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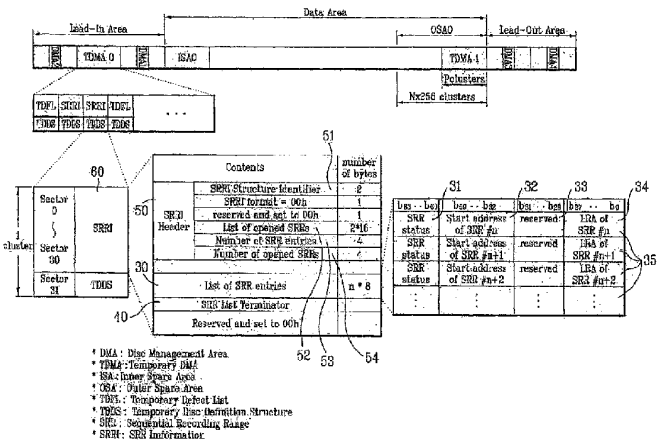

(57) **Abstract:** A write-once optical disc and a method and apparatus for recording management information on the disc are provided. The method includes recording an opened SRR information on a recording medium, and removing an identification of a certain SRR from the opened SRR information once the certain SRR is closed. The opened SRR information carries an identification of any opened SRR, and the number of opened SRRs allowed is at most a predetermined number.

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WRITE-ONCE OPTICAL DISC AND METHOD FOR RECORDING MANAGEMENT INFORMATION THEREON

Technical Field

The present invention relates to a write-once optical disc, a method for recording management information on the write-once optical disc, and a recording/playback apparatus using the method.

Background Art

As an optical recording medium, optical discs on which high-capacity data can be recorded are widely being used. Among them, a new high-density optical recording medium (HD-DVD), for example, a Blu-ray disc, has been recently developed for recording and storing high-definition video data and high-quality audio data for a long term period.

The Blu-ray disc is the next generation HD-DVD technology and the next generation optical recording solution, and has an excellent capability to store data more than the existing DVDs. Recently, a technical specification of international standard for HD-DVD has been established. Related with this, various standards for a write-once Blu-ray disc (BD-WO) are being prepared following the standards for a rewritable Blu-ray disc (BD-RE).

Among the standards for the write-once Blu-ray disc (BD-WO), a method for

recording management information has been discussed. This method involves a recording method of an information indicating a recorded status of the disc, which is one of the characteristics of the write-once optical disc. The information indicating the recorded status of the disc allows a host or a user to easily find a recordable area on the write-once optical disc. In the existing write-once optical discs, this information is named variously. For example, in the case of CD series, this information is named a track information; in the case of DVD series, this information is named an RZone or a fragment.

Accordingly, there is an increasing demand for a method of efficiently recording the management information corresponding to the recorded status of the high-density optical disc. And this method must be provided with the standardized information in order to secure mutual compatibility. In addition, there is a demand for a method of recording the management information on a disc, which can be applied to a write-once high-density optical disc performing defect management, as well as to the Blu-ray discs.

It is not admitted that any of the information in this specification is common general knowledge, or that the person skilled in the art could be reasonably expected to have ascertained, understood, regarded it as relevant or combined it in anyway at the priority date.

Disclosure of Invention

According to an aspect of the present invention there is provided a method of managing a recording medium including one or more sequential recording ranges (SRRs), the recording medium having a permanent defect management area for storing therein management information when the recording medium is to be closed, the method comprising steps of:

recording, onto a temporary disc management area storing therein, management information of the recording medium until the recording medium is closed, opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRRs existing on the recording medium, each opened SRR having a writable position therein, wherein a number of opened SRRs allowed is at most a predetermined number; and

removing an identification of a certain SRR from the opened information once the certain SRR is closed.

According to another aspect of the present invention there is provided a recording medium comprising:

one or more sequential recording range (SRRs) on the recording medium;

a permanent defect management area storing therein management information when the recording medium is to be closed; and

a temporary disc management area storing therein, management information of the recording medium until the recording medium is to be closed, the temporary disc management area storing therein opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRRs existing on the recording medium, each opened SRR having a writable position therein,

wherein a number of opened SRRs allowed is at most a predetermined number, and an identification of a certain SRR is removed from the opened SRR information once the certain SRR is closed.

According to another aspect of the present invention there is provided an apparatus for managing a recording medium including one or more recording ranges (SRRs), the recording medium having a permanent defect management area for storing therein management information when the recording medium is to be closed, the apparatus comprising:

a pickup configured to record/reproduce data to/from the recording medium directly;

a microcomputer, operatively coupled to the pickup, configured to control the pickup to:

record, onto a temporary disc management area storing therein management information of the recording medium until the recording medium is to be closed, opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRR existing on the recording medium, each opened SRR having a writable position therein; and

remove an identification of a certain SRR from the opened SRR information once the certain SRR is closed.

Described herein is a write-once optical disc and a method for managing the disc that substantially obviates one or more problems due to limitations and disadvantages of the related art.

The present invention may provide a method and apparatus for recording management information of a write-once optical disc, which are capable of recording and managing the disc recorded status information more efficiently.

Embodiments of the present invention may define different types of sequential recording ranges (SRRs) and to provide a method and apparatus for recording the SRRs on SRR information (SRRI).

Embodiments of the present invention may provide a structure of a write-once optical disc and a structure of SRRIs that facilitate the recording/playback operations of the disc.

Embodiments of the present invention may provide a method of recording SRRI, a method of recovering SRRI, and/or a recording/playback apparatus, which can be applied to a write-once optical disc.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

From hereon in, the phrase "the present invention" refers to preferred embodiments of the present invention. It is not intended to necessarily apply to all forms of the invention.

As used herein, except where the context requires otherwise the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude other additives, components, integers or steps.

Brief Description of Drawings

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment (s) of the invention and together with the description serve to explain the principle of the invention.

In the drawings:

FIG. 1 illustrates a structure of a write-once optical disc according to an embodiment of the present invention;

FIGs 2A to 2D illustrate different types of opened SRRs of the write-once optical disc of FIG. 1 according to the present invention;

FIGs. 3A to 3E illustrate different types of closed SRRs of the write-once optical disc of FIG. 1 according to the present invention;

FIG. 4A to 4G illustrate an example of a process of generating SRR (s) and session (s) of the write-once optical disc of FIGs. 1-3E according to an embodiment of the present invention;

FIG. 5A illustrate an example of a structure of an SRR entry according to a first embodiment of the present invention;

FIGs. 5B and 5C illustrate an example of using the SRR entry structure of FIG. 5A according to the first embodiment of the present invention;

FIG. 6A illustrate an example of a structure of an SRR entry according to a second embodiment of the present invention;

FIGs. 6B and 6C illustrate an example of using the SRR entry structure of FIG. 6A according to the second embodiment of the present invention;

FIGs. 7A to 11B illustrate examples of recording SRRI depending on a disc recording state in the write-once optical disc of FIG. 1 according to the present invention;

FIG. 12 is a flowchart illustrating a method of using SRRIs of a write-once optical disc when the latest SRRI is damaged according to an embodiment of the present invention;

FIGs. 13A and 13B illustrate a method of restoring the latest SRRI in the write-once optical disc according to an embodiment of the present invention; and

FIG. 14 illustrates a recording/playback apparatus for a write-once optical disc according to an embodiment of the present invention.

Best Mode for Carrying Out the Invention

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying

drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

According to the present invention, a plurality of regions are formed on an optical disc such as a BD-WO and each of these regions is referred to as a "sequential recording range" (SRR). A recording/playback operation is performed on/from these regions. Information indicating the recorded status of the disc will be referred to as "sequential recording range information" (SRRI), meaning it is applied to a sequential recording mode of the disc. The SRRI pertains to one or more SRRs.

FIG. 1 illustrates a structure of a write-once optical disc such as a BD-WO and a method for recording disc management information according to the present invention. The disc shown in FIG. 1 has a single recording layer as an example. But the present invention is not limited to such, and is applicable to a disc having dual or multiple recording layers.

Referring to FIG. 1, the disc includes a lead-in area, a data area, and a lead-out area, all at the recording layer. The lead-in and lead-out areas have a plurality of disc (or defect) management areas (DMA1 – DMA4) for storing the same defect management information repeatedly. In the data area, an inner spare area ISA0 and/or an outer spare area OSA0 for replacing defective areas is provided.

It is known that a rewritable optical disc does not have or need a large DMA

since its DMA can be written and erased repeatedly, even if the disc has the DMA of a limited size. This is not the case for a write-once optical disc such as a BD-WO. Since the write-once optical disc cannot be re-recorded on the area that was recorded once, the write-once optical disc needs and has a larger management area. To more effectively store management information, in the write-once optical disc the management information is temporarily stored in a temporary disc management area (TDMA). When the disc is ready to be finalized/closed, then the management information stored in a final/latest TDMA is transferred to a DMA for more permanent storage.

As shown in FIG. 1, the disc includes two TDMAs: TDMA0 and TDMA1. The TDMA0 is allocated to the lead-in area and has a fixed, non-variable size. The TDMA1 is allocated to the outer spare area OSA0 and has a size variable in accordance with the size of the spare area. The size P of the TDMA1 may be, for example, P = (N * 256) / 4 clusters where N is a positive integer, which is about one fourth of the size of the entire outer spare area OSA0.

In each of the TDMA0 and TDMA1, temporary defect list (TDFL) information and temporary disc definition structure (TDDS) information together (TDFL + TDDS) can be recorded in one recording-unit (e.g., one cluster in the case of a BD-WO), or SRRI and TDDS information together (SRRI + TDDS) can be recorded in one recording-unit as shown. The SRRI is recorded when a sequential recording mode is used, whereas SBM (space bit map) is used

when a random recording mode is used.

At each update time, (TDFL + TDDS) or (SRRI + TDDS) are recorded to the TDMA in the size of one cluster. In the example of FIG. 1, a TDFL and a TDDS are recorded in one cluster of the TDMA0, an SRRI and a TDDS are recorded in the next cluster of the TDMA0, an SRRI and a TDDS are recorded in the next cluster of the TDMA0, and so on.

If a defective area occurs within the data area, a process of replacing it with the spare area is carried out. The TDFL is the information that manages this process as the defect list. In the case of a single layer disc, the TDFL is recorded with the size of 1 cluster to 4 clusters according to the size of the defect list. Disc status information indicates whether a specific area of the disc is recorded or not-recorded. Specifically, it can be usefully applied to the case where the disc is recorded in a sequential or incremental recording mode. In addition, the TDDS information is generally recorded on the last sector among the 32 sectors within one cluster of the management area. Important information for general management and defect management of the disc is recorded as part of the TDDS information, and the TDDS information is generally always recorded last when the management information is updated within the TDMA.

The present invention provides a method of recording a recorded status information of a disc in a new high-density optical disc such as a BD-WO.

Specifically, SRRI is used as the recorded status information that indicates the recorded status of the disc. Each SRRI pertains to one or more SRRs (recording regions) on the disc. The present invention defines various types of SRRs, which will be discussed later referring to FIGs. 2A to 3E. The structure of the SRRI according to the present invention will be now described with reference to FIG. 1.

As shown in FIG. 1, each SRRI 60 in the TDMA(s) generally includes three parts: a header 50 for identifying the corresponding SRRI, a list of SRR entries (SRR entry list) 30 including SRR type information, and an SRR list terminator 40 for indicating the termination of the corresponding SRRI.

The SRRI header 50 is located at the head of the corresponding SRRI 60 and includes an "SRRI structure identifier" field 51 for making the SRRI identifiable, a "List of opened SRRs" field 52 for identifying the location of each opened SRR pertaining to the current SRRI, a "Number of SRR entries" field 53 for identifying the total number of SRRs, and a "Number of opened SRRs" field 54 for identifying the total number of opened SRRs. The "List of opened SRRs" field 52 stores SRR numbers (identifications) of the opened SRRs.

By accessing the SRRI header 50, the general contents of the entire SRRI 60 can be known without having to access the SRR entry list 30 directly. It is possible to newly define any new SRR types or other necessary information

and to insert this information into the header 50 as needed.

The SRR entry list ("List of SRR entries") 30 is recorded after the SRRI header 50. When the SRR entry list 30 is terminated, the termination of the SRR entry list 30 is identified with the SRR list terminator ("SRR List Terminator") 40. Specifically, the SRR list terminator 40 is information identifying the termination of the corresponding SRRI when the SRRI has a variable size.

The SRR entry list 30 is a list in which a plurality of SRR entries 35 are collected. Eight (8) bytes (or 64 bits) are allocated to each SRR entry 35, and one SRR entry 35 represents information on one SRR on the disc. Each SRR entry 35 includes an SRR status field 31, a start address field 32 for storing a start address of the corresponding SRR, a reserved area 33, and a last recorded address (LRA) field 34 for storing the LRA of the corresponding SRR.

According to an embodiment, the first 4 most significant bits (b63-b60) among the 64 bits of the SRR entry 35 are allocated to the SRR status field 31, the next 28 bits (b59-b32) of the SRR entry 35 are allocated to the start address field 32, the next 4 bits (b31-b28) of the SRR entry 35 are allocated to the reserved area 33, and the last 28 bits (b27-b0) of the SRR entry 35 are allocated to the LRA field 34.

Accordingly, as the management information of the disc, the SRRI includes the header, the list of SRR entries and the SRR list terminator, and all such

information is recorded collectively at each updating instance.

Embodiments of the present invention may define and distinguish various types of SRRs formed within the disc and to use them to record/playback to/from the disc. Therefore, the types of the SRRs will be defined and the method of recording an information that distinguishes the types of the SRRs within the SRRI will be described now in detail.

Particularly, an SRR is an area reserved for recording data or information on a write-once optical disc such as a BD-WO. The present invention defines the types of the SRRs according to necessity and/or a recording progress.

The detailed description of various SRR types that are defined by the present invention, is provided as follows referring to FIGs. 2A-3E.

FIGs. 2A to 2D illustrate different types of opened SRRs for the write-once optical disc (e. g., a BD-WO) according to the present invention. An opened SRR means an SRR that can be recordable on the corresponding area. "Recordable" means that the SRR has a next writable address (NWA). Accordingly, the opened SRR is an SRR with an NWA. An unrecordable SRR without NWA is a closed SRR. That is, the closed SRR is an SRR that cannot be recordable or has no NWA. The closed SRR types will be described later referring to FIGs. 3A to 3E.

More specifically, FIG. 2A illustrates an invisible SRR among the opened

SRRs. The invisible SRR is generally always formed at the outermost section of the disc or to the initial blank disc and means a non-recorded region. In other words, the invisible SRR has only a start address but has no end to its area. Since recording is not performed in the invisible SRR, its LRA is zero. The NWA of the invisible SRR becomes the same value as its start address.

FIG. 2B illustrates an incomplete SRR among the opened SRRs. The incomplete SRR is an SRR in which recording is performed to some portion of the SRR while the SRR is in the invisible SRR status. In other words, the incomplete SRR has only a start address but has no end to its area. Since the recording is performed to some portion of the SRR, the LRA of the incomplete SRR is a last recorded area on which normal data is recorded. Therefore, the NWA of the incomplete SRR is an address next to (or following) the LRA of the SRR.

FIG. 2C illustrates an empty SRR among the opened SRRs. Unlike the invisible SRR and the incomplete SRR of FIGs. 2A and 2B, the empty SRR is an SRR that is generally formed at an intermediate area of the disc, not at the outermost area of the disc, for recording. In other words, it is a case where the recording is not yet performed after the opened SRR is formed for a host or user's recording. The empty SRR has both a start address and an end address. However, since the empty SRR indicates the pre-recording state, the LRA is zero and the NWA has the same value as the start address

of the SRR.

FIG. 2D illustrates a partially recorded SRR among the opened SRRs. The partially recorded SRR is an SRR in which recording is performed to some portion of the SRR while the SRR is in the empty SRR status shown in FIG. 2C. Therefore, the partially recorded SRR has both a start address and an end address. Since the recording is performed to some portion of the SRR, the LRA of the partially recorded SRR is a last recorded area address and the NWA is an address next to the LRA.

According to an embodiment of the present invention, the number of opened SRRs that is allowed is advantageously limited to a predetermined number, since it is difficult to manage a large number of opened SRRs on the write-once optical disc. For example, in the case of BD-WOs, the total number of opened SRRs that is allowed at a given time is maximum sixteen. Information on the location and number of opened SRRs within the disc can be obtained by checking the "List of opened SRRs" field 52 and the "Number of opened SRRs" field 54 within the SRRI header 50 of FIG. 1.

FIGs. 3A to 3E illustrate different types of closed SRRs for a write-once optical disc such as a BD-WO according to the present invention. A closed SRR is an SRR that is non-recordable and "non-recordable" means that the SRR has no NWA. Therefore, the closed SRR can be formed by completing the recording of the SRR. Even if a recordable area remains in the SRR, the

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SRR may be forcibly closed by a user/host's close command.

More specifically, FIG. 3A illustrates an empty SRR among the closed SRRs. The empty SRR is an SRR that is closed by a close command with no recording to the SRR when the SRR is in the empty SRR state shown in FIG. 2C. In this regard, FIG. 3A is an example of a closed empty SRR and FIG. 2C is an example of an opened empty SRR.

FIG. 3B illustrates a partially recorded SRR among the closed SRRs. The partially recorded SRR is an SRR that is closed by a close command with no additional recording to the SRR when the SRR is in the partially recorded SRR state shown in FIG. 2D. In this regard, FIG. 3B is a closed partially recorded SRR and FIG. 2D is an opened partially recorded SRR.

FIG. 3C illustrates a complete SRR among the closed SRRs. The complete SRR is an SRR in which a normal user data recording is completed to the end of the SRR. The complete SRR exists only among the closed SRRs.

FIG. 3D illustrates another example of a closed partially recorded SRR among the closed SRRs. This SRR type involves an SRR that is closed after some recordable area (after the LRA) of the SRR is padded with specific dummy data when closing the opened partially recorded SRR of FIG. 2D. The entire area or some area of the recordable area of the SRR can be padded with the dummy data. As a variation, specific character code (ASCII characteristic) instead of the dummy data can be used to pad the SRR. The

padding data can be used to indicate that the SRR is closed. In one example, the specific character as the padding data may be "CLSD" indicating that the corresponding SRR is closed. In another example, dummy data of zero can be used such that if an SRR with such dummy data is detected, this SRR can be determined to be a closed SRR. When padding the opened SRR to close it, at least part of the recordable area of the SRR may be recorded with the padding data. This part of the SRR may be at least one recording-unit such as one cluster, and can be the first cluster after the LRA. That is, at least one recording-unit of the opened SRR starting from its NWA can be padded when closing the opened SRR.

FIG. 3E illustrates another example of a closed empty SRR among the closed SRRs. This SRR type involves an SRR that is closed after some recordable area of the SRR is padded with padding data when closing the opened empty SRR of FIG. 2C. The padding operation in FIG. 3D as discussed above is applied herein.

As shown in FIGs. 3A-3B and 3D-3E, when an opened SRR is changed into a closed SRR by a close command, the case that the non-recorded area is closed without padding (FIGs. 3A and 3B) and the case that the non-recorded area is closed with padding (FIGs. 3D and 3E) are defined differently.

Also, the case that the SRR is closed without padding and the case that the

SRR is closed after padding it with specific padding data can be selectively accomplished. In the case of existing Blu-ray discs, the non-recorded area is compatible with the playback-only disc even without padding. The recording/playback apparatus (FIG. 14) can selectively perform the padding operation, thereby securing the degree of freedom in the structure/operation of the recording/playback apparatus effectively. Further, in the padding operation, a recording/playback part (e.g., the component 10 in FIG. 14) of the recording/playback apparatus can prestore the padding data and automatically record it an SRR as needed. This reduces the padding operation time, compared to when a controller transmits the padding data and the padding occurs thereafter.

Further, if a portion (e.g., a first cluster after the LRA) of the recordable area within the SRR is padded with specific data in the closing of the SRR, it is possible to validly restore the current disc status even when a loss of the SRRI is present. A detailed description about this feature of the invention will be made later with reference to FIGs. 7A to 13B.

FIGs. 4A to 4G illustrate an example of a process of forming SRRs within the disc of FIGs. 1-3E according to an embodiment of the present invention. In these and other figures, a portion indicated by a thick arrow represents a NWA location. Herein, different types of sessions will be defined and described together according to the present invention.

A "session" is an upper-level recording-unit compared to the lower-level recording-unit such as an SRR, and includes at least one SRR. Also, since only one recordable session may be present within the disc at a given time, a new session must be allocated after all previously allocated sessions are closed. Accordingly, in case a session is closed, all SRRs existing within that session must be closed together. Also, each SRR can be closed by padding the entire area or some area of the recordable area within the SRR, or can be closed without padding the recordable area of the SRR, as discussed above. This operation can be selectively performed by the optical recording/playback apparatus.

Sessions can be classified into different types: an empty session having only an invisible SRR; an incomplete session having at least one opened SRR except for an invisible SRR; and a complete session having only one or more closed SRRs.

Particularly, FIG. 4A illustrates an initial blank disc that is in a recordable status all over the entire area. A start location of the disc becomes the NWA. In such a state, only one SRR is present on the disc. This is the same as the invisible SRR shown in FIG. 2A. Therefore, the session here has a disc initial status in which only one empty session is present.

FIG. 4B illustrate a case when some portion of the blank disc of FIG. 4A is recorded or the session of FIG. 4A is not closed. In such a state, only one

SRR is present on the disc. This is the same as the incomplete SRR shown in FIG. 2B. Therefore, the session here is in a status where only one incomplete session is present.

FIG. 4C illustrates a case when a session close command is executed when the disc is in the state of FIG. 4B. At this time, the existing data recorded area is separated into an independent closed SRR by the session close command and a new (empty) session is created. In other words, the entire recorded area in FIG. 4B becomes a complete SRR #1 which in turn constitutes a complete session #1. The non-recorded area then becomes an invisible SRR (shown in FIG. 2A) which in turn constitutes an empty session.

FIG. 4D illustrates a case when two opened SRRs are reserved in the empty session of FIG. 4C. Each new reserved opened SRR becomes the empty SRR and has a NWA. The remaining area of the empty session forms an invisible SRR. As a result, the empty session of FIG. 4C changes to an incomplete session.

FIG. 4E illustrates a case when data is recorded in the first empty SRR and the invisible SRR of FIG. 4D. Due to the recording, the first empty SRR changes to an opened partially recorded SRR and the invisible SRR changes to an incomplete SRR.

FIG. 4F illustrates a case when a session close command is executed from the state of FIG. 4E, but non-recorded area(s) of the session is closed

without padding. When closing the session, all SRRs contained in that session must be closed. For instance, the existing data recorded area of the incomplete session of FIG. 4E becomes an independent complete session (complete session #2) by the session close command. All SRRs contained in the complete session #2 change to closed SRRs to form a closed partially recorded SRR #2, a closed empty SRR #3 and a complete SRR #4. The remaining outermost SRR becomes an invisible SRR #5 as an opened SRR, and a newly reserved empty session #3 having the invisible SRR #5 is created.

FIG. 4G illustrates another case when a session close command is executed from the state of FIG. 4E, but non-recorded area(s) of the session is closed with padding. That is, the present process can proceed from the state of FIG. 4E to the state of either FIG. 4F or 4G. Referring to FIG. 4G, the existing data recorded area of the incomplete session of FIG. 4E becomes an independent complete session #2 by the session close command. After some or all of the remaining areas of the complete session #2 are padded with dummy data or specific character data as discussed above, all SRRs contained in the complete session #2 change to closed SRRs. As a result of the padding, three types of closed SRRs are reserved within the complete session #2. They are: a closed SRR #2 that is changed from the opened partially recorded SRR to the closed SRR after the padding; a closed SRR #3

that is changed from the opened empty SRR to the closed SRR after the padding; and a complete SRR #4 that is changed to the closed SRR since the physical user data is normally recorded. Although FIG. 4G shows that the entire recordable areas are padded in the closing of the SRRs, the present invention covers a scenario where only a portion (e.g., a first part or cluster after the LRA) of an SRR may be padded.

According to the present invention, when the SRRs are closed, different types of SRRs may be created depending on whether or not a padding operation is performed to the SRRs as shown in FIG. 4F or 4G. Therefore, there is need for a method of recording new SRR information, which can distinguish the defined types of SRRs in order to correctly indicate the recorded status of the disc.

Hereinafter, a method for identifying the type of an SRR will be described. For the convenience of explanation, this method as applied to the SRR entry within the SRRI of FIG. 1 will be described. The SRR type identification according to the present invention is performed according to the padding of the closed SRR, and it is apparent that various modifications and variations can be made in the present invention.

FIG. 5A illustrates a first embodiment of the SRR entry according to the present invention. The SRR entry structure of FIG. 5A is applied to each SRR entry 35 of FIG. 1, but can be applied to any other SRR entry of a disc.

As shown, the SRR entry 35 includes a SRR status field 31, a start address field 32, a reserved area 33 and an LRA field 34 as discussed above. The SRR status field 31 carries therein 4-bit SRR status information used to distinguish whether the corresponding SRR is closed with padding or without padding.

Particularly, 1 bit (31a) of the 4-bit SRR status information in the SRR status field 31 is used as a padding flag (hereinafter, referred to as a "P-flag") for identifying whether or not the padding is performed to the corresponding SRR, and the other 3 bits (31b) of the SRR status field 31 are a reserved area for coping with future modifications in the standard as needed. In the example, the first bit (b63) of the SRR status field 31 carries the P-flag and the remaining three bits (b62-b60) of the SRR status field 31 function as the reserved area. However, other variations are possible.

In the example, if the P-flag has a value of "1b", it means that the corresponding SRR is a closed SRR in which the padding has been performed. If the P-flag has a value of "0b", it means that the corresponding SRR is an SRR in which no padding has been performed. Other values may be used in the P-flag. Accordingly, if the P-flag has the value "0b", the corresponding SRR can be an opened SRR or a closed SRR. However, if the corresponding SRR is an SRR that is registered in the "List of opened SRRs" field 52 within the SRRI header 50, it means it is an opened SRR, but if it is

not registered, then it means it is a closed SRR.

In the start address field 32 of the SRR entry 35, the address corresponding to the start location of the corresponding SRR is recorded. Generally, it is represented with a physical sector number (PSN). The reserved area/field 33 of the SRR entry 35 is provided for future modifications in the standard as needed.

The LRA field 34 of the SRR entry 35 provides an LRA information of the corresponding SRR. That is, an information on the end address of the actually recorded user data (except for the padding data) of the corresponding SRR is recorded. In other words, in the case of a complete SRR, the end addresses of the LRA and the SRR accord with each other. However, in the case of a partially recorded SRR, the end addresses of the LRA and the SRR do not accord with each other. An LRA is an address of an area where the physical user data are recorded. Even if specific padding data are recorded in the SRR by the padding operation, the LRA value of the SRR is not changed. Also, in the case of an empty SRR, the LRA of the SRR becomes zero because there is no area where the physical user data are recorded.

FIGs. 5B and 5C illustrate two different examples of recording the P-flag of FIG. 5A based on the method of creating the SRR entry according to the first embodiment of the present invention. For the convenience of explanation,

FIG. 5B illustrates the case of FIG. 4F in which no padding is performed in the closing of the SRR(s), and FIG. 5C illustrates the case of FIG. 4G in which padding is performed in the closing of the SRR(s).

Referring to FIG. 5B, in this example, SRR numbers #1 to #5 are given to five SRRs in sequence, respectively. The SRR #1 is a complete SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #2 is a closed partially recorded SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #3 is a closed empty SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #4 is a complete SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #5 is an invisible SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b".

In the case of FIG. 5B, all SRRs have no padding as indicated by the P-flags of "0b". The opened SRR is only the SRR #5 (invisible SRR). Therefore, only the SRR #5 is recorded in the "List of opened SRRs" field 52 of the SRRI header 50 as "1st opened SRR" among the maximum 16 possible opened SRRs. The remaining "2nd to 16th opened SRR" fields of the field 52 (FIG. 7D) are set to zero.

Referring to FIG. 5C, again, SRR numbers #1 to #5 are given to five SRRs in sequence, respectively. The SRR #1 is a complete SRR without padding,

which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #2 is a closed partially recorded SRR with padding, which is indicated in the corresponding SRR entry by the P-flag of "1b". The SRR #3 is a closed empty SRR with padding, which is indicated in the corresponding SRR entry by the P-flag of "1b". The SRR #4 is a complete SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b". The SRR #5 is an invisible SRR without padding, which is indicated in the corresponding SRR entry by the P-flag of "0b".

In the case of FIG. 5C, three SRRs #1, #4 and #5 have no padding as indicated by the P-flags of "0b". Two SRRs #2 and #3 have padding as indicated by the P-flags of "1b". The opened SRR is the SRR #5 (invisible SRR). Therefore, only the SRR #5 is recorded in the "List of opened SRRs" field 52 of the SRRI header 50 as "1st opened SRR". The remaining "2nd to 16th opened SRR" fields of the field 52 are set to zero.

Accordingly, by defining the P-flag within the SRR status field of the SRR entry as in the first embodiment, different types of closed SRRs can be further distinguished. The LRA and start address information are present within the SRR entry. For example, as can be seen in FIGs. 3C, 3D and 3E, among these closed SRRs, the SRRs can be distinguished from each other because the locations of the LRAs are different from each other. However, comparing FIGs. 3B and 3D, the closed SRRs have the same LRAs. In this

case, SRR type identification through the LRA is difficult. In such cases, it may be necessary to distinguish the SRRs according to the padding operation using the P-flags. Similarly, in FIGs. 3A and 3E, the types of the SRRs can be distinguished according to the padding operation using the P-flags.

According to an embodiment of the present invention, in order to distinguish the types of SRRs, there is a method of directly representing the presence or absence of the padding within the padded cluster of the SRR, without recording the information on the presence of the padding using the P-flag in the SRR entry. It is apparent that such a method is included within the scope of this invention. In such a method, the presence or absence of predetermined padded data (e.g., dummy data or specific real data) in an SRR may be looked for to distinguish the type of that SRR.

FIG. 6A illustrates a second embodiment of the SRR entry according to the present invention. The SRR entry structure of FIG. 6A is applied to each SRR entry 35 of FIG. 1, but can be applied to any other SRR entry of a disc. As shown, the SRR entry 35 includes a SRR status field 31, a start address field 32, a reserved field 33 and an LRA field 34 as discussed above. Specifically, 4-bit SRR status information is stored in the SRR status field 31 and is used to distinguish whether the corresponding SRR is closed with padding or without padding and to distinguish whether or not the

corresponding SRR is the start SRR of a session. But, since the start address field and the LRA field of the SRR entry in FIG. 6A are the same as those shown in FIG. 5A, their description will be omitted.

The related art disc such as DVD requires additional areas (for example, boarder-in/boarder-out) in order to distinguish the session, but the additional area causes the entire recording capacity of the disc to be reduced. Therefore, the present invention advantageously provides information identifying the start of the session in order to allow the session structure of the entire disc to be easily checked using only a session flag without the allocation of the additional area.

Accordingly, the status field 31 of the SRR entry 35 as shown in FIG. 6A includes one bit (31a) carrying a P-flag for identifying whether or not the padding is performed in the corresponding SRR, and another bit (31c) used as a session flag (hereinafter, referred to as an "S-flag") for identifying whether or not the corresponding SRR is a session start SRR (start of a session). The remaining 2 bits (31d) of the status field 31 remain as a reserved area for coping with future modifications in the standard as needed.

As in the example of FIG. 5A, if the P-flag in FIG. 6A has a value of "1b", it means that the corresponding SRR is a closed SRR in which the padding has been performed. If the P-flag has a value of "0b", it means that the corresponding SRR is an SRR in which no padding has been performed.

Accordingly, if the P-flag has the value of "0b", the corresponding SRR can be an opened SRR or a closed SRR. However, if the corresponding SRR is an SRR that is registered in the "List of opened SRRs" field 52 within the SRRI header 50, it means the corresponding SRR is an opened SRR; however, if it is not registered, it means the corresponding SRR is a closed SRR.

Further, in the example of FIG. 6A, if the S-flag has a value of "1b", it means that the corresponding SRR is the session start SRR. If the S-flag has a value of "0b", it means that the corresponding SRR is not the session start SRR. Other values may be used for the S-flag and/or P-flag.

FIGs. 6B and 6C illustrate two examples of recording the P-flag and the S-flag of FIG. 6A based on the method of creating the SRR entry according to the second embodiment of the present invention. For the convenience of explanation, FIG. 6B illustrates the case of FIG. 4F in which no padding has been performed in the closing of the SRR(s), and FIG. 6C illustrates the case of FIG. 4G in which padding has been performed in the closing of the SRR(s). Referring to FIG. 6B, in the example, SRR numbers #1 to #5 are assigned to five SRRs in sequence, respectively, and the sessions include two complete sessions #1 and #2 and one empty session #3.

The SRR #2 in FIG. 6B is a closed partially recorded SRR without padding, which is indicated in the corresponding SRR entry (SRR #2 entry) by the P-flag of "0b". The S-flag in the SRR #2 entry has a value of "1b" because the

SRR #2 is the session start SRR, i.e., the start SRR of the session #2.

The SRR #3 in FIG. 6B is a closed empty SRR without padding, which is indicated in the SRR #3 entry by the P-flag of "0b". The S-flag in the SRR #3 entry has a value of "0b" because the SRR #3 is not the start SRR of the session #2.

The SRR #4 in FIG. 6B is a complete SRR without padding, which is indicated in the SRR #4 entry by the P-flag of "0b". The S-flag in the SRR #4 entry has a value of "0b" because the SRR #4 is not the start SRR of the session #2.

The SRR #5 in FIG. 6B is an invisible SRR without padding, which is indicated in the SRR #5 entry by the P-flag of "0b". The S-flag in the SRR #5 entry has a value of "1b" because the SRR #5 is the start/end SRR of the session #3.

In the case of FIG. 6B, all SRRs have no padding as indicated by the P-flags of "0b". In case of the session start SRRs #1, #2 and #5, their S-flags have a value of "1b". The opened SRR is the SRR #5 (invisible SRR). Therefore, only the SRR #5 is recorded in the "List of opened SRRs" field 52 within the SRRI header 50 as "1st opened SRR".

Referring to FIG. 6C, in the example, SRR numbers #1 to #5 are assigned to five SRRs in sequence, respectively and the sessions include two complete sessions #1 and #2 and one empty session #3.

The SRR #2 in FIG. 6C is a closed SRR #2 with padding, which is indicated in the corresponding SRR entry (SRR #2 entry) by the P-flag of "1b". The S-flag in the SRR #2 entry has a value of "1b" because the SRR #2 is the session start SRR, i.e., the start SRR of the session #2.

The SRR #3 in FIG. 6C is a closed empty SRR with padding, which is indicated in the SRR #3 entry by the P-flag of "1b". The S-flag in the SRR #3 entry has a value of "0b" because the SRR #3 is not the start SRR of the session #2.

The SRR #4 in FIG. 6C is a complete SRR without padding, which is indicated in the SRR #4 entry by the P-flag of "0b". The S-flag in the SRR #4 entry has a value of "0b" because the SRR #4 is not the start SRR of the session #2.

The SRR #5 in FIG. 6C is an invisible SRR without padding, which is indicated in the SRR #5 entry by the P-flag of "0b". The S-flag in the SRR #5 entry has a value of "1b" because the SRR #5 is the start SRR of the session #3.

In the case of FIG. 6C, three SRRs #1, #4 and #5 have no padding as indicated by their P-flags of "0b". Two SRRs #2 and #3 have the padding as indicated by their P-flags of "1b". In the session start SRRs #2 and #3, their S-flags are recorded with "1b". Also, similar to the case of FIG. 6B, the opened SRR is only the SRR #5 (invisible SRR). Therefore, only the SRR #5

is recorded in the "List of opened SRRs" field 52 of the SRRI header 50 as "1st opened SRR".

Accordingly, by defining both the "P-flag" and "S-flag" within the SRR status information as in the second embodiment, the closed SRRs can be distinguished using the padding. Different types of sessions can be distinguished without having to allocate additional areas to the start and end of the session, thus improving the efficiency of the optical recording/playback operations significantly.

A method of recording and updating the SRRI that indicates the recorded status of the disc according to the present invention will be now described. Specifically, specific data are padded in closing the SRR(s) and the lost SRRI can be effectively recovered using the padded SRR(s).

FIG. 7A illustrates an initial blank disc that is in a recordable status all over the entire area. A start location of the disc becomes the NWA. In such a state, only one SRR is present at the disc. This is the same as the invisible SRR shown in FIG. 2A. Therefore, the session is in the disc initial status in which only one empty session is present. This is the case of the blank disc in which the SRRI is not yet recorded.

FIG. 7B illustrate a case that some portion of the blank disc of FIG. 7A is recorded with data, but the session is not closed. In such a state, only one SRR (SRR #1) is present at the disc. This is the same as the incomplete SRR

shown in FIG. 2B. Therefore, the disc is in such a status that only one incomplete session is present.

FIG. 7C illustrates a process of recording an SRRI in the management area of the disc when the disc is in the state of FIG. 7B. For the convenience of explanation, only certain portions among all the different components of the disc structure and SRRI structure shown in FIG. 1 are shown. For instance, although the (SRRI + TDDS) or (TDFL + TDDS) are recorded in each cluster of the TDMA such as the TDMA0 of the disc as discussed above, only the SRRI is shown in the TDMA0 of FIG. 7C, and the TDFL and/or TDDS is omitted for the sake of clarity. Further, only the "List of opened SRRs" field 52 and the "List of SRR entries" field 30 among the different fields of the SRRI shown in FIG. 1 are shown.

The disc recorded status of FIG. 7C is the case where only one opened SRR (SRR #1) is present in all the disc area as in FIG. 7B. As shown in FIG. 7C, when the incomplete SRR #1 is formed without closing the session as in FIG. 7B, the SRRI #1 (60a) pertaining to the SRR #1 is generated and recorded in the TDMA0. In the SRRI #1 (60a), the SRR number of the opened SRR #1 is recorded in its "List of opened SRRs" field 52a. In the "List of SRR entries" field 30a of the SRRI #1 (60a), only one SRR entry 35a pertaining to the SRR #1 is present. The SRR entry 35a (or SRR entries 35b-35p discussed later) can have the SRR entry structure of FIG. 5A or 6A discussed above.

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FIG. 7D illustrates a detailed structure of the "List of opened SRRs" field, which is recorded in the SRRI header, according to an embodiment of the present invention. The structure of this field as shown in FIG. 7D is applicable to any "List of opened SRRs" field of the present invention, such as the fields 52 and 52a-52f (discussed later). The information stored in this field is used to identify the location of any opened SRR(s). The usage of this field is described as follows in more detail.

The opened SRR entry number is recorded, as the information on the location of the opened SRR entry, in the "List of opened SRRs" field of the SRRI. That is, the location of the opened SRR entry is identified using the "opened SRR number" wherein the total number of opened SRRs that is allowed at a given time is maximum sixteen, in this example. Two bytes are allotted to store each of the sixteen different opened SRR numbers.

To carry out an operation on a disc, the recording/playback apparatus must determine the recordable location(s) of the disc when the optical disc is loaded. This is possible by obtaining the NWA value from any opened SRR. Accordingly, the recording/playback apparatus needs to know the location of any opened SRR on the disc to be able to determine the recordable location(s) on the disc. However, since there is no information that identifies directly whether a particular SRR is an opened SRR or a closed SRR, the present invention provides the "List of opened SRRs" field at the header of

an SRRI and accesses this field to obtain the location of any opened SRR by the SRR numbers. Once the opened SRR number is identified, the corresponding SRR number entry can be accessed from the SRRI to obtain the exact location (i.e., by accessing the start address in the start address field of the SRR entry) of the opened SRR. In this manner, the optical recording/playback apparatus can read out the opened SRR entry information more easily.

According to the present invention, only the SRR whose SRR number is recorded in the "List of opened SRRs" field of the SRRI is considered to be an opened SRR. If the opened SRR is changed to a closed SRR, the SRR number of the changed SRR is erased or removed from "List of opened SRRs" field. Applied differently, to close a particular opened SRR, e.g., in response to a close command, the SRR of that SRR is removed from the "List of opened SRRs" field of the SRRI. Removal of the SRR number from the "List of opened SRRs" field then indicates the closing of the corresponding SRR.

FIG. 8A illustrates a case when a session close command is executed when the disc is in the state of FIG. 7B. As shown in FIG. 8A, the existing data recorded area is separated into an independent closed SRR by the session close command and a new session is generated. In other words, the complete recorded area in FIG. 7B becomes a complete SRR #1, which in

turn constitutes a complete session #1. The non-recorded area then becomes an invisible SRR #2, which in turn constitutes an empty session #2.

FIG. 8B illustrates a process of recording the disc recorded status as it pertains to the disc state as of FIG. 8A. As shown in FIG. 8B, an SRRI #2 (60b) is recorded in the TDMA0, next to the previously recorded SRRI #1 (60a). Since the disc recorded status of FIG. 8A is the case where only one opened SRR (SRR #2) and one closed SRR (SRR #1) are present on the entire disc area, the corresponding opened SRR number (SRR #2) is recorded in the "List of opened SRRs" field 52b of the SRRI #2 (60b). Further, information on the two SRR entries (SRR #1 and SRR #2) is recorded in the "List of SRR entries" field 30b of the SRRI #2 (60b) as SRR entries 35b and 35c.

In FIG. 8B, a closed SRR entry has been indicated using a shaded mark. Although not shown, it should understood that along with the recording of the SRRI #2 (60b) in the TDMA0, other management information such as the updated TDDS information is also recorded in the corresponding cluster (or recording-unit) of the TDMA0.

FIG. 9A illustrates a case when two opened SRRs are reserved for a new recording from the disc state of FIG. 8A. As shown in FIG. 9A, the newly reserved opened SRRs become an opened empty SRR #2 and an opened empty SRR #3 each having an appropriate NWA as indicated by the thick

arrows. The remaining area becomes an invisible (opened) SRR #4. The sessions include the complete session #1 and the session #2 which has been changed from the empty session to the incomplete session.

FIG. 9B illustrates a process of recording the disc recorded status as it pertains to the disc state as of FIG. 9A. As shown in FIG. 9B, another SRRI #3 (60c) is recorded in the TDMA0, next to the previously recorded SRRI #2 (60b). Since the disc recorded status of FIG. 9A is the case where three opened SRRs (SRRs #2, #3, #4) and one closed SRR (SRR #1) are present, the corresponding opened SRR numbers (SRRs #2, #3, #4) are recorded in the "List of opened SRRs" field 52c of the SRRI #3 (60c). Further, information on all four SRR entries (SRRs #1- #4) is recorded in the "List of SRR entries" field 30c of the SRRI #3 (60c) as SRR entries 35d-35g, respectively.

In FIG. 9B, a closed SRR entry has been indicated using a shaded mark. Although not shown, it should understood that along with the recording of the SRRI #3 (60c) in the TDMA0, other management information such as the updated TDDS information is also recorded in the corresponding cluster (or recording unit) of the TDMA0.

FIG. 10A illustrates a case when data are recorded to the first empty SRR (SRR #2) and to the invisible SRR (SRR #4) in the disc state of FIG. 9A. As a result, the first empty SRR is changed to the opened partially recorded SRR

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#2, the invisible SRR is changed to the incomplete SRR #4, but the opened empty SRR #3 is not changed.

FIG. 10B illustrates a process of recording the disc recorded status as it pertains to the disc state as of FIG. 10A. As shown in FIG. 10B, another SRRI #4 (60d) is recorded in the TDMA0, next to the previously recorded SRRI #3 (60c). Since the disc recorded status of FIG. 10A is the case where three opened SRRs (SRRs #2, #3, #4) and one closed SRR (SRR #1) are present, the corresponding opened SRR numbers (SRRs #2, #3, #4) are recorded in the "List of opened SRRs" field 52d of the SRRI #4 (60d). Further, information on all four SRR entries (SRRs #1- #4) is recorded in the "List of SRR entries" field 30d of the SRRI #4 (60d) as SRR entries 35h-35k, respectively.

In FIG. 10B, a closed SRR entry has been indicated using a shaded mark. Although not shown, it should understood that along with the recording of the SRRI #4 (60d) in the TDMA0, other management information such as the updated TDDS information is also recorded in the corresponding cluster (or recording unit) of the TDMA0.

The number of SRR entries and the location of the opened SRRs in FIG. 10B are equal to the case of FIG. 9B. However, since recording in the specific opened SRR has been performed as shown in FIG. 10A, the LRA information within the opened SRR entry in which such recording is performed is

changed. Therefore, the additionally recordable NWA location is also changed.

FIG. 11A illustrates a case when a session close command is executed in the disc state of FIG. 10A, but its opened SRR is closed after some additionally recordable area of the opened SRR is padded. In the padding operation, the entire or some part of the additionally recordable area of the opened SRR may be selectively padded as discussed above. The padding is performed using dummy data (e.g., zero) or specific real data (e.g., character code "CLSD") as padding data as discussed above. That is, the padding operation in FIG. 11A is the same as that discussed in connection with FIGs. 3D and 3E.

As shown in FIG. 11A, the existing data recorded area becomes an independent complete session by the session close command and all SRRs contained in that complete session are changed to closed SRRs. For instance, in response to the session close command, a part (e.g., a first cluster after the LRA) of each opened SRR is padded and the SRRs are closed. In this case, the LRA information recorded in the SRR entry means the last recorded area on which the actual user data are recorded, and the dummy data portion does not influence the determination of the LRA location. After the close command has been executed, this results in a closed partially recorded SRR #2, a closed empty SRR #3 and the complete

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SRR #4, which in turn constitute a newly reserved complete session #2. The remaining outermost SRR becomes an invisible (opened) SRR #5, which in turn constitutes an empty session #3.

FIG. 11B illustrates a process of recording the disc recorded status as it pertains to the disc state as of FIG. 11A. As shown in FIG. 11B, another SRRI #5 (60e) is recorded in the TDMA0, next to the previously recorded SRRI #4 (60d). Since the disc recorded status of FIG. 11A is the case where only one opened SRR (SRR #5) and four closed SRRs (SRRs #1 - #4) are present, the corresponding opened SRR number (SRR #5) is recorded in the "List of opened SRRs" field 52e of the SRRI #5 (60e). Further, information on all five SRR entries (SRRs #1- #5) is recorded in the "List of SRR entries" field 30e of the SRRI #5 (60e) as SRR entries 35l-35p, respectively.

In FIG. 11B, a closed SRR entry has been indicated using a shaded mark. Although not shown, it should understood that along with the recording of the SRRI #5 (60e) in the TDMA0, other management information such as the updated TDDS information is also recorded in the corresponding cluster (or recording unit) of the TDMA0.

In the case of the SRR #2 and SRR #3 in which the dummy data are padded by the close command, the last location in which the actual user data are recorded is recorded in the LRA field of the corresponding SRR entry.

Also, if the P-flag is present in the status field of the SRR entry as discussed

above, it is possible to recognize that the corresponding closed SRR is closed by the padding. If the P-flag is not present in the SRR entry, it can be determined that the corresponding SRR is a padded SRR by examining the recorded status of the SRR area after its LRA, i.e., by checking to see the presence or absence of specific padding data at the NWA (after LRA) of the SRR.

As can be seen through FIGs. 7A to 11B, SRRI is the information indicating the recorded status of the current disc. The recording/playback apparatus must check the latest SRRI (SRRI #5, in the above example) finally recorded in the management area, when the corresponding disc is loaded. Since only the latest SRRI correctly indicates the final recorded status of the disc, it is possible to check the location of the additionally recorded SRR.

However, when the power is suddenly turned off while using the disc or the disc is damaged, the latest SRRI of the disc may be not read out correctly. At this time, the final recorded status need to be reconstructed using the latest SRRI among the non-damaged SRRIs. According to the present invention, the SRR is padded in the padding operation when the SRR is to be closed, and this padding information can be used to reconstruct the final recorded status of the disc even when the latest SRRI on the disc is at a damaged condition. Through it, it is possible to recover the latest SRRI and the current recorded status of the disc.

FIGs. 12, 13A and 13B illustrate a recording method of a write-once optical disc according to the present invention. This method recovers the latest SRRI of the disc, even when the latest SRRI is damaged, and the recording/playing back can be performed using the finally recorded status obtained from the latest SRRI.

When the corresponding SRRI is judged as a defective area and the recorded information is not reliable, the SRRI is said to be damaged. If the latest SRRI is damaged, it means that the finally recorded status of the disc cannot be obtained from the latest SRRI. Therefore, the recordable location of the disc cannot be known. In the worst case, the disc itself cannot be used any more.

The present invention provides the method of correctly recovering the finally recorded status of the disc when the latest SRRI is damaged. Particularly, FIG. 12 is a flowchart illustrating a method of recovering the finally recorded status of a write-once optical disc such as a BD-WO and performing the recording/playback operation on the disc according to an embodiment of the present invention. The disc contains the disc structure and the SRRI structure as discussed above.

Referring to FIG. 12, if the disc is loaded in an optical recording/playback apparatus such one shown in FIG. 14, the latest SRRI recorded within the management area (e.g., the TDMA0) is read out. Then, it is checked whether

or not the read SRRI is damaged (S10).

If the latest SRRI is not damaged, the final disc recorded status is obtained from the latest SRRI (S21). Then using the latest SRRI, the recording is performed to only the additionally recordable area and/or the playback operation is performed to the already recorded area (S22). The information on such areas is obtained from the latest SRRI.

On the other hand, if the step S10 determines that the latest SRRI is damaged, the latest SRRI among the non-damaged SRRI(s) is determined (S31). Then this latest non-damaged SRRI is read out (S32). The damaged SRRI can be recovered using the latest non-damaged SRRI and the actual recorded status of the disc (S33). Step S33 may be an optional step. The recording is performed to the additionally recorded area and/or the playback operation is performed to the already recorded area (S34). Information on such areas can be determined from the latest non-damaged SRRI and/or the actual recorded status of the disc. After the recording/playback step S34, the newly changed recorded status may be recorded as a new SRRI in the management area.

FIGs. 13A and 13B illustrates an example of the step S33 in FIG. 12 of recovering the finally recorded status when the latest SRRI (SRRI #5 in the example of FIG. 11B) is damaged. For the convenience of explanation, the SRRI recording method of FIGs. 7A to 11B will be described as an example.

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As shown in FIG. 13A, if the SRRIs are in the normal status, the SRRI #5 (60e) becomes the latest SRRI of the disc. However, if the SRRI #5 is damaged, the recording/playback apparatus reads the latest SRRI among the non-damaged SRRIs. In the example, the SRRI #4 (60d) is the latest SRRI among the non-damaged SRRIs #1 - #4.

The actual recorded status associated with step 6 in FIG. 11A can be determined from the SRRI #5 (60e) which is written as indicated in FIG. 11B. However, since the SRRI #5 (60e) is damaged, the latest SRR information that can be checked by the recording/playback apparatus is the SRRI #4 (60d). But the SRRI #4 does not necessarily carry the finally recorded status of the disc since the SRRI #5 carries this information. Then, in order to recover the finally recorded status of the disc without using the SRRI #5, the SRRI #4 and the actual finally recorded status of the disc need to be compared. This can be accomplished as follows.

The recording/playback apparatus checks the location of the opened SRR(s) and the associated LRA information from the SRRI #4. In the example of FIG. 13A, it is determined from the "List of opened SRRs" field 52d of the SRRI #4 (60d) that there are three opened SRRs #2, #3 and #4. Then by accessing the LRA field of these SRR entries corresponding to these opened SRRs from the "List of SRR entries" field 30d of the SRRI #4 (60d), the LRAs are obtained and used to verify whether the corresponding SRR is truly an

opened SRR. In this regard, only the opened SRR(s) identified in the field 52d of the SRRI #4 (60d) are examined. The location recorded with the closed SRR(s) may not be verified. Once an opened SRR is changed to a closed SRR, the closed SRR cannot be changed back to an opened SRR. As a result, the recovery of the final SRR information is possible by checking whether each of the opened SRR(s) is changed to the closed SRR.

In the case of the SRRs #2 and #3 that are identified as the opened SRRs in the field 52d of the SRRI #4 (60d), each of the SRRs #2 and #3 is examined to determine whether or not predetermined padding data (e.g., dummy data) are recorded after its LRA (identified in the LRA field of the entry), as can be seen from FIG. 11A (actual final disc recorded status). If the padding is detected, then the recording/playback apparatus determines that the corresponding opened SRR is changed to a closed SRR.

In the case of the SRR #4 that is recognized as the opened SRR from the field 52d of the SRRI #4, the recording/playback apparatus examines the SRR #4 to determine whether or not the padding data (e.g., dummy data) are presented after its LRA location in FIG. 11A (actual final disc recorded status). The SRR #4 can be analyzed as the opened SRR in the actual final disc recorded status. Also, it can be seen that an area after the LRA location of the SRR #4 is recordable, i.e., this area is the NWA. Then in the recording/playback apparatus, the already recorded area of the original SRR

#4 is determined to a closed SRR (new closed SRR #4) and only the recordable area of the original SRR #4 is analyzed as the opened SRR (new SRR #5). Thus the contents of the damaged SRRI #5 can be reconstructed by using the above analysis results. Moreover, since the information necessary to perform the recording operation by the recording/playback apparatus is the additionally recordable position information (NWA), the NWA location in association with the old and new SRR #4 is not changed and thus can be used by the recording/playback apparatus.

FIG. 13B illustrates a result of the recovery of the latest SRRI #5 by the process of FIG. 13A as discussed above. This result accords with the final recorded status of the actual disc. Accordingly, the recording/playback apparatus again records the selectively recovered latest SRRI #5 within the management area (at this time, as the SRRI #6 (60f)), or performs the recording to only the additionally recordable area. The SRRI #6 (60f) includes the "List of opened SRRs" field 52f identifying the SRR #5, and the "List of SRR entries" field 30f containing SRR entries 35q-35u corresponding respectively to the SRRs #1 - #5. Also, even if the recovered SRRI #5 is not recorded as the SRRI #6, data recording is performed from the recovered NWA information and the recorded status as changed by the data recording to the recovered NWA is recorded as a new SRRI #6.

FIG. 14 illustrates an optical disc recording/playback apparatus according

to the present invention. This apparatus or other suitable apparatus or system can be used to implement the disc and/or SRRI structures and methods of the present invention discussed herein.

Referring to FIG. 14, the optical disc recording/playback apparatus includes a recording/playback unit 10 for recording and/or reproducing data to/from the optical disc and a controller 20 for controlling the recording/playback unit 10. All the elements of the recording/playback apparatus are operatively coupled. The controller 20 transmits a command for recording and/or reproducing to/from a special recording area such as an SRR/session on the disc, to the recording/playback unit 10. The recording/playback unit 10 records and/or reproduces data to/from the disc according to the commands of the controller 20.

The recording/playback unit 10 includes an interface unit 12, a pick-up unit 11, a data processor 13, a servo unit 14, a memory 15 and a microcomputer 16. The interface unit 12 communicates with external devices such as the controller 20. The pick-up unit 11 records or reproduces data to/from the optical disc directly. The data processor 13 receives a reproduction signal from the pick-up unit 11, restores a preferred signal, modulates a signal proper to the optical disc, and transmits the signal. The servo unit 14 controls the pick-up unit 11 to read the signal from the optical disc or to record the signal to the optical disc. The memory

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15 stores temporarily data and various information including management information as discussed herein. The microcomputer 16 controls the components of the recording/playback unit 10. Since the recording/playback apparatus shown in FIG. 14 can selectively perform a padding operation, a designer can more freely design the recording/playback apparatus. The recording/playback unit 10 can automatically store specific data during a padding operation.

Industrial Applicability

The recording/playback method of the optical disc according to the present invention may be divided into mainly two parts. First, as in the cases of FIGs. 4 to 6C, the padding is determined in the selective closed SRR and an information (e.g., P-flag) for identifying whether or not the padding is performed is recorded. Second, as in the cases of FIGs. 7A to 13B, the SRRI is effectively recovered by examining the SRR to determine if padding has been performed in the SRR. In other words, the presence or absence of the padding in the closed SRR is a selective matter. However, according to the present invention, the case of closing the SRR with padding may be more advantageous to data restoration.

The recording/playback method of the optical disc according to an embodiment of the present invention will be now described in detail. First, if

the optical disc is loaded into the recording/playback apparatus, the SRRI recorded in a preset management area of the optical disc as the latest disc management information is read out together with the header and SRR entry(ies) of the SRRI, and the read out information is temporarily stored in the memory 15 of the recording/playback unit 10. Since the latest disc recorded status is recorded within the SRRI, the opened SRR is identifiable through the SRRI header information. The recorded or non-recorded status of the disc can be checked through the SRRI header information. Also, the presence or absence of the padding can be identifiable. This can be used in the recording/playback of the disc.

For instance, the microcomputer 16 can accurately check the SRR status existing within the disc from the SRRI, so that the recordable location (NWA) can be known from the checked opened SRR(s). Also, the presence or absence of the padding can be checked as discussed above. If the SRR is closed by the close command of the controller 20, the microcomputer 16 can select the closing with padding or the closing without padding. Also, it is possible to close the SRR without the padding in response to a specific command of the controller 20.

In case the SRR status is changed by the padding, the P-flag of the corresponding SRR entry is modified and recorded, such that other recording/playback apparatus can use this information. Such a function

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can be named "automatic padding function" of the recording/playback unit 10. This function is advantageous because it reduces the padding operation time. According to the present invention, the recording/playback apparatus with desired performance can be designed in various manners by defining the types of SRRs and providing the methods of recording the SRRs and SRRIs.

Another recording/playback method according to the present invention will be described now. First, if the optical disc is loaded into the recording/playback apparatus, the controller 20 controls the pickup unit 11 to read out the latest SRRI recorded in the TDMA and determines whether the latest SRRI is damaged. If the latest SRRI is damaged, the latest SRRI is recovered from non-damaged SRRIs, as described in FIGs. 12, 13A and 13B. The latest SRRI can be recovered by checking the dummy data padded within the disc when the opened SRR is changed to the closed SRR.

If there is no damage in the latest SRRI, the recording/playback unit 10 performs the recording by checking the location of the additionally recordable opened SRR. Then, if the close command is received from the controller 20, the recording/playback unit 10 performs the padding to some or the entire area of additionally recordable areas remaining in the opened SRR, to close the SRR. Then, the changed recorded status of the disc is recorded in the latest SRRI within the management area. Even if any

recording/playback apparatus again loads the corresponding optical disc and there is damage to the latest SRRI, the final recorded status of the disc can be checked.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

2004271477 07 Oct 2009

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of managing a recording medium including one or more sequential recording ranges (SRRs), the recording medium having a permanent defect management area for storing therein management information when the recording medium is to be closed, the method comprising steps of:

recording, onto a temporary disc management area storing therein management information of the recording medium until the recording medium is closed, opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRRs existing on the recording medium, each opened SRR having a writable position therein, wherein a number of opened SRRs allowed is at most a predetermined number; and

removing an identification of a certain SRR from the opened information once the certain SRR is closed.

2. The method of claim 1, wherein in the opened SRR information, the identification of the certain SRR is an SRR number of the certain SRR.

3. The method of claim 1 or 2, further comprising:

recording a sequential recording range information (SRRI) on the temporary disc management area, the SRRI indicating a recorded status of each of the one or more SRRs,

wherein the opened SRR information is recorded as a part of the SRRI.

4. The method of any one of claims 1 to 3, wherein the predetermined number is 16.

5. A recording medium comprising:

one or more sequential recording range (SRRs) on the recording medium;

a permanent defect management area storing therein management information when the recording medium is to be closed; and

a temporary disc management area storing therein management information of the recording medium until the recording medium is to be closed, the temporary disc management area storing therein opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRRs existing on the recording medium, each opened SRR having a writable position therein,

wherein a number of opened SRRs allowed is at most a predetermined number, and an identification of a certain SRR is removed from the opened SRR information once the certain SRR is closed.

6. The recording medium of claim 5, wherein in the opened SRR information, the identification of the certain SRR is an SRR number of the certain SRR.

7. The recording medium of claim 5 or 6, wherein the temporary disc management area stores therein sequential recording range information (SRRI) indicating a recorded status of each of the one or more SRRs, wherein the opened SRR information is included in the SRRI.

8. The recording medium of any one of claims 5 to 7, wherein the predetermined number is 16.

9. An apparatus for managing a recording medium including one or more recording ranges (SRRs), the recording medium having a permanent defect management area for storing therein management information when the recording medium is to be closed, the apparatus comprising:

a pickup configured to record/reproduce data to/from the recording medium directly;

a microcomputer, operatively coupled to the pickup, configured to control the pickup to record, onto a temporary disc management area storing therein management information of the recording medium until the recording medium is to be closed, opened SRR information carrying one or more identifications corresponding respectively to one or more opened SRR existing on the recording medium, each opened SRR having a writable position therein, and remove an identification of a certain SRR from the opened SRR information once the certain SRR is closed.

10. The apparatus of claim 9, wherein the microcomputer is configured to control the pickup to pad at least a part of the certain SRR with padding data when closing the certain SRR.

11. The apparatus of claim 10, wherein the part of the certain SRR consists of at least one cluster.

12. The apparatus of claim 10 or 11, wherein the microcomputer is configured to control the pickup to pad the part of the certain SRR starting from a next writable position after a last recorded position of the certain SRR.

13. The apparatus of any one of claims 10 to 12, wherein the padding data is dummy data, zero, or specific real data.

14. The apparatus of any one of claims 10 to 13, wherein the microcomputer is configured to control the pickup to record, onto the

recording medium, padding status information indicating whether or not a part of the certain SRR has been padded.

15. The apparatus of any one of claims 9 to 14, wherein the microcomputer is configured to control the pickup to record a sequential recording range information (SRRI) onto the temporary disc management area, the SRRI indicating a recorded status of each of the one or more SRRs, wherein the SRRI includes the opened SRR information.

16. The apparatus of any one of claims 9 to 15, wherein the identification of the certain SRR is an SRR number of the certain SRR.

17. The apparatus of any one of claims 9 to 16, wherein the microcomputer is configured to control the pickup to record, onto the temporary disc management area, session start information indicating whether the certain SRR is a start of a session.

18. The apparatus of any one of claims 9 to 17, wherein the predetermined number is 16.

19. The apparatus of any one of claims 9 to 18, wherein the certain SRR does not have a next writable position once the certain SRR is closed.

20. The apparatus of any one of claims 9 to 19, further comprising:

a data processor configured to receive and restore a reproduction signal from the pickup, and modulate a signal proper to the recording medium; and

a servo configured to control the pickup to read/record the signal from/to the recoding medium;

wherein the microcomputer is operatively coupled to the data processor and the servo, and configured to control the pickup, the data processor and the servo so that the apparatus records, onto the temporary disc management area, opened SRR information from which the identification of the certain SRR has been removed.

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FIG. 1

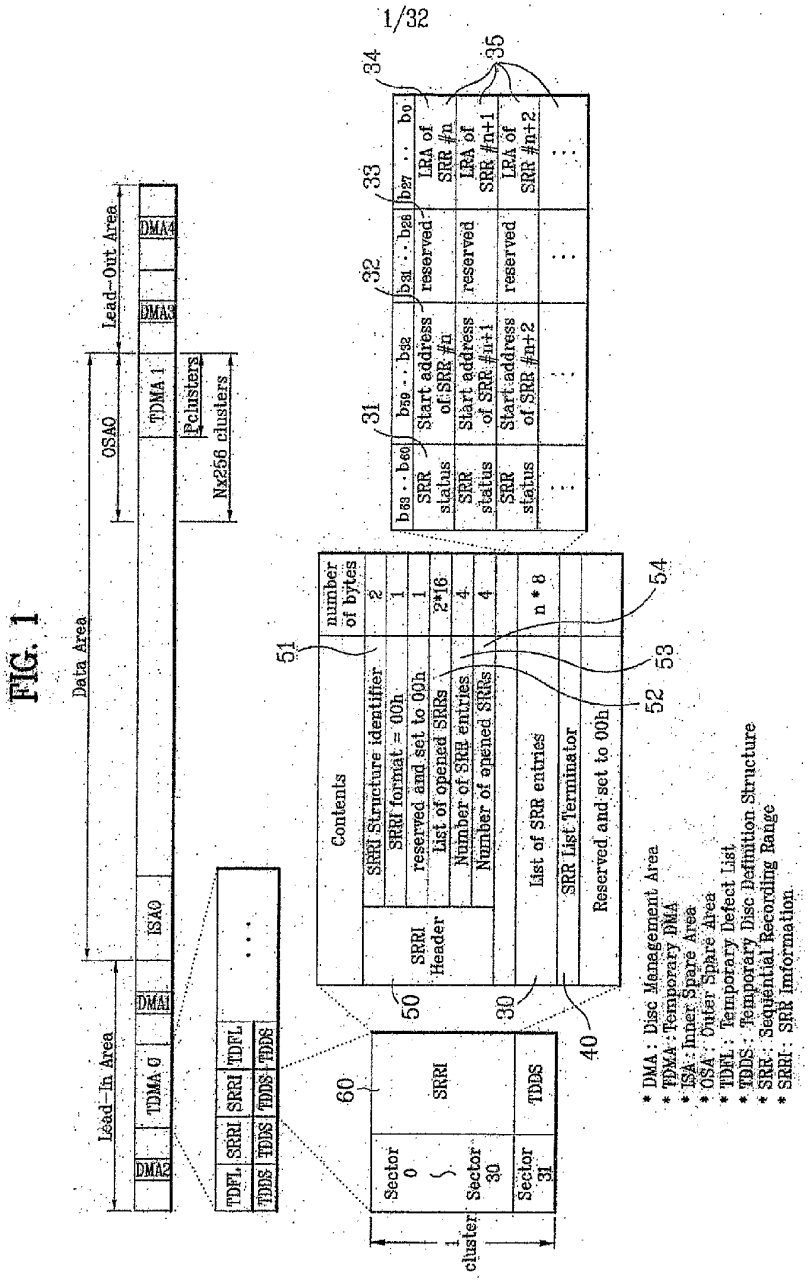

1/32
Data Area
Lead-In Area
Lead-Out Area
OSA0
ISA0
TDMA 0
TDMA 1
DMA1
DMA2
DMA3
DMA4
Nx256 clusters
TDFL
SRRI
TDDS
Contents
number of bytes
SRRI Structure identifier
SRRI format = 00h
reserved and set to 00h
List of opened SRRs
Number of SRR entries
Number of opened SRRs
List of SRR entries
SRR List Terminator
Reserved and set to 00h
SRRI Header
SRR status
Start address of SRR #n
reserved
LRA of SRR #n
Sector 0
Sector 30
Sector 31
cluster
* DMA : Disc Management Area
* TDMA : Temporary DMA
* ISA : Inner Spare Area
* OSA : Outer Spare Area
* TDFL : Temporary Defect List
* TDDS : Temporary Disc Definition Structure
* SRR : Sequential Recording Range
* SRRI : SRR Information

FIG. 2A

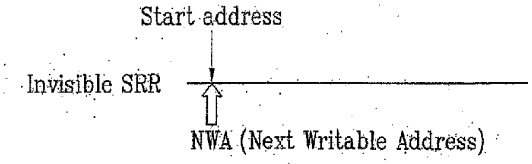


FIG. 2B

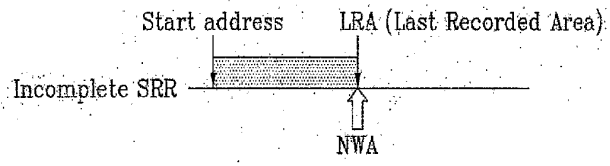


FIG. 2C

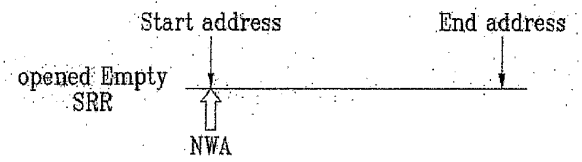


FIG. 2D

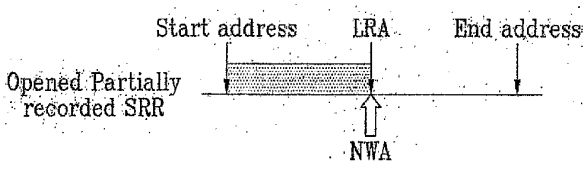


FIG. 3A

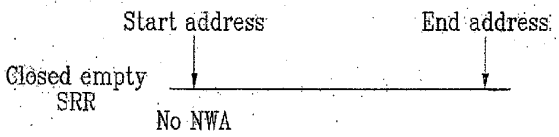


FIG. 3B

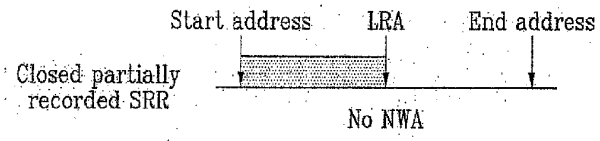


FIG. 3C

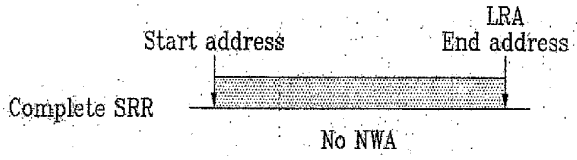


FIG. 3D

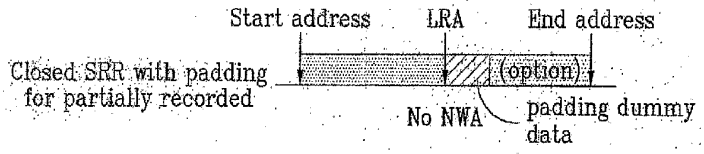


FIG. 3E

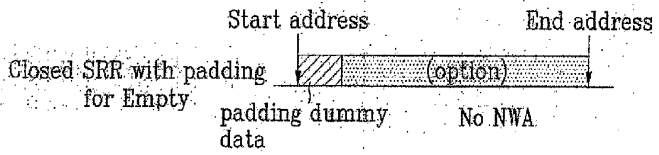


FIG. 4A

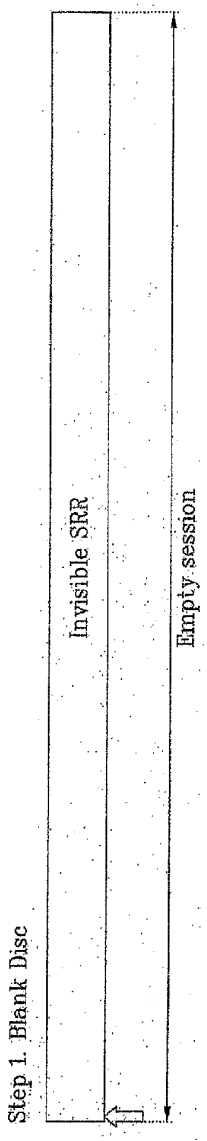


FIG. 4B

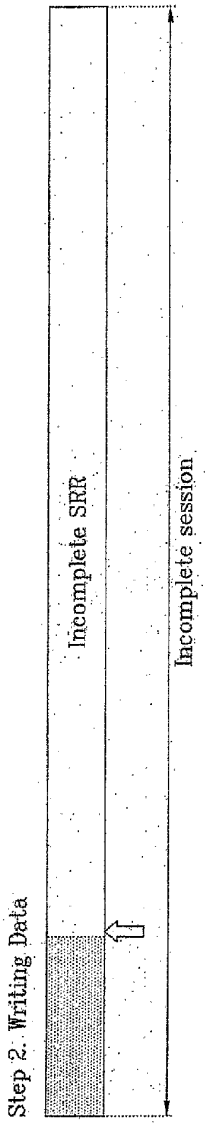


FIG. 4C

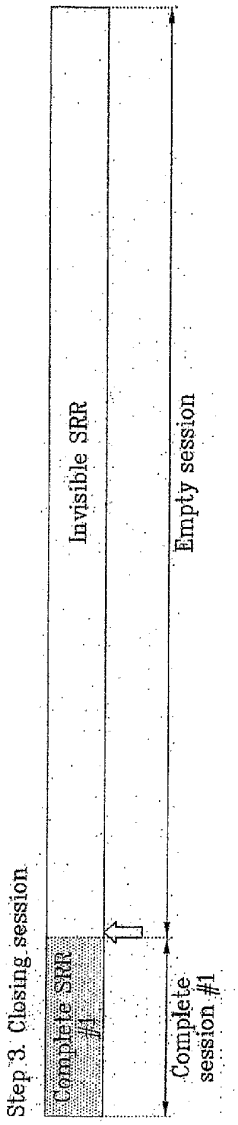

Step 3. Closing session
Complete SRR #1
Invisible SRR
Empty session
Complete session #1

FIG. 4D

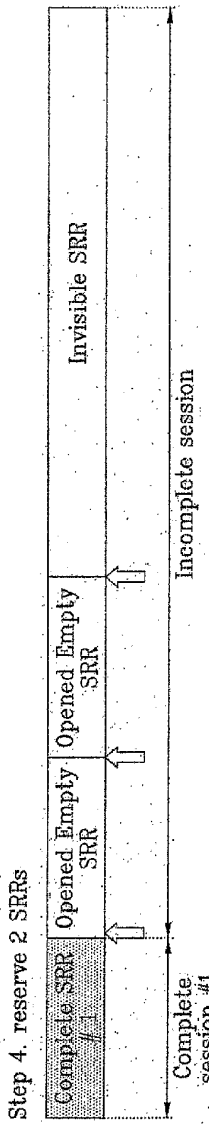

Step 4. reserve 2 SRRs
Complete SRR #1
Opened Empty SRR
Opened Empty SRR
Invisible SRR
Complete session #1
Incomplete session

FIG. 4E

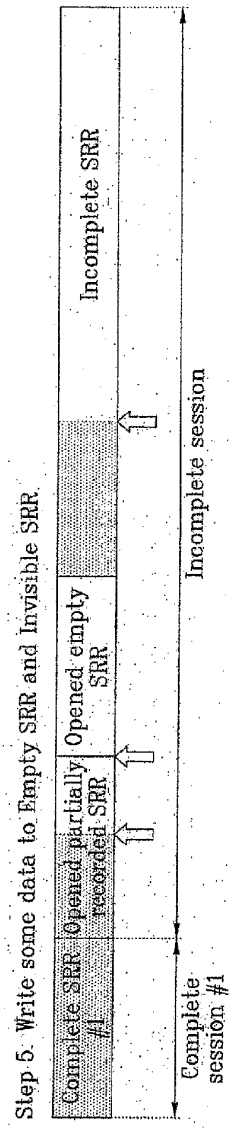

Step 5: Write some data to Empty SRR and Invisible SRR
Complete SRR #1
Opened partially recorded SRR
Opened empty SRR
Incomplete SRR
Complete session #1
Incomplete session

FIG. 4F

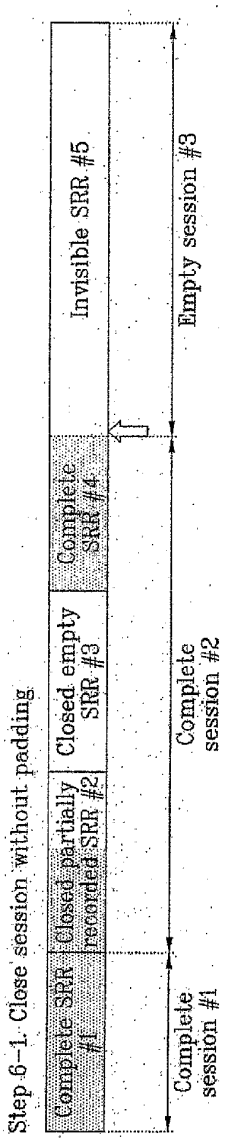

Step 6-1. Close session without padding
Complete SRR #1
Closed partially recorded SRR #2
Closed empty SRR #3
Complete SRR #4
Invisible SRR #5
Complete session #1
Complete session #2
Empty session #3

FIG. 4G

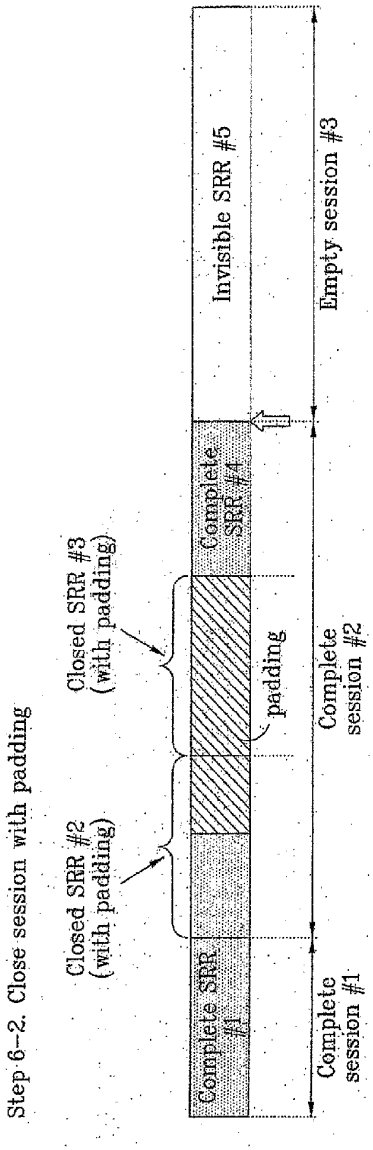

Step 6-2. Close session with padding
Closed SRR #2 (with padding)
Closed SRR #3 (with padding)
Complete SRR #1
Complete SRR #4
Invisible SRR #5
padding
Complete session #1
Complete session #2
Empty session #3

FIG. 5A

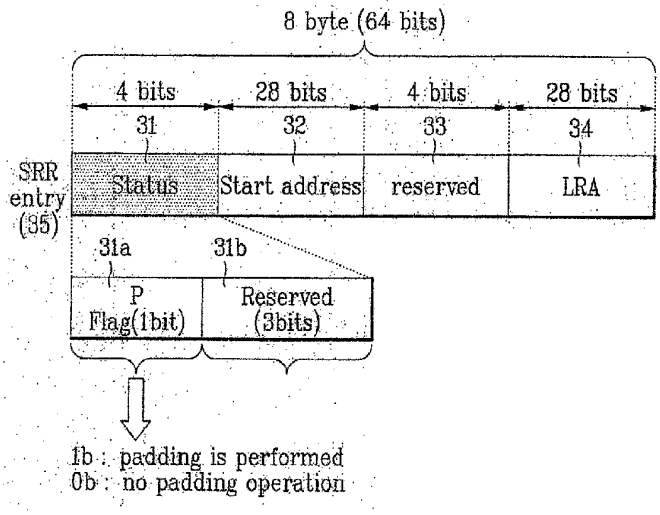

8 byte (64 bits)
4 bits
28 bits
4 bits
28 bits
31
32
33
34
SRR entry (35)
Status
Start address
reserved
LRA
31a
31b
P Flag(1bit)
Reserved (3bits)
1b : padding is performed
0b : no padding operation

FIG. 5B

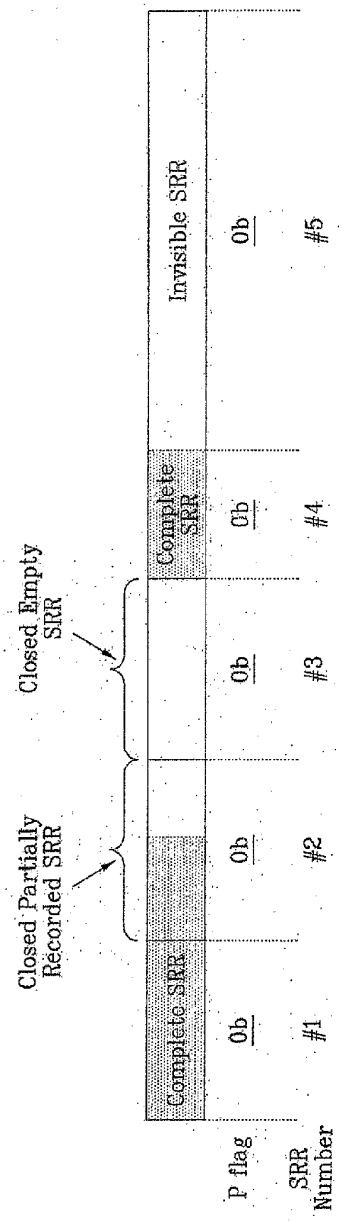

Closed Partially Recorded SRR
Closed Empty SRR
Complete SRR
Invisible SRR
P flag
SRR Number
0b
#1
0b
#2
0b
#3
0b
#4
0b
#5

FIG. 5C

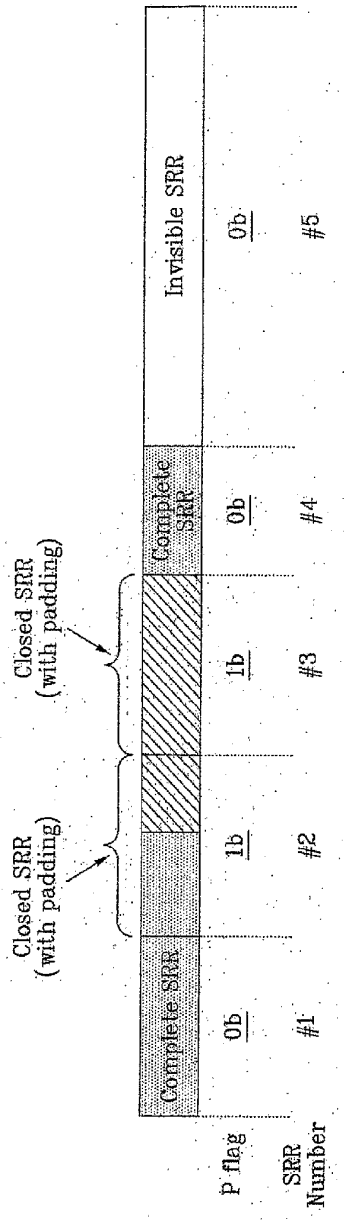

Complete SRR
Closed SRR (with padding)
Closed SRR (with padding)
Complete SRR
Invisible SRR
P flag
SRR Number
0b
1b
1b
0b
0b
#1
#2
#3
#4
#5

FIG. 6A

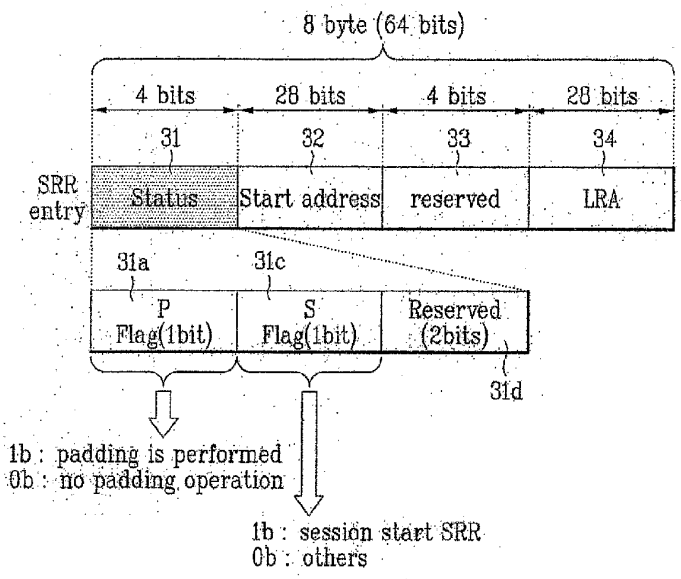

8 byte (64 bits)
4 bits
28 bits
4 bits
28 bits
31
32
33
34
SRR entry
Status
Start address
reserved
LRA
31a
31c
P Flag(1bit)
S Flag(1bit)
Reserved (2bits)
31d
1b : padding is performed
0b : no padding operation
1b : session start SRR
0b : others

FIG. 6B

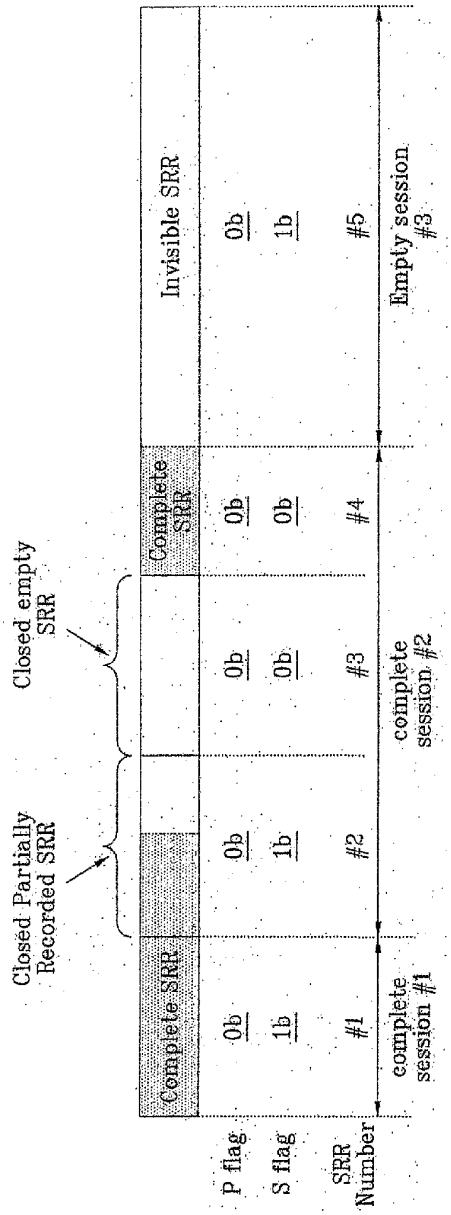

Closed Partially Recorded SRR
Closed empty SRR
Complete SRR
Invisible SRR
P flag
S flag
SRR Number
0b
1b
#1
#2
#3
#4
#5
complete session #1
complete session #2
Empty session #3

FIG. 6C

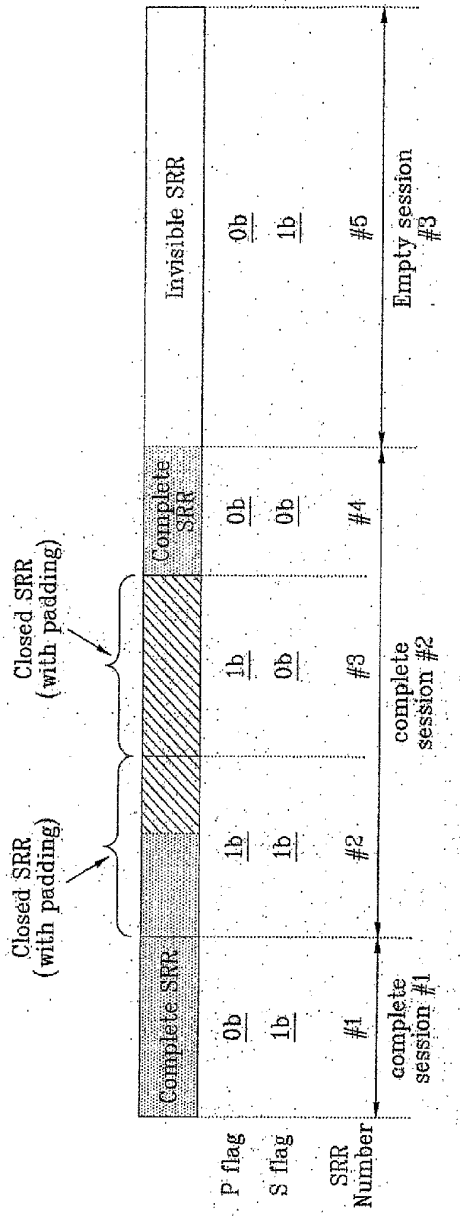

Complete SRR
Closed SRR (with padding)
Closed SRR (with padding)
Complete SRR
Invisible SRR
P flag
S flag
SRR Number
0b
1b
#1
#2
#3
#4
#5
complete session #1
complete session #2
Empty session #3

FIG. 7A

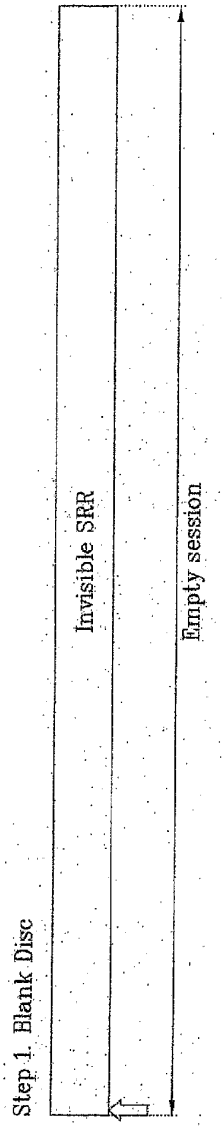


FIG. 7B

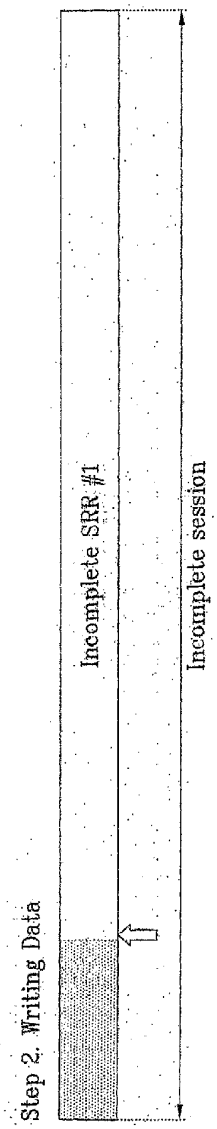


FIG. 7C

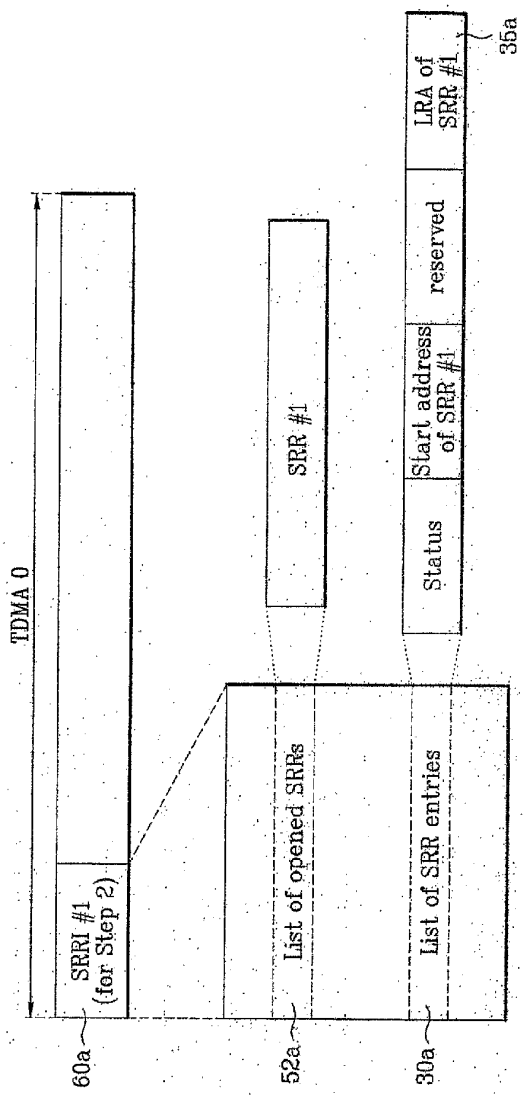

TDMA 0
SRRI #1 (for Step 2)
60a
SRR #1
List of opened SRRs
52a
Status
Start address of SRR #1
reserved
LRA of SRR #1
35a
List of SRR entries
30a

FIG. 7D

Contents	number of bytes
1st Opened SRR number	2
2nd Opened SRR number	2
⋮	⋮
16th Opened SRR number	2

FIG. 8A

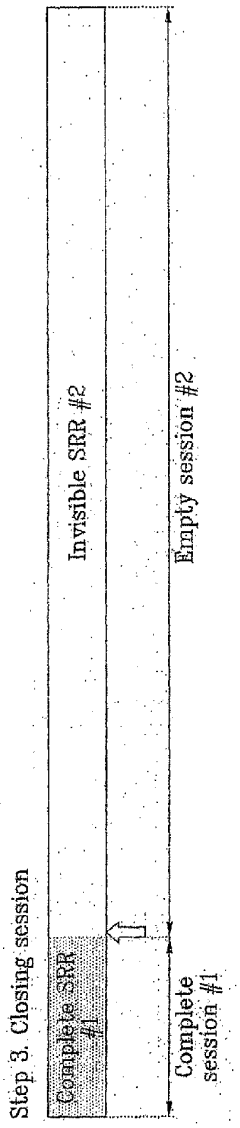

Step 3. Closing session
Complete SRR #1
Invisible SRR #2
Complete session #1
Empty session #2

FIG. 8B

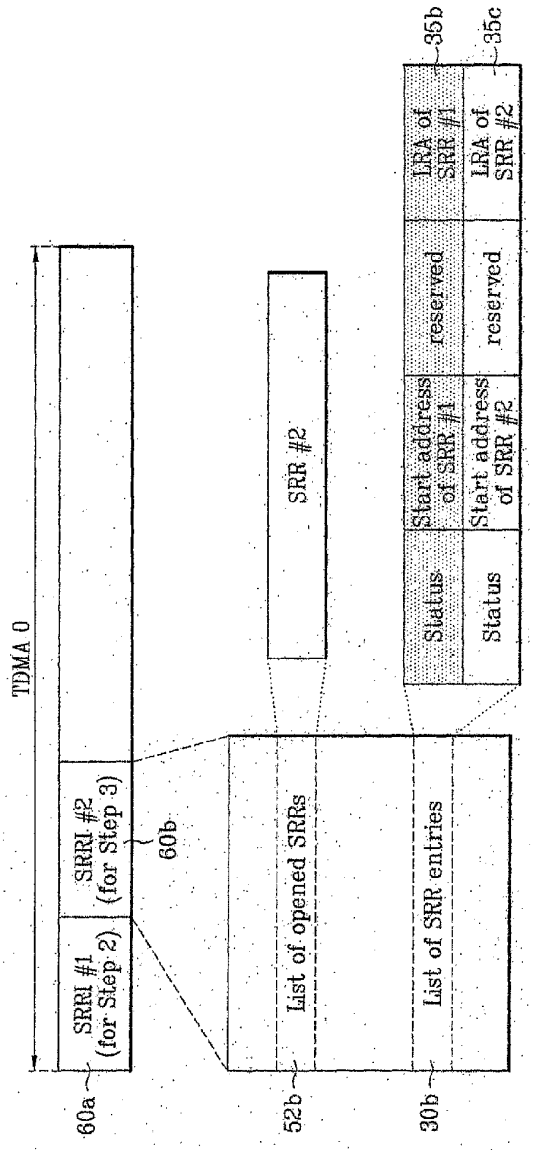

TDMA 0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
60a
60b
SRR #2
List of opened SRRs
52b
Status
Start address of SRR #1
reserved
LRA of SRR #1
Status
Start address of SRR #2
reserved
LRA of SRR #2
35b
35c
List of SRR entries
30b

FIG. 9A

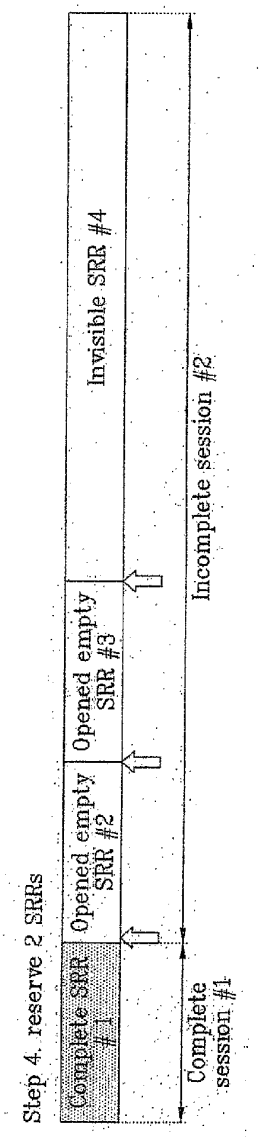

Step 4. reserve 2 SRRs
Complete SRR #1
Opened empty SRR #2
Opened empty SRR #3
Invisible SRR #4
Complete session #1
Incomplete session #2

FIG. 9B

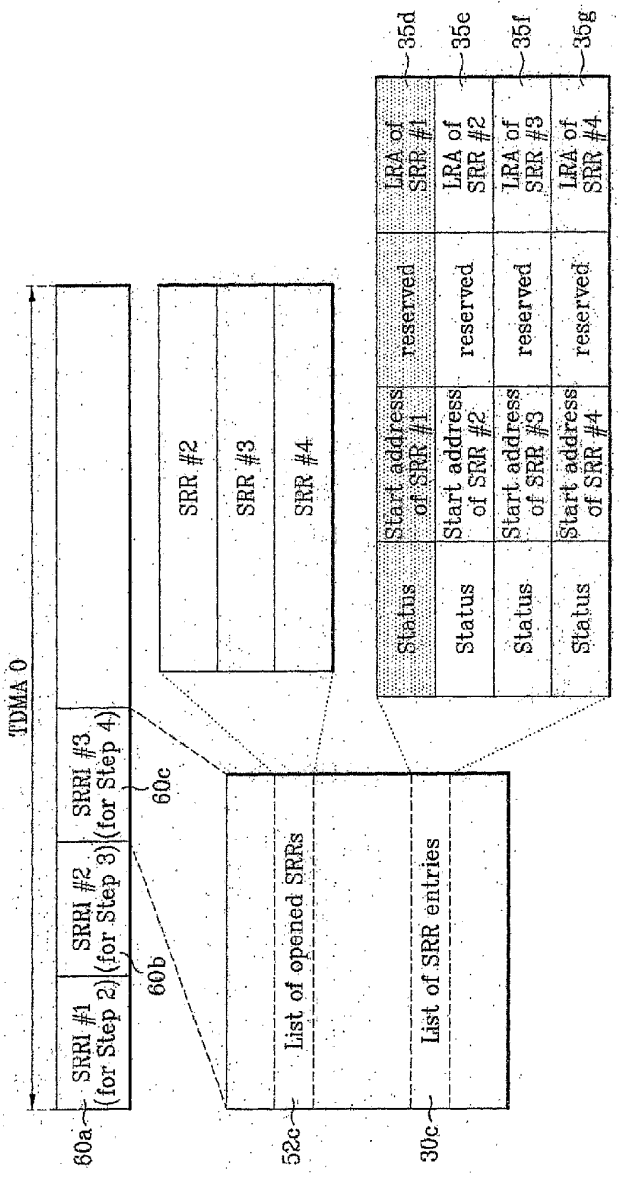

TDMA 0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
SRRI #3 (for Step 4)
60a
60b
60c
SRR #2
SRR #3
SRR #4
List of opened SRRs
List of SRR entries
52c
30c
Status
Start address of SRR #1
reserved
LRA of SRR #1
Status
Start address of SRR #2
reserved
LRA of SRR #2
Status
Start address of SRR #3
reserved
LRA of SRR #3
Status
Start address of SRR #4
reserved
LRA of SRR #4
35d
35e
35f
35g

FIG. 10A

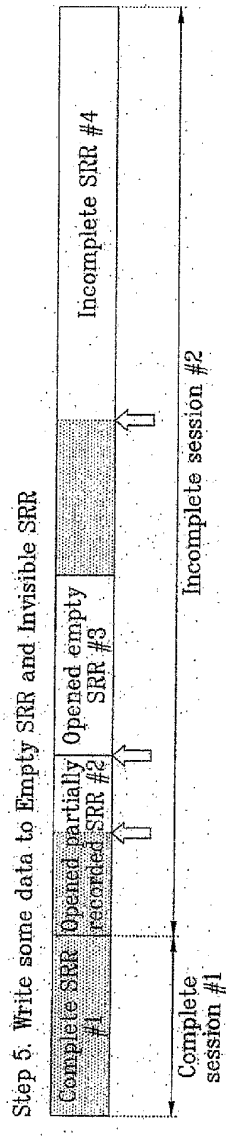

Step 5. Write some data to Empty SRR and Invisible SRR
Complete SRR #1
Opened partially recorded SRR #2
Opened empty SRR #3
Incomplete SRR #4
Complete session #1
Incomplete session #2

FIG. 10B

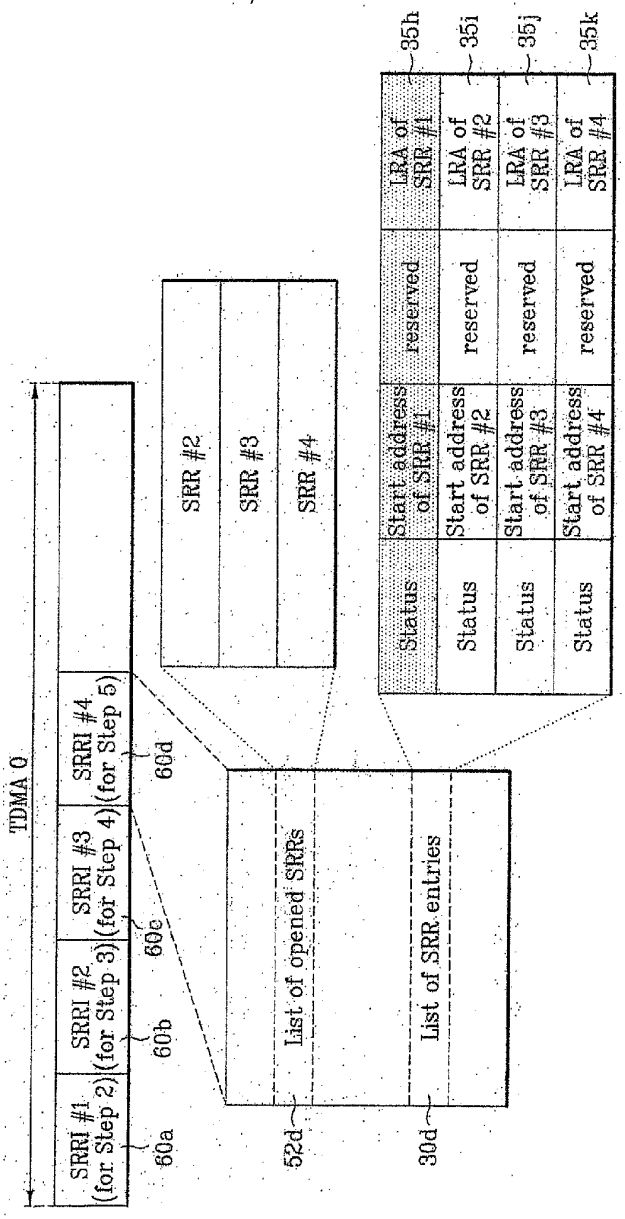

TDMA 0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
SRRI #3 (for Step 4)
SRRI #4 (for Step 5)
60a
60b
60c
60d
SRR #2
SRR #3
SRR #4
List of opened SRRs
List of SRR entries
52d
30d
Status
Start address of SRR #1
reserved
LRA of SRR #1
Status
Start address of SRR #2
reserved
LRA of SRR #2
Status
Start address of SRR #3
reserved
LRA of SRR #3
Status
Start address of SRR #4
reserved
LRA of SRR #4
35h
35i
35j
35k

FIG. 11A

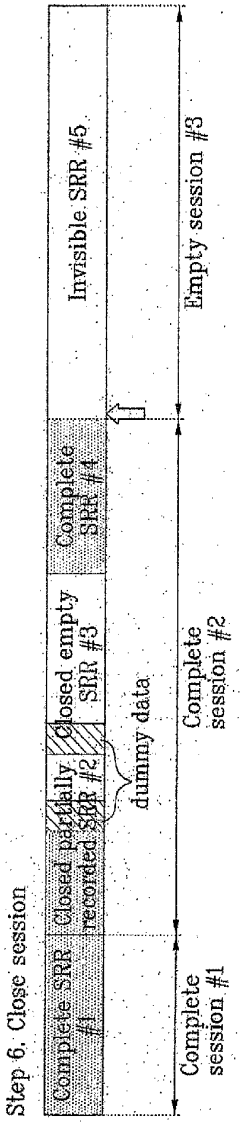

Step 6. Close session
Complete SRR #1
Closed partially recorded SRR #2
Closed empty SRR #3
Complete SRR #4
Invisible SRR #5
dummy data
Complete session #1
Complete session #2
Empty session #3

FIG. 11B

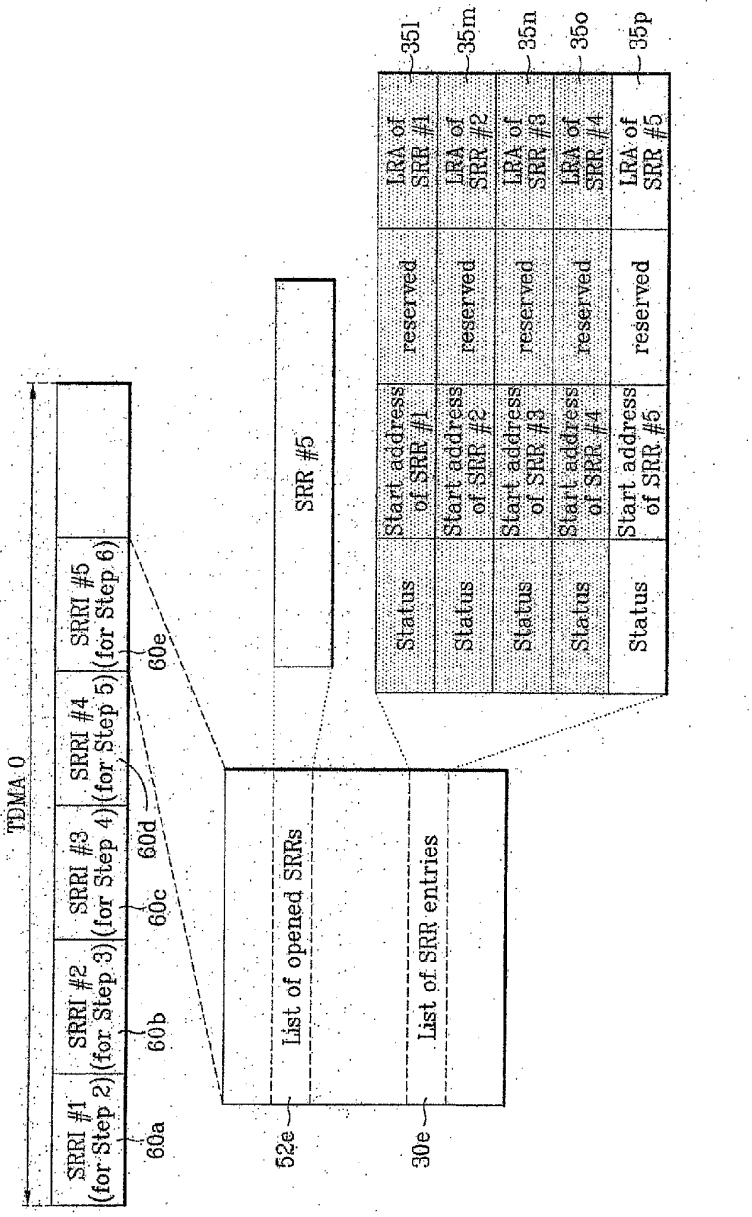

TDMA 0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
SRRI #3 (for Step 4)
SRRI #4 (for Step 5)
SRRI #5 (for Step 6)
60a
60b
60c
60d
60e
List of opened SRRs
SRR #5
52e
List of SRR entries
30e
Status
Start address of SRR #1
reserved
LRA of SRR #1
351
Status
Start address of SRR #2
reserved
LRA of SRR #2
35m
Status
Start address of SRR #3
reserved
LRA of SRR #3
35n
Status
Start address of SRR #4
reserved
LRA of SRR #4
35o
Status
Start address of SRR #5
reserved
LRA of SRR #5
35p

FIG. 12

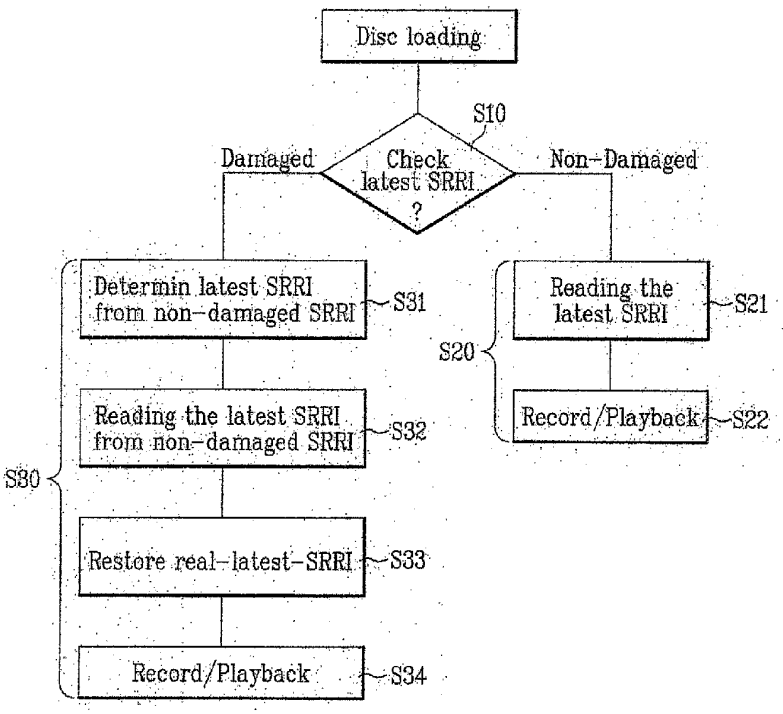

Disc loading
S10
Check latest SRRI ?
Damaged
Non-Damaged
Determin latest SRRI from non-damaged SRRI
S31
Reading the latest SRRI from non-damaged SRRI
S32
Restore real-latest-SRRI
S33
Record/Playback
S34
S30
Reading the latest SRRI
S21
Record/Playback
S22
S20

FIG. 13A

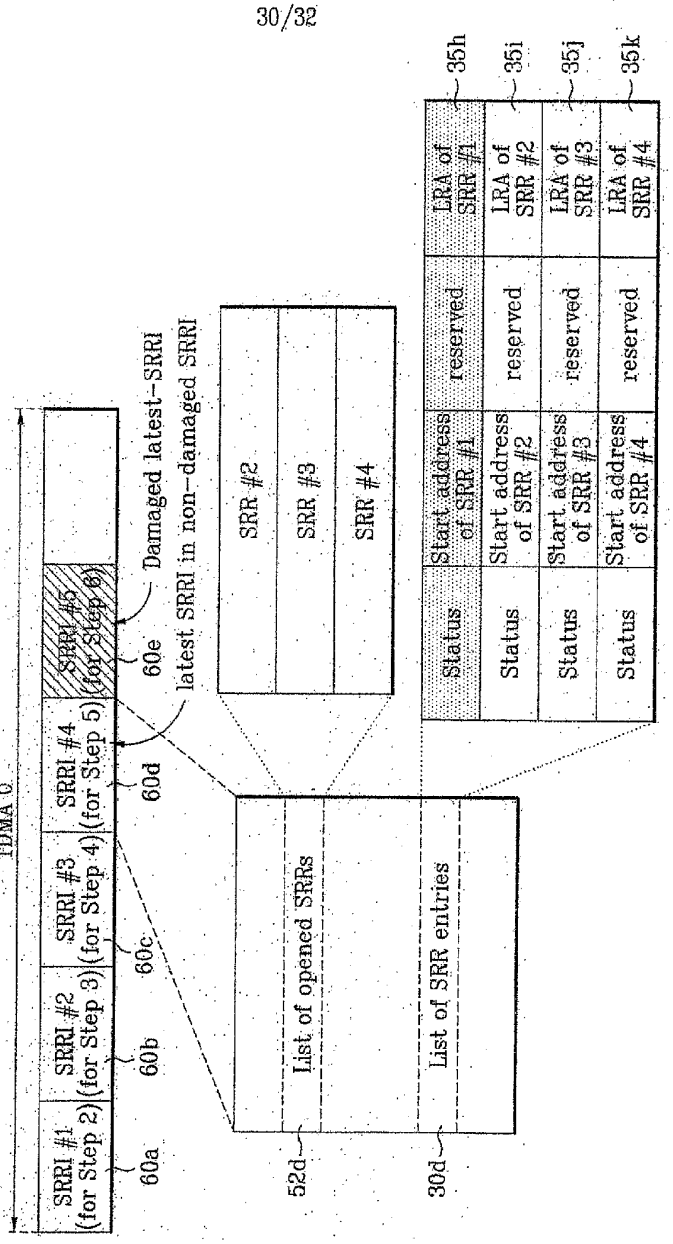

TDMA 0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
SRRI #3 (for Step 4)
SRRI #4 (for Step 5)
SRRI #5 (for Step 6)
60a
60b
60c
60d
60e
Damaged latest-SRRI
latest SRRI in non-damaged SRRI
SRR #2
SRR #3
SRR #4
52d
List of opened SRRs
30d
List of SRR entries
Status
Start address of SRR #1
reserved
LRA of SRR #1
35h
Status
Start address of SRR #2
reserved
LRA of SRR #2
35i
Status
Start address of SRR #3
reserved
LRA of SRR #3
35j
Status
Start address of SRR #4
reserved
LRA of SRR #4
35k

FIG. 13B

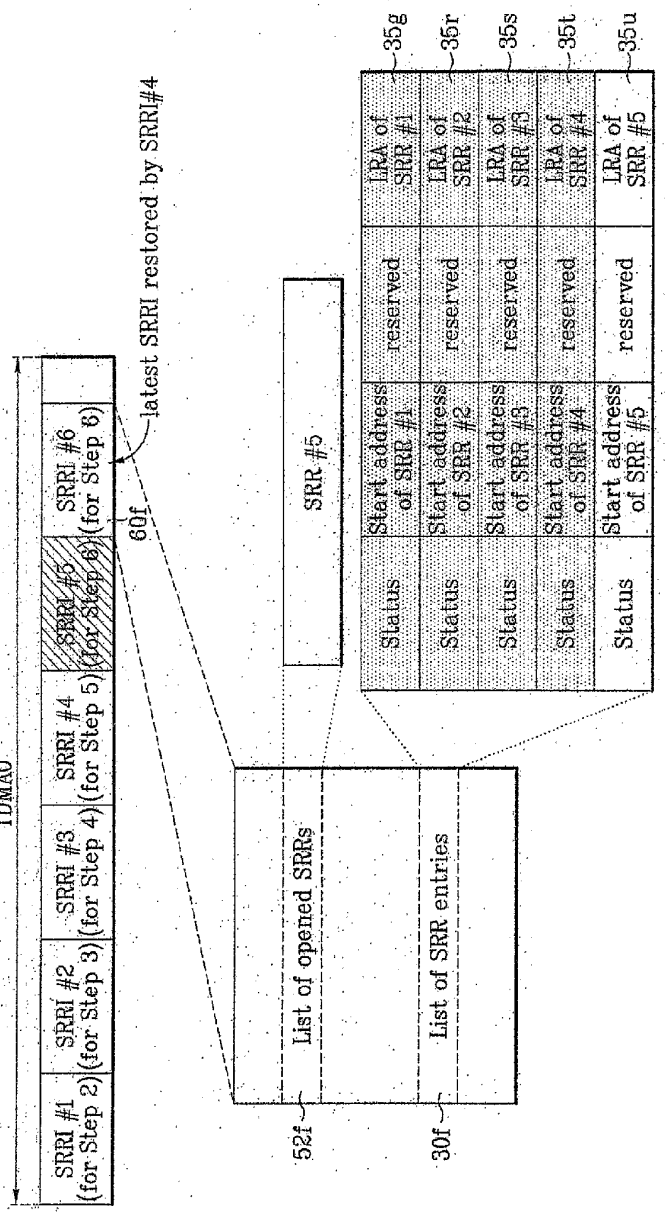
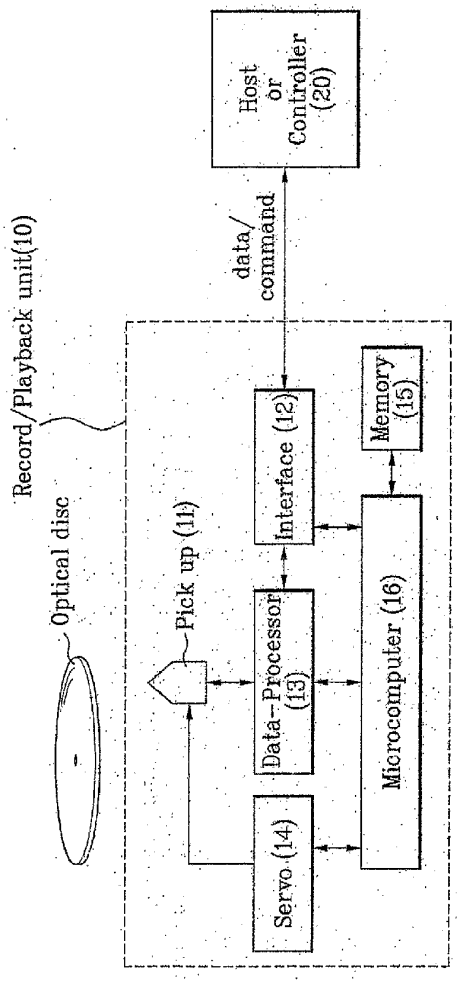

TDMA0
SRRI #1 (for Step 2)
SRRI #2 (for Step 3)
SRRI #3 (for Step 4)
SRRI #4 (for Step 5)
SRRI #5 (for Step 6)
SRRI #6 (for Step 6)
latest SRRI restored by SRRI#4
60f
SRR #5
List of opened SRRs
52f
List of SRR entries
30f
Status
Start address of SRR #1
reserved
LRA of SRR #1
35g
Start address of SRR #2
LRA of SRR #2
35r
Start address of SRR #3
LRA of SRR #3
35s
Start address of SRR #4
LRA of SRR #4
35t
Start address of SRR #5
LRA of SRR #5
35u

FIG. 14


Host or Controller (20)
data/ command
Record/Playback unit(10)
Optical disc
Pick up (11)
Interface (12)
Memory (15)
Data-Processor (13)
Microcomputer (16)
Servo (14)