-speed reproduction in accordance with prior art, one I picture is reproduced once for a constant number of GOP(s). In this method, the number of the pictures composing one GOP is assumed to be constant. In such a case, I pictures to be high-speed reproduced are pictures to be reproduced at regular time intervals in a normal reproduction. Assuming that two adjacent pictures reproduced at a time interval **Th** in the high-speed reproduction are reproduced at a time interval **Tn** in the normal reproduction, the reproduction scale factor **R** can be defined by the equation: R = Tn / Th. Therefore, in the prior art, if the number of pictures composing one GOP is constant, then the reproduction scale factor **R** also becomes constant.

Figure 12 is a chart for illustrating the reproduction scale factor **R** used for a case where an image, including GOPs composed of a variable number of pictures, is high-speed reproduced by prior art. Figure 12 shows a high-speed reproduction in which one I picture is reproduced once for every two GOPs. In a normal reproduction, two successive pictures are assumed to be reproduced at an interval of 1/30 (s). In **(A)** in Fig-

ure 12, an image in which one GOP includes 15 pictures is shown. In the case of (A) in Figure 12, the time interval Tn is Tn = 15 × 2/30 = 1 (s), while the time interval Th is Th = 1/30 (s). Accordingly, the reproduction scale factor R = 30. In other words, a normally reproducible image has been time-axis compressed by 30.

Assuming the same intervals, in the case of (B) in Figure 12, the reproduction scale factor R = Tn / Th = (10 × 2/30) / (1/30) = 20. In the cases of (C) and (D) in Figure 12, the reproduction scale factors R become 10 and 8, respectively. As described above, in the case where the number of the pictures composing one GOP is varied, the reproduction scale factor R is also varied.

The prior art, however, has paid no regard to the fact that, when the number of the pictures per GOP is varied, the reproduction scale factor R is also varied.

The present invention has been developed in view of the variation of the reproduction scale factor R in accordance with the variation of the number of pictures per GOP and has an objective of providing an apparatus and a method for recording image information without varying the reproduction scale factor R in a trick play reproduction.

DISCLOSURE OF THE INVENTION

The image information recording apparatus of the present invention includes: a coder for generating a plurality of group data, each of the plurality of group data including at least intra-coded picture data, by

receiving and coding a plurality of picture data, each of the plurality of picture data corresponding to a picture; a sector address generator for generating a sector address indicating a top sector among a plurality of sectors on a recording medium in which auxiliary data corresponding to each of the plurality of group data is recorded; a jump address generator for outputting, as a jump address of first group data among the plurality of group data, a top sector address among a plurality of sector addresses of the auxiliary data, the auxiliary data being located immediately anterior to second group data including second picture data to be reproduced in a normal reproduction at a second time later than a first time by a predetermined fixed time period, the first time being a time when first picture data located at a top of the first group data is reproduced in the normal reproduction; and a recorder for recording on the recording medium the first group data and the auxiliary data including the jump address corresponding to the first group data so that the auxiliary data including the jump address of the first group data is located adjacent to the first group data on the recording medium.

In one embodiment, assuming that the first time and the second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a first equation:

$$T2 = T1 + \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and the auxiliary data includes the n kinds of jump addresses corresponding to the second time determined by the first equation.

In one embodiment, assuming that the first time and the second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a second equation:

$$T2 = T1 - \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and the auxiliary data further includes the n kinds of jump addresses corresponding to the second time determined by the second equation.

In one embodiment, the positive value ΔTi monotonically increases for the natural number i.

In one embodiment, the auxiliary data including the jump addresses is recorded on the recording medium so that the intra-coded picture data is reproduced at a time interval in a range from 0.4 (s) to 1.0 (s), both inclusive, in the normal reproduction, the intra-coded picture data being recorded adjacent to the plurality of sectors in which the auxiliary data including the jump addresses is recorded.

In one embodiment, the natural number n satisfies $1 \leq n \leq nmax$ (where nmax is a natural number) and $nmax \geq 5$.

In one embodiment, the auxiliary data including the jump addresses includes offset data corresponding to a difference between a third time and the second time, the third time being a time when third picture data, located in a top sector of the second picture data, is reproduced in the normal reproduction.

In one embodiment, the offset data represents an interval between the second time and the third time.

In one embodiment, the offset data represents a difference between a picture number of a picture represented by the second picture data and a picture number of a picture represented by the third picture data.

The image information recording method of the present invention includes the steps of: generating a plurality of group data, each of the plurality of group data including at least intra-coded picture data, by receiving and coding a plurality of picture data, each of the plurality of picture data corresponding to a picture; generating a sector address indicating a top sector among a plurality of sectors on a recording medium in which auxiliary data corresponding to each of the plurality of group data is recorded; outputting, as a jump address of first group data among the plurality of group data, a top sector address among a plurality of sector addresses of the auxiliary data, the auxiliary data being located immediately anterior to second group data including second picture data to be reproduced in a normal reproduction at a second time later than a first time by a predetermined fixed time period, the first time being a time when first picture data located at a top of the first group data is reproduced in the normal reproduction; and recording on the recording medium the first group data and the auxiliary data including the jump address corresponding to the first group data so that the auxiliary data including the jump address of the first group data is located adjacent to the first group data on the recording medium.

According to the present invention utilizing the above-described configurations, a top sector address among a plurality of sector addresses, at which the auxiliary data of a succeeding GOP is recorded, is recorded on the recording medium as a jump address among the auxiliary data of a preceding GOP. As a result, the time-axis linearity during reproduction is improved. Moreover, in one embodiment, a parameter corresponding to a difference between a destination picture and a succeeding picture is recorded on the recording medium as offset data for the auxiliary data of a preceding GOP. As a result, precise seeking can be performed during reproduction.

BRIEF DESCRIPTION OF THE DRAWINGS

(A) through (D) of Figure 1 are charts illustrating an operation of high-speed reproducing the image information which has been recorded in accordance with the first example of the image information recording apparatus and method of the present invention.

Figure 2 is a chart schematically showing the data recorded on a recording medium in accordance with the first example of the image information recording apparatus and method of the present invention.

Figure 3 is a flow chart of the image information recording method of the present invention.

Figure 4 is a flow chart illustrating a method for obtaining jump addresses based on the table.

(A) and (B) of Figure 5 are charts for illustrating the jump addresses in the first example of the image information recording apparatus and method of the present invention.

Figure 6 is a chart showing a format for a jump address JA corresponding to a plurality of reproduction scale factors.

Figure 7 is a block diagram in the first example of the image information recording apparatus of the present invention.

(A) through (D) of Figure 8 are timing charts showing the respective data in Figure 7.

Figure 9 is a chart showing a format in which the jump addresses corresponding to a plurality of reproduction scale factors and offset data corresponding to the respective jump addresses are recorded.

Figure 10 is a block diagram of a reproducing apparatus for an optical disk on which image information has been recorded by the image information recording apparatus and method of the present invention.

(A) and (B) of Figure 11 are charts showing the formats of respective GOPs.

(A) through (D) of Figure 12 are charts for illustrating the reproduction scale factor used for a case where an image, including GOPs composed of a variable number of pictures, is high-speed reproduced in

accordance with the prior art.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the examples of the present invention will be described with reference to the accompanying drawings. It is noted that the same reference numeral denotes the same component. In addition, a term "picture data", for example, refers to "data representing a picture" for simplicity. The same is true of terms such as "GOP data".

(Example 1)

In the following examples, a GOP defined in compliance with the MPEG2 standard (or the above-mentioned international standard ISO/IEC 13818) will be used as the GOP. In this specification, a "picture" is assumed to mean a frame when the MPEG2 for a frame mode is used and to mean a field when that for a field mode is used. In other words, the present invention is applicable to both of the case where a frame is used as a picture and a case where a field is used as a picture.

In this specification, two successive pictures are assumed to be reproduced at an interval of 1/30 (s) (or a picture rate is assumed to be 30) in the normal reproduction. However, the picture rate is not limited to this value, but may be 29.97 or 25, for example. In the high-speed reproduction, the interval between pictures to be reproduced is equal to that of the normal reproduction, i.e., 1/30 (s). However, in the high-speed reproduction, all the pictures are not reproduced but

some pictures are skipped (not reproduced). For example, if the reproduction scale factor is 30, then, after the first picture is reproduced, the second to the thirtieth pictures are not reproduced and the thirty-first picture is reproduced. The interval between the time when the first picture is reproduced and the time when the thirty-first picture is reproduced is equal to the interval in the normal reproduction, i.e., 1/30 (s).

Hereinafter, the former picture of two adjacent pictures reproduced in the high-speed reproduction will be called a "preceding picture", while the picture to be reproduced immediately after the preceding picture is reproduced will be called a "succeeding picture". Also, the respective times when a preceding picture and a succeeding picture are reproduced in the normal reproduction will be called a "preceding picture time" and a "succeeding picture time", respectively. In the above-described example where the reproduction scale factor **R** is 30, the first picture is a preceding picture and the thirty-first picture is a succeeding picture. Also, if the reproduction scale factor **R** is 30, the interval between a preceding picture time and a succeeding picture time is 1 (s). That is to say, since the picture to be reproduced at an interval of 1 (s) in the normal reproduction is reproduced at an interval of 1/30 (s), the reproduction scale factor **R** becomes 30.

In the present invention, for the sake of simplicity, time required for a jump operation (specifically, the movement of an optical pickup on an optical disk, tracking and the like) which occurs between the reproduction of a preceding picture and the reproduction of a

succeeding picture in the high-speed reproduction is assumed to be zero.

The high-speed reproduction includes a forward high-speed reproduction and a backward high-speed reproduction. A forward high-speed reproduction refers to a high-speed reproduction in which a succeeding picture time is later than a preceding picture time. On the other hand, a backward high-speed reproduction refers to a high-speed reproduction in which a succeeding picture time is earlier than a preceding picture time.

Figure 1 is a chart illustrating an operation of high-speed reproducing the image information which has been recorded in accordance with the first example of the image information recording apparatus and method of the present invention. In this case, a state where the reproduction scale factor R is a constant value of 30 is assumed to be ideal. In other words, it is assumed to be ideal to set the interval between a preceding picture time and a succeeding picture time at 1 (s). In (A) through (D) in Figure 1, the numbers sequentially assigned from the top (or sequentially from left to right on the time axis) indicate the positions of respective pictures in a GOP. The number of the pictures included in one GOP (group of pictures) (hereinafter, the number will be simply referred to as a "picture number of GOP") is 15, 10, 5 or 4. In addition, a picture 1 to be normally reproduced at a time t = 0 (s) is assumed to be a preceding picture. In (A) through (D) in Figure 1, the pictures in the periods indicated by the solid-line arrows are reproduced but the pictures in the periods indicated by the broken-line arrows are not reproduced.

For the sake of simplicity, it is assumed that the pictures indicated by the broken-line arrow are instantaneously skipped after a preceding picture has been reproduced. In this specification, the description will be made while assuming the top picture of a GOP on the time axis to be an I picture before a coding, for the sake of simplicity. However, the top picture of a GOP on the time axis is not limited thereto, but may also be a B picture or a P picture. Furthermore, a GOP may be composed of I pictures and P pictures without any B pictures, or may be composed of I pictures only.

In any of the cases (A) to (C) in Figure 1, the interval between a preceding picture time and a succeeding picture time is 1.0 (s) and the reproduction scale factor R is 30.

In the case (D) in Figure 1, in order to set the interval between the preceding picture time and the succeeding picture time at 1 (s), when the preceding picture is located at the time t = 0, the succeeding picture should be a picture 3 of GOP8. However, it is required to start the reproduction with the top picture of a GOP which is an intra-coded picture. Therefore, in the first example, in such a case, it is assumed that the picture 1 of GOP8 is reproduced instead of the picture 3 of GOP8 immediately after the preceding picture or the picture 1 of GOP1 has been reproduced. A picture which should be a succeeding picture for realizing a constant reproduction scale factor R (e.g., the picture 3 of GOP8 in the above-described example) will be called a "destination picture". On the other hand, a picture actually reproduced as the succeeding picture (e.g., the picture 1

of GOP8 in the above-described example) will be called a "succeeding picture". In the cases (A) to (C) in Figure 1, the destination pictures accord with the succeeding pictures. In the case (D) in Figure 1, the destination picture (the picture 3 of GOP8) is different from the succeeding picture (the picture 1 of GOP8), the interval between the preceding picture and the succeeding picture is 28/30 (s) and the reproduction scale factor R is 28.

To sum up the foregoing description, a succeeding picture may be represented as the top picture of a GOP including a destination picture in reproducing the image information recorded according to the present invention. Hereinafter, respective GOPs including a preceding picture and a succeeding picture will be called a "preceding GOP" and a "succeeding GOP", respectively. A destination picture is also included in a succeeding GOP.

A "top picture of a GOP" to which a plurality of pictures belong refers to a picture represented by the picture data to be decoded first in the normal reproduction among the picture data recorded as GOP data. According to the MPEG1 and the MPEG2 to which the present invention is applied, the top picture of GOP data is I picture data on an optical disk. In this specification, the preceding picture is a top picture of a GOP (i.e., an I picture).

If the image information recorded by the apparatus and the method of the invention is reproduced, even if a high-speed reproduction is performed, the interval between a preceding picture time and a succeeding picture

time becomes substantially regular (i.e., the reproduction scale factor **R** becomes substantially constant) as shown in **(A)** to **(D)** in Figure 1, unlike the prior art example shown in Figure 12. A jerky unnatural image to be generated in a high-speed reproduction when the number of the pictures included in one GOP is variable can be eliminated by utilizing the apparatus and/or the method of the present invention (or by setting the reproduction scale factor **R** to be substantially constant). In this specification, the degree to which the reproduction scale factor **R** is constant in the high-speed reproduction will be called a "time-axis linearity". For example, the time-axis linearity can be regarded as being completely maintained in **(A)** to **(C)** in Figure 1.

Figure 2 is a chart schematically showing the data recorded on a recording medium in accordance with the first example and the second example to be described later of the image information recording apparatus and recording method of the present invention. In the following examples, a DVD (digital versatile disk), one of optical disks, is used as a medium on which the image data is recorded. The data has been recorded on the tracks spirally formed on an optical disk. By making a motor rotate the optical disk, an optical head for reading out the recorded data moves relative to the tracks. In Figure 2, the optical head moves from left to right in the normal reproduction. It is noted that the rotation of the disk is controlled by CLV (constant linear velocity), and the linear velocity is about 4 m/s.

As shown in Figure 2, GOP data (denoted by **GOP1** and **GOP2**) and auxiliary data (denoted by **AUX1** and **AUX2**)

are recorded on a sector basis. The sectors are obtained by partitioning a part of the tracks on the optical disk, and a lead-in area, a file management information area and a data area are disposed in this order from the inner peripheral side to the outer peripheral side on the optical disk. The GOP data and the auxiliary data to be described in detail later are recorded in the data area.

The numbers assigned to the respective sectors are called "sector addresses" (denoted by **SA** in Figure 2) and are integers represented by the data of 4 bytes. A sector address **SA** is included in a sub-code (denoted by **SC** in Figure 2) having a data length of 16 bytes. In the area of 16 bytes of the sub-code other than the area of 4 bytes of the sector address **SA**, necessary information for controlling a disk, an error correction code for the sub-code and the like are recorded. The sub-code **SC** (16 bytes) and the data area **DA** (2048 bytes) are recorded in each sector. As shown in Figure 2, the sub-code **SC** is recorded on the recording medium so as to be located immediately anterior to the region where the data area **DA** has been recorded. The "anterior" direction indicated by "immediately anterior", "precedence" and the like in this specification refers to a direction in which reading of data is temporally precedent in the normal reproduction (i.e., the optical head reaches the data in precedence). For example, when data A is "anterior" to data B, data A is read out before data B is read out from the optical disk in the normal reproduction mode.

Both the GOP data and the auxiliary data corresponding thereto are recorded in the region for the data area **DA** in each sector. When the data consisting of the

sub-code **SC** and the data area **DA** in each sector are actually recorded on the recording medium, an ECC (error correction code) is added to the data having 2064 bytes (i.e., 16 bytes of the sub-code and 2048 bytes of the data area **DA**) per sector, and then the data is recorded. Figure 2 shows a detailed format for the sectors **0** to **2** only. However, all of the GOP data and the auxiliary data are recorded as the data area **DA**. It is assumed that a sector address begins with zero for convenience of description.

The GOP data **GOP1** shown in Figure 2 includes intra-coded picture data (I picture data) and inter-coded picture data (P picture data and/or B picture data). The I picture data of the GOP data **GOP1** is included in the sectors **2** to **4** shown in Figure 2. In **GOP1**, the P picture data **P1** to **P4** and the B picture data **B1** to **B8** are included in the sectors **4** to **14**. A boundary between adjacent picture data is not always aligned with the boundary between the sectors. In the region of the sector **14** in which the P picture data **P4** is not recorded is filled with so-called stuffing bytes **S**. As a result, the end of the GOP data **GOP1** is aligned with the end of the sector (sector **14** in Figure 2). The end of GOP data is always aligned with the end of a sector. At the top of GOP data, I picture data is recorded.

The auxiliary data **AUX** is recorded in the two sectors (e.g., sectors **0** and **1** in Figure 2) immediately anterior to the GOP data on the optical disk. The auxiliary data **AUX** is data other than the picture data (I picture data, P picture data and B picture data) and includes at least a jump address **JA**, but may also include

other types of data except for the picture data. In this specification, description will be made while assuming the auxiliary data **AUX** to include the jump address (e.g., sector **0** in Figure **2**) and video blanking information **VBI** (e.g., sector **1** in Figure **2**). However, it does not mean that the auxiliary data not including the video blanking information **VBI** is excluded from the applications of the present invention. In addition, the auxiliary data **AUX** may also be recorded either in one sector or in three or more sectors. The video blanking information **VBI** is a signal output during a vertical retrace interval of a video signal and includes a signal for a closed caption, a signal for a copy generation management, and the like.

The jump address **JA** recorded in the sector **0** indicates a top sector address of the auxiliary data **AUX** which is located immediately anterior to the succeeding GOP data. For example, when the succeeding picture is an I picture to be recorded from the sector **17** on, the succeeding GOP is **GOP2**, and the jump address **JA** of the preceding picture is "15".

As described above, plural sets of the coded image data and the associated data thereof (i.e., the jump address **JA** and the video blanking information **VBI**), each set consisting of GOP data and auxiliary data which is located immediately anterior to the GOP data and corresponds to the GOP data, are recorded on the tracks. In other words, sectors in which the GOP data has been recorded and the sectors on which the auxiliary data corresponding to the GOP data has been recorded are adjacent to each other in precedence to the GOP data. Although, in an actual recording medium, a sub-code is

located between the GOP data and the auxiliary data corresponding thereto, such positional relationship is also referred to as being "adjacent" in this specification. Other data are sometimes added to the jump address **JA** and the video blanking information **VBI** but each of these data is recorded within a single sector. In addition, the beginning and the end of each GOP data can be aligned with the corresponding boundaries of the sectors. It is noted that Figure 2 schematically shows a structure in which the data are recorded in the respective sectors and that the length of the data is variable depending upon the original image and the coding method.

GOP1 shown in Figure 2 is composed of I pictures, P pictures and B pictures. However, it is not limited thereto, but the GOP may also be composed of I pictures and P pictures or I pictures only. That is to say, GOP data includes at least intra-coded picture data (or the I picture data). In addition, the number of the pictures composing the GOP may be appropriately increased or decreased. For example, if totally different pictures appear picture by picture, then adverse effects caused by the prediction error due to the inter-picture coding can be prevented by composing the GOP of I pictures only. On the other hand, in the case of increasing the entry points used for the jump operation during reproduction, it is only necessary to compose the GOP of a smaller number of pictures.

Figure 3 is a flow chart of the image information recording method of the present invention. Hereinafter, the image information recording method of the present invention will be described with reference to Figure 3.

A common format for a video signal complying with NTSC or PAL is used as a format for an input video signal. The input video signal is converted into a plurality of picture data, each of which represents a picture. The format of these picture data is defined so as to comply with the Recommendation BT.601 (originally with the Rec. 601 of CCIR) of ITU-R (International Telecommunication Union Radiocommunication Sector).

In Step **S1**, the picture data are grouped into a plurality of GOP data. In the case where each of the GOP data includes a plurality of picture data, the plurality of picture data included in each GOP data represent successive pictures on the time axis. As described above, the number of pictures composing one GOP may be set at an arbitrary number depending upon the type of the image, the number of entry points in the trick play reproduction and the like. A group start code (e.g., "group_start_code" having 32 bits defined in MPEG1 and MPEG2) indicating the top of the GOP data is located at the beginning of each GOP data.

In Step **S2**, the divided GOPs are compression-coded so as to include at least the intra-coded picture data (I picture data). In the case where one GOP includes a plurality of pictures, the compression rate may be increased by performing an inter-picture coding instead of the intra-picture coding depending upon the necessity. To the contrary, a case where the GOP data include no inter-coded picture data (P picture data and B picture data) may also occur. The intra-picture coding and the inter-picture coding are realized by known methods. In the following description, the coded GOP

data (not the GOP data generated in Step S1 and yet to be coded but the GOP data generated in Step S2) will be simply referred to as "GOP data".

In Step S3, the sector addresses on the optical disk, at which the plurality of GOP data and the auxiliary data corresponding to the respective GOP data are recorded, are calculated. A sector address is calculated using the length of GOP data, the length of auxiliary data and the sector length. More specifically, a counter having an initial value of "0" and an increment of "1" is used. First, since the auxiliary data consisting of two sectors is recorded immediately anterior to the GOP data, the count value of the counter is incremented from "0" to "2". Next, by receiving the GOP data, the count value is incremented by "1" every time 2048 bytes, i.e., the length of the data area (DA in Figure 2), are input. When the top of the GOP data is detected, the counter is incremented by "2". The sector addresses of the auxiliary data and the GOP data are obtained by this counting operation.

In Step S4, the GOP numbers of the GOP data generated in Step S2 are calculated. More specifically, a counter having an initial value of "1" and an increment of "1" is used. By incrementing the count value by "1" every time one GOP data is input, the GOP numbers can be obtained. The input of one GOP data can be identified by the group start code added in Step S2.

In Step S5, the picture numbers of the picture data included in the GOP data generated in Step S2 are calculated. More specifically, every time the beginning

of the next picture (or the "picture_start_code" having 32 bits defined in MPEG1 and MPEG2) is detected, the picture number is counted from the initial value = 0 by the increment = 1.

In Step **S6**, the time when each picture is reproduced in the normal reproduction is calculated based on the picture number thereof calculated in Step **S5**. In the first example, the reproduction interval between two pictures in the normal reproduction is 1/30 (s). Therefore, the product obtained by multiplying together "1/30 (s)" and the "picture number" becomes equal to the time when the reproduction of the picture is started.

In Step **S7**, a table for generating the jump addresses is generated using the GOP numbers, the picture numbers, the reproduction times of the pictures, the sector addresses and the top addresses of the auxiliary data which have been calculated in Steps **S3** to **S6**. Table 1 is a table for generating the jump addresses.

Table 1

GOP Number	Picture Number	Reproduction Time	Sector Address	Top Address of Aux. Data	Type of Picture
1	0	0.0000	2−30	0	Preceding
1	1	0.0333	31−33	0	
1	2	0.0666	34−36	0	
1	3	0.1000	37−51	0	
1	4	0.1333	52−54	0	
1	5	0.1666	55−57	0	
1	6	0.2000	58−72	0	
1	7	0.2333	73−75	0	
1	8	0.2666	76−78	0	
1	9	0.3000	79−93	0	
1	10	0.3333	94−96	0	
1	11	0.3666	97−99	0	
2	12	0.4000	102−130	100	
2	13	0.4333	131−133	100	
2	14	0.4666	134−136	100	
2	15	0.5000	137−151	100	
2	16	0.5333	152−154	100	
2	17	0.5666	155−157	100	
3	18	0.6000	160−190	158	Succeeding

3	19	0.6333	191−193	158	
...	...	...	...	...	
3	29	0.9666	257−259	158	
3	30	1.0000	260−274	158	Destination
3	31	1.0333	275−277	158	
...	...	...	...	...	

It is noted that the column of "type of picture" is provided for Table 1 for convenience of description and is not necessary for generating the jump addresses.

In Table 1, the GOP data **GOP1** (or the GOP data having a GOP number of "1") is composed of 12 picture data (picture **0** to picture **11**), for example. The normal reproduction of each picture data is started at an interval of 1/30 (s). Auxiliary data corresponding to two sectors are recorded immediately anterior to each GOP data. Accordingly, the sectors in which the GOP data **GOP1** is recorded start from the sector address of "2". Auxiliary data corresponding to two sectors are also inserted between the GOP data **GOP1** and the GOP data **GOP2**. Therefore, the difference between the sector address at the end of the GOP data **GOP1** (i.e., 99) and the sector address at the beginning of the GOP data **GOP2** (i.e., 102) becomes 3.

In Step **S8**, the jump addresses are obtained based on the table reproduced in Step **S7**. Hereinafter, a method for obtaining the jump addresses will be described. Herein, assuming that the reproduction scale

factor R is 30 and the preceding picture is a picture having a picture number of "0" (the reproduction time thereof = 0.0000 (s)), the reproduction time of the destination picture (hereinafter, simply referred to as a "destination picture time") becomes 1.0000 (s) in the normal reproduction. A succeeding picture is the top picture of a GOP in which the destination picture is included (i.e., a succeeding GOP), no matter whether or not the destination picture is the top picture of the GOP.

Figure 4 is a flow chart illustrating a method for obtaining the jump addresses from the table. Hereinafter, description will be made with reference to Figure 4 and Table 1.

In Step S81, a picture number is given for the preceding picture. Herein, the picture 0 included in GOP1 is assumed to be the preceding picture.

In Step S82, the reproduction time of the preceding picture is obtained using the table. Herein, "a preceding picture time = 0.0000 (s)" is obtained by reference to the column of the reproduction time of the picture 0.

In Step S83, the interval between the preceding picture time and the destination picture time is given based on the reproduction scale factor R. Herein, the reproduction scale factor R is assumed to be 30. Therefore, (the interval between the preceding picture time and the destination picture time) = (the reproduction time interval between pictures) × (the reproduction scale

factor R) = (1/30) × 30 = 1 (s).

In Step **S84**, the reproduction time of the destination picture is calculated. (The destination picture time) = (the preceding picture time) + (the interval between the preceding picture time and the destination picture time) = 0.0000 + 1.0000 = 1.0000 (s).

In Step **S85**, a picture number is obtained for the destination picture using the destination picture time (1.0000 (s)). The picture number may be obtained by sequentially scanning the column of the reproduction time from the picture number **0** so as to find a picture number of which the reproduction time becomes equal to or larger than the destination picture time of 1.0000 (s) for the first time in Table 1. In the example shown in Table 1, such a picture number is "30".

In Step **S86**, a GOP number is obtained for the succeeding GOP (or the GOP in which the destination picture or the picture **30** is included). Referring to the column of the GOP number of the picture **30**, the GOP number is found to be 3.

In Step **S87**, the succeeding picture (or the top picture of the succeeding GOP) is obtained. The succeeding picture may be obtained by sequentially scanning the column of the GOP number from the GOP number **1** in Table 1 so as to find a picture number of which the GOP number becomes equal to the GOP number **3** for the first time. In the example shown in Table 1, such a picture number is 18.

In Step S88, the top address is obtained for the auxiliary data corresponding to the succeeding GOP in which the succeeding picture is included by reference to Table 1. Referring to the column of "top address of auxiliary data" on the row of the picture 18 or the succeeding picture in Table 1, the top address of the auxiliary data corresponding to the succeeding GOP is found to be 158. This value of 158 is recorded at the sector address 0 as the jump address of the picture 0 or the preceding picture, when the reproduction scale factor R is 30 (i.e., the interval between the preceding picture time and the destination picture time is 1.0000 (s)). This sector address 0 is the sector address at which the jump address of the auxiliary data corresponding to the data of GOP1 or the preceding GOP is recorded.

Figure 3 will be referred to again. In Step S9, formatting is performed so that the auxiliary data including the jump address generated in Step S8 and the GOP data corresponding thereto are adjacent to each other on the recording medium, thereby outputting the data thus obtained as a recording data stream. Referring to Figure 2 again, it will be described specifically. The jump address generated by performing the formatting in Step S9 is placed in the data area DA of the sector 0 (JA1), for example. In this specification, the "auxiliary data" refers to the data recorded in the sectors other than the sectors in which the GOP data is included (e.g., the sectors 2 to 14 and 17 in Figure 2), that is to say, the data recorded in the sectors (e.g., the sectors 0 and 1 in Figure 2) adjacent to and anterior to the sectors in which the GOP data is recorded. In the same way as the GOP data, the jump address included in the auxiliary data

is also recorded in the data area **DA** (2048 bytes) in a sector.

The auxiliary data is disposed so as to be adjacent to the top of each GOP data. Therefore, in the column of "top address of auxiliary data" in Table 1, the top sector addresses of the sectors, in which the auxiliary data corresponding to the respective GOP data is recorded, are shown.

In Step **S10**, the recording data stream generated in Step **S9** is subjected to various kinds of processing such as the addition of an error correction signal, and a digital modulation, thereby generating a recording signal. As an error correction method, an RS-PC (Reed-Solomon Product Code) method is employed. As a modulation method, an eight to sixteen modulation is employed.

In Step **S11**, by supplying the recording signal obtained in Step **S10** to an optical write head, the recording data stream is written onto the tracks on the optical disk.

In the foregoing description, all the steps are sequentially processed. However, the processing is not limited to such a manner. For example, Steps **S4** and **S5** may be processed in parallel. In addition, the order of the respective steps is not limited to that shown. For example, the processing order of Steps **S3** to **S5** is interchangeable.

Figure 5 is a diagram for illustrating the jump addresses in the first example of the image information

recording apparatus and method of the present invention. It is assumed that the high-speed reproduction is performed using the table shown in Table 1 both in (A) and (B) in Figure 5.

In (A) of Figure 5, the data to be recorded on the sectors on the optical disk are schematically shown. The GOP data **GOP1** includes the intra-coded picture data I1 and the inter-coded picture data **PB1**. The inter-coded picture data **PB1** includes the P picture data and/or the B picture data. That is to say, the inter-coded picture data **PB1** corresponds to "B1, B2, P1, B3, B4, P2,... P4, S" shown in Figure 2. However, the GOP data is not limited thereto, but may be composed of intra-coded picture data only without any inter-coded picture data.

The auxiliary data **AUX1**, located immediately anterior to the GOP data **GOP1**, includes a jump address **JA1** and video blanking information **VBI1**. The jump address **JA1** is located at the sector address **0** which is anterior to the top sector of the GOP data **GOP1** by two sectors. The auxiliary data **AUX1** corresponds to the GOP data **GOP1**. The auxiliary data **AUX1** indicates the top sector address of the auxiliary data corresponding to the GOP data in which the destination picture data is included.

More specifically, if the picture **0** or the top picture of **GOP1** is assumed to be the preceding picture as described referring to Table 1 and the reproduction scale factor **R** is assumed to be 30, then it is necessary to reproduce a picture to be reproduced in the normal reproduction 1 (s) later than the time when the picture **0**

or the preceding picture is reproduced. That is to say, a picture reproduced in the normal reproduction at the destination picture time **t2** which is 1 (s) later than the preceding picture time **t1** is the destination picture. Herein, the destination picture is the picture **30**. The succeeding picture is the top picture of **GOP3** in which the destination picture **30** is included, i.e., the picture **18**. Therefore, in the high-speed reproduction in which the reproduction scale factor **R** = 30, the picture **18** or the succeeding picture is reproduced in succession with the picture **0** or the preceding picture. The picture **18** or the succeeding picture is reproduced at a time **t3** in the normal reproduction.

The jump address **JA1** corresponding to the GOP data **GOP1** indicates the top sector address of the auxiliary data corresponding to the GOP data in which the destination picture is included. As shown in **(A)** in Figure 5, 158 or the top sector address of the auxiliary data **AUX3** corresponding to **GOP3** or the succeeding GOP is recorded in the jump address **JA1** corresponding to the GOP data **GOP1**.

Ideally, the reproduction should be started from the picture **30** or the destination picture. However, in the first example, the picture **18** or the succeeding picture is reproduced by reading out the data of **GOP3** or the succeeding GOP from the top thereof. As a result, it is possible to advantageously simplify hardware and software for realizing the high-speed reproduction of the first example.

It is noted that, in an actual reproducing

apparatus, it is impossible to predict when a high-speed reproduction command is given by a user to a reproducing apparatus. Therefore, a high-speed reproduction may be instructed by a user when the picture 3 shown in (B) in Figure 5 is being reproduced, for example. However, in the first and the second examples, the preceding picture is assumed to be nothing but the top picture of a preceding GOP (e.g., a picture 0, 12 or 18 shown in (B) in Figure 5). Therefore, the preceding picture time is set at the time t1 when the top picture of a preceding GOP is normally reproduced.

In the case of making variable the reproduction scale factor R for a high-speed reproduction, it is necessary to record the jump addresses corresponding to the respective reproduction scale factors R. For example, in order to realize the reproduction scale factors R = ±15, ±30, ±75 and ±300, it is necessary to record eight kinds of jump addresses in total. Herein, the signs "+" and "-" of the reproduction scale factors R indicate a forward direction and a backward direction, respectively.

Figure 6 is a chart showing a format for the sector including jump addresses JA corresponding to a plurality of reproduction scale factors R. The subcode SC, the jump addresses JA and the extra data ED shown in Figure 6 correspond to the sector 0 (JA1) shown in Figure 2, for example. The jump addresses JA and the extra data ED shown in Figure 6 are recorded in the data area DA (2048 bytes) shown in Figure 2. The jump addresses JA used in the first example include addresses FWD60, FWD30, FWD10, FWD7.5, FWD5, FWD2.5, FWD2, FWD1.5,

FWD1, ... BWD7.5, BWD10, BWD30, and BWD60 (each of which has 4 bytes) and extra data **ED** (1968 bytes) in this order from the top thereof. In these addresses, the reference sign "FWD" indicates a forward high-speed reproduction, while the reference sign "BWD" indicates a backward high-speed reproduction. The numeral following "FWD" or "BWD"indicates the interval between the preceding picture time and the destination picture time. For example, "FWD10" in Figure 6 indicates the top sector address of the auxiliary data corresponding to the GOP including the destination picture to be normally reproduced 10 seconds later than the preceding picture time in the forward high-speed reproduction. In addition, various kinds of data, such as a time when the reproduction of the GOP is started and a sector address at which audio data corresponding to the GOP data is recorded, may be recorded as the extra data **ED**.

Assuming that a time when a preceding picture is normally reproduced is denoted by **T1** and a time when a destination picture is normally reproduced is denoted by **T2** and that a positive value **ΔTi** (where i = 1 to n and i and n are natural numbers) is used, the time **T2** in the case shown in Figure 6 can be represented as:

$$T2 = T1 \pm \sum_{i=1}^{n} \Delta Ti$$

where "Σ" indicates a summation for i = 1 to n, and $1 \leq n \leq nmax$ (where nmax is a natural number). In Figure 6, nmax = 10, ΔT1 to ΔT5 = 0.5 (s), ΔT6 to ΔT8 = 2.5 (s), ΔT9 = 20, and ΔT10 = 30. That is to say, in the case shown in Figure 6, ΔTi monotonically increases for the variable i. ΔTi either remains the same or increases

when the variable i increases. As a result, it is possible to advantageously realize reproduction scale factors R over a wide range while saving the region in which the jump address is recorded.

In general, the precision with respect to a high-speed reproduction is required to be high at the time of a low speed. However, the higher the speed becomes, the less the precision is required. Accordingly, in the case where the reproduction scale factor R is small, or the case where the jump distance (i.e., the interval between the preceding picture time and the destination picture time) is temporally short, the number of types of the jump addresses is preferably larger. Conversely, in the case where the reproduction scale factor R is large, the number of types of the jump addresses may as well be small. The jump address table shown in Figure 6 includes jump addresses for realizing 10 kinds of reproduction scale factors R in the forward direction and 10 kinds of reproduction scale factors R in the backward direction, i.e., 20 kinds of reproduction scale factors R in total. However, the jump addresses are not limited to the addresses corresponding to the 20 kinds of reproduction scale factors R, but may include only the 10 kinds of jump addresses used for the forward high-speed reproduction in the above-described example. In addition, the interval between the preceding picture time and the destination picture time is not limited to the values (such as 0.5 (s), 1.0 (s), 1.5 (s), 2.0 (s) and 2.5 (s)) exemplified above.

In the first and the second examples, the natural number nmax in the above-described equation is preferably

equal to or larger than 5. More preferably, the natural number **nmax** is equal to or larger than 10.

Figure 7 is a block diagram of the first example of the image information recording apparatus of the present invention. Figure 7 shows a configuration for an apparatus for implementing the image information recording method of the invention as has been described mainly referring to Figures 3 to 5. A video signal **100** is input to an A/D converter **110**. The video signal **100** is a signal having the above-described NTSC or PAL format. The A/D converter **110** receives the video signal **100** so as to convert it into picture data **120** represented by binary data. The picture data **120** is data representing pictures to be displayed at an interval of 1/30 (s), for example. More specifically, the picture data **120** is data having a format defined by the Recommendation BT.601 of ITU-R.

A group divider **130** receives the picture data **120** and divides it into a plurality of groups so that each of the groups includes a predetermined number of pictures, thereby generating GOP data **140** and outputting the data to a coder **150** and a GOP counter **160**. In the case where the GOP data **140** includes a plurality of picture data, the plurality of picture data included in the GOP data **140** are successive on the time axis. The number of pictures represented by one GOP data **140** may be arbitrarily set depending upon the type of the image, the number of entry points in the trick play reproduction and the like. A group start code indicating the top of the GOP data is added to the beginning of the GOP data **140** output from the group divider **130**.

The coder **150** performs compression coding processing on a GOP basis for the GOP data **140**, thereby outputting the coded GOP data **170** to a sector divider **180**. The GOP data **140** is compression-coded so as to include at least intra-coded picture data (I picture data). In the case where the GOP data **140** includes a plurality of picture data, the compression rate may be increased by performing an inter-picture coding instead of the intra-picture coding depending on the necessity. To the contrary, a case where the coded GOP data **170** include no inter-coded picture data (P picture data and B picture data) may also occur. The intra-picture coding and the inter-picture coding are implemented by known methods.

The sector divider **180** receives the coded GOP data **170**, thereby calculating the sector addresses on the optical disk at which the GOP data **170** and the auxiliary data corresponding to the respective GOP data **170** are recorded. The sector divider **180** outputs not only the data **190** indicating the calculated sector addresses to a table generator **200** but also the GOP data **170** to a formatter **210**. The sector divider **180** calculates the sector addresses based on the length of GOP data, the length of auxiliary data and the sector length. The sector divider **180** includes a counter having an initial value of "0" and an increment of "1". Since the auxiliary data is recorded immediately anterior to the GOP, the sector divider **180** first increments the count value from "0" to "2". Next, the sector divider **180** receives the GOP data **170** and increments the count value by "1" every time 2048 bytes, i.e., the length of the data area, are input thereto. By performing such an operation, the

sector divider **180** generates the data **190** indicating the sector addresses at which the respective GOP data **170** are recorded and the sector addresses at which the auxiliary data corresponding to the respective GOP data are recorded. The sector divider **180** counts so that two sector addresses are skipped in the boundary between two GOP data, because the auxiliary data is recorded in the two sectors located in the boundary between two adjacent GOP data. The sector divider **180** detects the beginning of each GOP data by the group start code.

The GOP counter **160** calculates the GOP number of the GOP data **140** yet to be coded, thereby outputting the data **220** indicating the GOP number to the table generator **200**. The GOP counter **160** includes a counter having an initial value of "1" and an increment of "1". By incrementing the count value by "1" every time one GOP data is input thereto, the GOP counter **160** generates the GOP numbers. The GOP counter **160** detects the input of one GOP data by examining the data amount of the input GOP.

A picture number counter **240** calculates the picture numbers of the picture data **120** included in the GOP data **140**, thereby outputting the data **250** indicating the picture numbers. The picture number counter **240** includes a counter having an initial value of "0" and an increment of "1". By incrementing the count value by "1" every time one picture data is input thereto, the picture number counter **240** generates the picture numbers. The picture number counter **240** detects the input of one picture data by examining the data amount of the input picture.

Although the GOP counter **160** and the picture number counter **240** perform count operation based on the input data amount, but the operation is not limited thereto. For example, the GOP numbers and the picture numbers may be respectively counted by detecting the group start code and the picture start code (defined in MPEG 1 and MPEG 2) included in the data output from the coder **150**.

A picture number/time converter **260** calculates a time when each picture is reproduced in the normal reproduction based on the data **250** indicating the picture numbers, thereby outputting the data **270** indicating the time to the table generator **200**. Specifically, the reproduction interval between two pictures in the normal reproduction is 1/30 (s) in the first example. Therefore, the picture number/time converter **260** outputs the data **270** indicating the product obtained by multiplying together "1/30 (s)", i.e., the time when the reproduction of the picture is started, and the "picture number" to the table generator **200**.

The table generator **200** generates a table such as that shown in Table 1 based on the data **220** indicating the GOP numbers, the data **250** indicating the picture numbers, the data **270** indicating the times when the pictures are reproduced in the normal reproduction and the data **190** indicating the sector addresses of the GOP data **170**, thereby storing the generated table in a memory **280**. The column of the "top address of auxiliary data" in Table 1 is generated in the following manner. Specifically, the table generator **200** outputs a sector address (e.g., 158 in **GOP3** in Table 1) obtained by

subtracting 2 (corresponding to the number of the sectors in which the auxiliary data is recorded) from the top sector address (e.g., a sector address 160 of **GOP3** in Table 1) of the sectors in which each GOP is recorded as the "top address of auxiliary data" for all the pictures (e.g., the pictures having picture numbers equal to or larger than 18 in **GOP3** in Table 1) included in the GOP. The table generator **200** performs the steps for obtaining the jump address from the table, as described referring to Steps **S7** and **S8** in Figure 3, by way of software, thereby outputting the resulting jump addresses **290** to the formatter **210**. Therefore, the table generator **200** may be typically implemented as a combination of a microprocessor and the associated programs stored in a memory **280**.

The formatter **210** receives the GOP data **170** and the jump addresses **290** and adds the auxiliary data including the jump addresses **290** to the GOP data **170**, thereby outputting these data as recording data **300** to a recording signal processor **310**. The recording format of the recording data **300** is as shown in Figure **2**, for example, while the recording format of the sectors including the jump addresses **290** among the auxiliary data is as shown in Figure **6**, for example. That is to say, the formatter **210** specifies the format such that the auxiliary data including the corresponding jump address **290** is recorded in the two sectors immediately anterior to the GOP data **170**.

The recording signal processor **310** receives the recording data **300**, subjects the data to various kinds of processing such as the addition of an error correction

signal and a digital modulation, amplifies the recording signal 320 to a degree sufficient to drive an optical head 330 for recording and then outputs the amplified signal to the optical head for recording 330. The optical head for recording 330 writes the recording data 300 on the tracks on the optical disk by irradiating light having an intensity corresponding to the recording signal 320 onto the optical disk.

Figure 8 is a timing chart showing data for the respective components shown in Figure 7. In Figure 8, (A) to (D) represent the data 220 indicating the GOP numbers, the data 250 indicating the picture numbers, the data 270 indicating the times when the pictures are reproduced in the normal reproduction, and the data 190 indicating the sector addresses of the GOP data 170, respectively. In (D) in Figure 8, a vicinity of the boundary between GOP2 and GOP3 is enlarged on the time axis and shown. The table generator 200 receives these data, generates a table and then outputs the table to the memory 280.

In the first example, the auxiliary data is assumed to be recorded in two sectors. However, the number is not limited thereto, but the data may be recorded in one sector, or three or more sectors. In the latter case, it is also preferable that the auxiliary data is recorded immediately anterior to the GOP data. In addition, it is also preferable for a jump address to indicate a top sector address of the sectors in which the auxiliary data corresponding to the succeeding GOP data is recorded.

The jump address may also be disposed in each of the sectors of I picture data instead of being recorded in only the top sector of the auxiliary data.

In the first example, a case where auxiliary information is provided for the I picture of each GOP has been illustrated. However, in the case where the number of pictures included in one GOP is small, for example, it is not always necessary to place auxiliary data so as to correspond to all of the GOPs. In such a case, it is only necessary to dispose the auxiliary data so that the times when the pictures of respective GOPs having auxiliary data are first reproduced in the normal reproduction are at substantially regular intervals. For example, as for the intra-coded picture data to be recorded in the sectors adjacent to the sectors in which the auxiliary data including the jump addresses is recorded, the auxiliary data is preferably recorded in such a format as to be reproduced at an interval in a range from 0.4 (s) to 1.0 (s), both inclusive, in the normal reproduction. This advantageously enhances the time-axis linearity when the reproduction scale factor R is small.

(Example 2)

In the second example of the image information recording apparatus and method of the present invention, data indicating a difference between the picture number of a destination picture and the picture number of a succeeding picture (hereinafter, such data will be referred to as "offset data") together with the jump addresses are recorded on the optical disk as auxiliary data. By using this offset data, the reproduction can be

muted until the time when the destination picture is reproduced. As a result, it is possible to exactly seek a picture and further improve the time-axis linearity during the high-speed reproduction. In the following explanation, only the points different from the first example will be described.

Figures **4** and **5** will be referred to again. The offset data is a number obtained by subtracting the picture number (18) of a succeeding picture from the picture number (30) of a destination picture, that is to say, 30 - 18 = 12 in Figure **5**, for example. In the case of recording a plurality of jump addresses, the offset data corresponding to the respective addresses are also recorded.

In Step **S85** shown in Figure **4**, the picture number of a destination picture is obtained. In Step **S87**, the picture number of a succeeding picture is obtained. Therefore, a step of calculating (the picture number of the destination picture) - (the picture number of the succeeding picture) is performed as Step **S89** after Step **S88**. From Step **S89** on, the jump addresses and the offset data corresponding thereto may be treated as the auxiliary data instead of the jump addresses in the first example. For example, in Step **S9** shown in Figure **3**, formatting is performed so that the jump addresses and the offset data are recorded within one sector.

Figure **9** is a chart showing a format in which the jump addresses **JA** corresponding to a plurality of reproduction scale factors **R** and the offset data **OD** corresponding to the respective jump addresses are recorded.

In Figure 9, "FOS" and "BOS" indicate the offset data in a forward high-speed reproduction and a backward high-speed reproduction, respectively. The numeral following "FOS" or "BOS"indicates the interval between a preceding picture time and a destination picture time. For example, the offset data "FOS10" in Figure 9 indicates the number obtained by subtracting the picture number of a succeeding picture from the picture number of a destination picture to be normally reproduced at a time 10 seconds later than the preceding picture time, in the forward high-speed reproduction. The sub-code **SC**, the jump address **JA**, the offset data **OD** and the extra data **ED** shown in Figure 9 correspond to **JA1** shown in Figure 2, for example. The jump address **JA**, the offset data **OD** and the extra data **ED** shown in Figure 9 are recorded in the data area **DA** (2048 bytes) shown in Figure 2, for example.

Figure 7 will be referred to again. In the second example, the table generator **200** shown in Figure 7 performs the calculation of the above-described Step **S89**, thereby generating the offset data. The generated offset data together with the jump addresses **290** shown in Figure 7 are output to the formatter **210**. As shown in Figure 9, the formatter **210** specifies the format so that the sub-code **SC**, the jump address **JA**, the offset data **OD** and the extra data **ED** are recorded in this order in the top sector of the auxiliary data.

As described above, in this second example, a number obtained by subtracting the picture number of a succeeding picture from the picture number of a destination picture is recorded as the offset data. For example, in the case shown in Table 1, offset data "12" is

obtained by subtracting the picture number "18" of the succeeding picture from the picture number "30" of the destination picture. This offset data "12" together with the jump address value "158" (the top address of the auxiliary data corresponding to the succeeding GOP) are recorded in the sector having a sector address "0" as the auxiliary data corresponding to the data of GOP1 in which the preceding picture (having a picture number 0) is included.

However, the offset data is not limited to the above-described difference between the picture numbers so long as the data corresponds to the difference between the picture number of a destination picture and the picture number of a succeeding picture. For example, data indicating the time interval obtained by subtracting a succeeding picture time from a destination picture time may also be recorded. For example, in the case shown in Table 1, by subtracting the succeeding picture time "0.6000 (s)" from the destination picture time "1.0000 (s)", "0.4000" is obtained as the offset data. This offset data "0.4000" together with the jump address value "158" (the top address of the auxiliary data corresponding to the succeeding GOP) may be recorded in the sector having a sector address "0" as the auxiliary data corresponding to the data of GOP1 in which the preceding picture (having a picture number 0) is included.

Also, it is preferable to record the offset data so as to correspond to all the jump addresses. However, the correspondence is not limited thereto. For example, the offset data may be recorded so as to be associated with jump addresses having relatively small reproduction

scale factors R.

Although each of the offset data shown in Figure 9 has 4 bytes, the data length is not limited thereto. Especially in the case where the difference between a destination picture number and a succeeding picture number is recorded as the offset data, the offset data may have only one byte, for example.

Hereinafter, the reproduction of the image information which has been recorded in accordance with the second example will be described. In the first example, in the case where a destination picture is different from a succeeding picture in the high-speed reproduction, the succeeding picture is reproduced immediately after the reproduction of the destination picture. On the other hand, in this second example, the offset data recorded on the recording medium may be used during the reproduction, unlike the first example. By muting the reproduction of pictures only during a period corresponding to the offset data, the destination picture can be reproduced immediately after the reproduction of the preceding picture without reproducing the succeeding picture. As a result, the destination picture is always reproduced immediately after the preceding picture is reproduced, so that any picture demanded by a user can be advantageously and directly sought.

Figure **10** is a block diagram of a reproducing apparatus for an optical disk on which image information has been recorded by the image information recording apparatus and method of the present invention. This image information reproducing apparatus reproduces the

image compression-coded information which has been recorded on a recording medium such as an optical disk by the image information recording apparatus and method in the first example described above. In the following description, the recording medium will be assumed to be an optical disk. Alternatively, any other type of recording medium may also be used.

In Figure 10, 1001 denotes an optical disk; 1002 denotes an optical pickup; 1003 denotes an optical pickup driver circuit; 1004 denotes a reproduced signal processor circuit; 1005 denotes a buffer memory; 1006 denotes an auxiliary data extractor; 1007 denotes a control circuit; and 1008 denotes a decoder. Hereinafter, the operation thereof will be described.

During reproduction, a signal reproduced from the optical disk 1001 by the optical pickup 1002 is supplied to the reproduced signal processor circuit 1004. Various kinds of processing such as digitization, digital demodulation and error correction is performed in the reproduced signal processor circuit 1004. The data output from the reproduced signal processor 1004 is transmitted to the auxiliary data extractor 1006 and the buffer memory 1005. The auxiliary data is extracted in the auxiliary data extractor 1006. The auxiliary data output from the auxiliary data extractor 1006 is transmitted to the control circuit 1007, thereby controlling the optical pickup driver circuit 1003. The output of the buffer memory 1005 is transmitted to and decoded by the decoder 1008 so that an image data 1009 is output.

The operation of the reproducing apparatus shown

in Figure 10 when high-speed reproduction at a constant reproduction scale factor R is performed will be described below. Assuming a currently retrieved GOP is a preceding GOP, the auxiliary data which corresponds to the preceding GOP and is located immediately anterior to the preceding GOP data has already been extracted by the auxiliary data extractor 1006. If a command for high-speed reproduction is applied by a user when a picture included in the preceding GOP is being reproduced, the jump operation which enables jump to a sector represented by the jump address included in the extracted auxiliary data will be conducted. The command for high-speed operation is given via an input interface (not shown) by the user to the control circuit 1007. The control circuit 1007 retrieves the jump address from the extracted auxiliary data of the preceding GOP, and outputs to the optical pickup driver circuit 1003 a control signal for the track jump to jump to a sector represented by the jump address. This jump address is an address indicating a top sector among the sectors which are located immediately anterior to the succeeding GOP and in which the auxiliary data corresponding to the succeeding GOP is recorded.

After the track jump has been performed based on the jump address of the auxiliary data corresponding to the preceding GOP, auxiliary data corresponding to the succeeding GOP and I picture data of the succeeding GOP which is located immediately posterior to the auxiliary data are retrieved, and then the I picture is reproduced. The auxiliary data of the succeeding GOP also includes a jump address. Immediately after the reproduction of the I picture, a track jump to the next GOP is further

performed based on the jump address included in the auxiliary data of the succeeding GOP. Repetition of similar track jumps and reproduction of the I pictures results in the high-speed reproduction. Herein, the jump addresses included in the respective auxiliary data are obtained as described in the first example, and therefore the reproduction scale factor R is constant.

Among various data recorded in the second example, the offset data is used in the following manner. The offset data among the auxiliary data extracted by the auxiliary data extractor **1006** represents a difference between the picture number of a destination picture and the picture number of a succeeding picture. Therefore, during the high-speed reproduction, first, a track jump is performed for jumping to the sector in which the auxiliary data corresponding to the succeeding GOP has been recorded.

The buffer memory **1005** outputs the picture data to the decoder **1008**. The decoder **1008** decodes the picture data received from the buffer memory **1005**. Based on the offset data output from the auxiliary data extractor **1006**, the decoder **1008** does not output the decoded picture data between the time when the succeeding picture data is decoded and the time when the destination picture data is decoded (i.e., "mutes" the decoded picture). Therefore, the decoder **1008** may output the destination picture data as the image data **1009** immediately after the output of the preceding picture data. By performing this operation, the destination picture which is originally to be reproduced then may be reproduced immediately after the reproduction of the preceding picture. Instead of

the mute operation, repetitive output of the succeeding picture may be performed until the destination picture is decoded in order to "freeze" (or hold) the succeeding picture until then.

In the image information recording apparatus of the present invention shown in Figure 7, components other than the A/D converter **110**, the memory **280** and optical head for recording **330** may be implemented either by means of a microprocessor and a software program for controlling the microprocessor, or by means of hardware such as an ASIC (application specific integrated circuit).

It is noted that the image information recording apparatus of the present invention may include a section associated with information reproduction. For example, the image information recording apparatus of the present invention includes an apparatus for recording/reproducing image information. In the same way as in the case of apparatus, the image information recording method of the present invention may also include steps for reproducing image information.

INDUSTRIAL APPLICABILITY

As described above, according to the present invention, a top sector address among a plurality of sector addresses, at which the auxiliary data of a succeeding GOP is recorded, is recorded on the recording medium as a jump address among the auxiliary data of a preceding GOP. As a result, an image information recording apparatus and recording method for implementing a

recording medium exhibiting high time-axis linearity during reproduction are provided.

In addition, according to the present invention, a parameter corresponding to a difference between a destination picture and a succeeding picture is recorded on the recording medium as offset data for the auxiliary data of a preceding GOP. As a result, an image information recording apparatus and recording method for implementing a recording medium in which seeking can be performed precisely during reproduction are provided.

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CLAIMS

1. An image information recording apparatus comprising:

a coder for generating a plurality of group data, each of the plurality of group data including at least intra-coded picture data, by receiving and coding a plurality of picture data, each of the plurality of picture data corresponding to a picture;

a sector address generator for generating a sector address indicating a top sector among a plurality of sectors on a recording medium in which auxiliary data corresponding to each of the plurality of group data is recorded;

a jump address generator for outputting, as a jump address of first group data among the plurality of group data, a top sector address among a plurality of sector addresses of the auxiliary data, the auxiliary data being located immediately anterior to second group data including second picture data to be reproduced in a normal reproduction at a second time later than a first time by a predetermined fixed time period, the first time being a time when first picture data located at a top of the first group data is reproduced in the normal reproduction; and

a recorder for recording on the recording medium the first group data and the auxiliary data including the jump address corresponding to the first group data so that the auxiliary data including the jump address of the first group data is located adjacent to the first group data on the recording medium.

2. An image information recording apparatus according to claim 1, wherein, assuming that the first time and the

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second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a first equation:

$$T2 = T1 + \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and wherein the auxiliary data includes the n kinds of jump addresses corresponding to the second time determined by the first equation.

3. An image information recording apparatus according to claim 2, wherein, assuming that the first time and the second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a second equation:

$$T2 = T1 - \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and wherein the auxiliary data further includes the n kinds of jump addresses corresponding to the second time determined by the second equation.

4. An image information recording apparatus according to claim 3, wherein the positive value ΔTi monotonically increases for the natural number i.

5. An image information recording apparatus according to claim 4, wherein the auxiliary data including the jump addresses is recorded on the recording medium so that the intra-coded picture data is reproduced at a time interval in a range from 0.4 (s) to 1.0 (s), both inclusive, in the normal reproduction, the intra-coded picture data being recorded adjacent to the plurality of sectors in

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which the auxiliary data including the jump addresses is recorded.

6. An image information recording apparatus according to claim 5, wherein the natural number n satisfies $1 \leq n \leq nmax$ (where nmax is a natural number) and $nmax \geq 5$.

7. An image information recording apparatus according to claim 4, wherein the auxiliary data including the jump addresses includes offset data corresponding to a difference between a third time and the second time, the third time being a time when third picture data, located in a top sector of the second picture data, is reproduced in the normal reproduction.

8. An image information recording apparatus according to claim 7, wherein the offset data represents an interval between the second time and the third time.

9. An image information recording apparatus according to claim 7, wherein the offset data represents a difference between a picture number of a picture represented by the second picture data and a picture number of a picture represented by the third picture data.

10. An image information recording method comprising the steps of:

generating a plurality of group data, each of the plurality of group data including at least intra-coded picture data, by receiving and coding a plurality of picture data, each of the plurality of picture data corresponding to a picture;

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generating a sector address indicating a top sector among a plurality of sectors on a recording medium in which auxiliary data corresponding to each of the plurality of group data is recorded;

outputting, as a jump address of first group data among the plurality of group data, a top sector address among a plurality of sector addresses of the auxiliary data, the auxiliary data being located immediately anterior to second group data including second picture data to be reproduced in a normal reproduction at a second time later than a first time by a predetermined fixed time period, the first time being a time when first picture data located at a top of the first group data is reproduced in the normal reproduction; and

recording on the recording medium the first group data and the auxiliary data including the jump address corresponding to the first group data so that the auxiliary data including the jump address of the first group data is located adjacent to the first group data on the recording medium.

11. An image information recording method according to claim 10, wherein, assuming that the first time and the second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a first equation:

$$T2 = T1 + \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and wherein the auxiliary data includes the n kinds of jump addresses corresponding to the second time determined by the first equation.

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12. An image information recording method according to claim 11, wherein, assuming that the first time and the second time are denoted by T1 and T2, respectively, and that a positive value ΔTi (where i = 1 to n, and i and n are natural numbers) is used, a second equation:

$$T2 = T1 - \sum_{i=1}^{n} \Delta Ti$$

is satisfied, and wherein the auxiliary data includes the n kinds of jump addresses corresponding to the second time determined by the second equation.

13. An image information recording method according to claim 12, wherein the positive value ΔTi monotonically increases for the natural number i.

14. An image information recording method according to claim 13, wherein the auxiliary data including the jump addresses is recorded on the recording medium so that the intra-coded picture data is reproduced at a time interval in a range from 0.4 (s) to 1.0 (s), both inclusive, in the normal reproduction, the intra-coded picture data being recorded adjacent to the sectors in which the auxiliary data including the jump addresses is recorded.

15. An image information recording method according to claim 14, wherein the natural number n satisfies $1 \leq n \leq nmax$ (where nmax is a natural number) and $nmax \geq 5$.

16. An image information recording method according to claim 13, wherein the auxiliary data including the jump addresses includes offset data corresponding to a differ-

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ence between a third time and the second time, the third time being a time when third picture data, located in a top sector of the second picture data, is reproduced in the normal reproduction.

17. An image information recording method according to claim 16, wherein the offset data represents an interval between the second time and the third time.

18. An image information recording method according to claim 16, wherein the offset data represents a difference between a picture number of a picture represented by the second picture data and a picture number of a picture represented by the third picture data.

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