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(54) Record medium, and method for recording to and reproducing from a record medium

Aufzeichnungsmedium und Aufzeichnungs- und Wiedergabeverfahren eines Aufzeichnungsmediums

Support d'enregistrement et méthode pour enregistrer et reproduire un support d'enregistrement

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a record medium such as an optical disk, a compact disk, and so forth, and method for recording to and reproducing from a record medium which is used in, for example, a magneto-optical disk drive.

[0002] Currently, there are a variety of different types of optical disks, including magneto-optical disks, "phase changing" optical disks, write-once disks, read-only memory compact disks (CD-ROMs), etc. These and other types of optical disks generally can be classified either as writable-type disks or read-only-type disks.

[0003] Upon certification or testing of a writable magneto-optical disk during or after manufacture thereof, if a defective sector is detected on the disk, the data originally recorded on the defective sector is re-recorded on a sector adjacent to the defective sector and data that identifies the existence and location of the defective sector is recorded on a predefined area of the magneto-optical disk. During reproduction of the magneto-optical disk, the sector adjacent to the defective sector is reproduced. Similarly, when data is recorded on a magneto-optical disk in, for example, a consumer magneto-optical disk drive, if a sector on which data is to be recorded is found to be defective, the data instead is recorded in a separate region used exclusively as a substitute area for defective sectors. Of course, a CD-ROM is a read-only record medium and, therefore, cannot be recorded on by, for example, an optical disk drive except during the manufacture thereof.

[0004] When data is recorded on a magneto-optical disk or on a CD-ROM during the manufacture thereof, or when data is recorded on a magneto-optical disk by an optical disk drive, error detection and error correction data also generally are recorded on each disk so that errors which occur during the reproduction of the recorded data can be detected and corrected in the reproducing device.

[0005] One type of error-correcting data is known as a Reed-Solomon code. This code provides for multiple error correction and defines code symbols from n-bit bytes or symbols (e.g., eight bits per symbol). When original data is comprised of k symbols, parity is added to the k-symbol data to produce a code of n symbols. As is known, a "minimum distance" in Reed-Solomon codes indicates the amount of error correction of which the code is capable.

[0006] For example, when one symbol is comprised of one bit, n symbols are represented by n bits, and a data series of the n symbols (i.e., n bits) can have 2^n different values (referred to as a "2^n data series"). Similarly, a series of the original k symbols can have 2^k different values (referred to as a "2^k data series"). If the 2^k data series is extracted from the 2^n data series, the number of different bits d between two series of data which have been arbitrarily taken out is known as the "distance." That distance d which similarly is obtained for all of the different 2^k data series is known as the "minimum distance." In the following discussion, for purposes of convenience, references to "distance" refer to "minimum distance."

[0007] In general, the distance d of a data code and the number of errors t1 that can be corrected have a relationship as shown in Equation 1.

$$d \geq 2 \cdot t1 + 1 \qquad (1)$$

[0008] For example, if the distance d for a particular code is 17, then errors that occur in up to eight symbols can be corrected.

[0009] Reed-Solomon codes also provide error detection capability. For example, if t2 represents the number of errors that can be detected using Reed-Solomon codes, the amount of error detection capability (t2) is expressed as shown in Equation 2.

$$t2 = d - (2 \cdot t1 + 1) \quad (t2 \geq 0) \qquad (2)$$

[0010] Table 1 below illustrates the different values of t1 and t2 when the distance d equals 17.

Table 1

0 symbol correction	t1 = 0	t2 = 16
1 symbol correction	t1 = 1	t2 = 14
2 symbol correction	t1 = 2	t2 = 12
3 symbol correction	t1 = 3	t2 = 10
4 symbol correction	t1 = 4	t2 = 8
5 symbol correction	t1 = 5	t2 = 6
6 symbol correction	t1 = 6	t2 = 4
7 symbol correction	t1 = 7	t2 = 2
8 symbol correction	t1 = 8	t2 = 0

[0011] As is apparent, the value of distance d must be increased for the number of errors that can be corrected to increase. In addition, an LDC (long distance code) of (n, k, d) for a large value of distance d provides for a relatively large amount of data.

[0012] In the above example, it is possible to correct eight symbol errors when distance d is 17. The types of such errors generally may be random errors and/or burst errors. However, the occurrence of a burst error may result in a number of erroneous symbols greater than the number of symbols that can be corrected using Reed-Solomon codes of a predetermined distance.

[0013] One known method of correcting burst errors is to provide on one or more tracks a parity sector. Here, an exclusive-or of data stored on one or more tracks is utilized as the parity data. When a burst error occurs, both error detection and error correction are accom-

plished using the parity data stored in the parity sector.

[0014] One difficulty encountered using the above-described methods of detecting and correcting errors is the general inability to process data in real time. For example, the utilization of a parity sector causes an excessive delay in the reproduction of data because there is a "two-fold" reproduction and error detection/correction process when a burst error occurs: (1) the original data is reproduced and error corrected; and (2) the data stored in the parity sector is reproduced and error corrected.

[0015] In addition, increasing the distance d of the code to increase the error detection/correction capability of a reproducing device causes a substantial increase in the amount of Reed-Solomon codes.

[0016] Another problem with the above-described methods is that the added error correction code, which may be in the form of a parity sector or increased Reed-Solomon codes, causes a reduction in the recording capacity of the record medium.

[0017] An optical disk exclusively for reproduction with an improved yield by allowing a parity sector to be adjacent to a data sector other than the corresponding data sector is known from JP-A-4159661.

SUMMARY OF THE INVENTION

[0018] It is an object of the present invention to provide record medium and method for recording to and reproducing from a record medium which overcome the shortcomings of the above-described methods.

[0019] Another object of the present invention is to provide a recording format of a record medium and method for recording data in that format to and reproducing data in that format from a record medium in which the affect of a burst error can be minimized.

[0020] A further object of the present invention is to provide a recording and reproducing technique which minimizes the affect of a burst error without decreasing the recording capacity of a record medium.

[0021] Various other objects, advantages and features of the present invention will become readily apparent to those of ordinary skill in the art, and the novel features will be particularly pointed out in the appended claims.

[0022] These objects are achieved by a record medium and method for recording to and reproducing from a record medium according to the enclosed independent claims. Advantageous features of the present invention are defined in the corresponding subclaims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The following detailed description, given by way of example and not intended to limit the present invention solely thereto, will best be appreciated in conjunction with the accompanying drawings, wherein like reference numerals denote like elements and parts, in which:

Fig. 1 is a block diagram of an optical disk drive which carries out the method of recording to and reproducing from a record medium in accordance with the present invention;

Figs. 2A to 2D illustrate the format of the servo area of address and data segments on a magneto-optical disk of the present invention;

Figs. 3A and 3B illustrate the data structure of tracks on a record medium in accordance with the present invention;

Fig. 4 illustrates the various regions of an optical disk;

Fig. 5 is a table which identifies the location and data clock rate of each of the regions of the optical disk shown in Fig. 4;

Fig. 6 is a block diagram of disk drive controller 2 shown in Fig. 1;

Fig. 7 is a block diagram of controller 44 shown in Fig. 6; ***[deletion(s)]***

Figs. 8 and 9 illustrate an exemplary data structure of a sector of an optical disk in accordance with the present invention;

Fig. 10 illustrates the data structure of sectors in a writable region of an optical disk in accordance with the present invention;

Fig. 11 illustrates the data structure of adjacent sectors in read-only areas of a disk in accordance with an embodiment of the present invention;

Fig. 12 shows a specific example of the data structure of sectors whose data structure are broadly shown in Fig. 11;

Figs. 13 - 15 are flow charts of the method of recording to and reproducing from a record medium in accordance with the present invention;

Fig. 16 illustrates the data structure of sectors of an optical disk in accordance with another embodiment of the present invention;

Fig. 17 illustrates a specific example of the data structure of sectors shown in Fig. 16;

Fig. 18 illustrates the data structure of sectors of an optical disk in accordance with a further embodiment of the present invention;

Fig. 19 illustrates a specific example of the data structure of sectors shown in Fig. 18; and

Fig. 20 illustrates another specific example of the data structure of sectors of an optical disk.

DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

[0024] Referring now to the drawings, Fig. 1 is a block diagram of an optical disk drive which carries out the method of recording to and reproducing from a record medium in accordance with present invention. The optical disk drive includes a drive unit 1 for recording data to and reproducing data from an optical disk 4 (e.g., a

magneto-optical disk) and a drive controller 2 which controls the drive unit. A host computer 3 is coupled to the drive controller at an input/output (I/O) terminal io1 (e. g., a SCSI-small computer systems interface) so as to access data stored on optical disk 4 via drive 1 and drive controller 2.

[0025] The optical disk drive of Fig. 1 generally is capable of: recording data to and reproducing data from a magneto-optical disk and a write-once type disk; reproducing data from a read-only disk (e.g., CD-ROM); recording data to and reproducing data from a writable region of a hybrid (or partial) read-only memory having both writable and read-only regions; and reproducing data from the read-only regions of a hybrid-type disk. As is appreciated, data is recorded on read-only disks and on the read-only regions of hybrid disks during manufacture thereof. Furthermore, for purposes of the present invention, optical disk 4 may be a magneto-optical disk, a "phase change media" optical disk, a write-once disk, a hybrid disk which has both a writable region (RAM) and a read-only region (ROM), a CD-ROM, etc.

[0026] Drive 1 is comprised of a loading mechanism 5 which loads optical disk 4 therein, a spindle motor 6 which rotates optical disk 4, a driver 7 which drives spindle motor (SM) 6, an optical block 8 (to be described), a driver 14 which drives a laser diode (LD) 13 located in optical block 8, and I-V/matrix amplifier 16 which converts a reproduced signal supplied from optical block 8 into I-V (current/voltage) form and which supplies this signal to drive controller 2, a magnetic head 17 which provides a magnetic field to optical disk 4, and a driver 18 which drives magnetic head 17.

[0027] Optical block 8 is comprised of an objective lens 9 which radiates laser light from laser diode 13 onto optical disk 4, a slide motor 10 which moves optical block 8 in a radial direction of optical disk 4, a galvano-motor 11 which provides tracking by turning a galvano-mirror (not shown) that reflects the laser beam onto the optical disk, a focus actuator 12 which focuses the laser light and laser diode 13 which produces the laser light.

[0028] Various drive and control signals are supplied to drive 1 via input terminals 1i1-1i7 from drive controller 2 through the output terminals thereof (201-207), as follows. Drive controller 2 supplies drive signals to: driver 18 (via terminal 1i1) which drives magnetic head 17; driver 14 (via terminals 1i2 and 1i3) which drives laser diode 13; focus actuator 12 (via terminal 1i4) which focuses the laser light; galvano-motor 11 (via terminal 1i5) which provides tracking; slide motor 10 (via terminal 1i6) which moves optical block 8; driver 7 (via terminal 1io) which drives spindle motor 6; and loading mechanism 5 (via terminal 1i7) which loads the optical disk. I-V/matrix amplifier 16 supplies various signals to drive controller 2 via output terminals 1o1-1o5 of drive 1 and terminals 2i1-2i5 of drive controller 2, to be described.

[0029] Figs. 2-5 schematically illustrate a data format of optical disk 4 to which data is recorded and from which data is reproduced by the optical disk drive shown in Fig. 1. During manufacture, concentric recording tracks are sequentially formed on the optical disk from the outer to the inner peripheries thereof, and plural servo areas (SA) are formed on each of the tracks at predetermined angles thereof. Figs. 3A and 3B illustrate the format of the recording tracks of the optical disk, to be further described, and Figs. 2A to 2D illustrate the structure of four different servo areas formed on each track.

[0030] Referring first to Fig. 3A, each track is divided into 100 frames and each frame includes an address segment and 13 data segments, for a total of 1400 segments (address and data) per track. Each segment has a length of 216 servo clocks. Each of the address and data segments includes a servo area (SA) at the beginning thereof so as to provide tracking control based on the servo pattern (i.e., pit-pattern) of the respective servo area, further described below.

[0031] Fig. 2B schematically illustrates the pit-pattern of the servo area SA of each of the address segments on each of the tracks. As shown, an address mark (AM) (i.e., pit) is formed during manufacture of the disk at a position AR1 and wobble pits (WP) are formed at particular respective positions so as to provide proper tracking, as will be further discussed below. Following the servo area of each address segment is an address area (Fig. 3A) in which address data AD is recorded during manufacture of the optical disk. The address data identifies the radial position of the track (i.e., the track number) as well as the tangential (i.e., angular) position of the frame in which the address sector is located (i.e., the frame within the track). Following the address area of each address segment is an auto laser power control (ALPC) area in which data is recorded which provides for the upward adjustment of the amount of laser light from laser diode 13.

[0032] Figs. 2A, 2C and 2D schematically illustrate the pit-patterns of each of three different data servo areas SA that may be formed at the beginning of each of the data segments. As shown, the data servo area of a data segment includes either a segment mark (SM), a sector flag 1 mark (SF1) or a sector flag 2 mark (SF2) formed at a position AR4, AR2 and AR3, respectively. In addition, wobble pits (WP) are formed at positions similar to those formed in the servo area of each address segment. Each of the three different data servo areas shown in Figs. 2A, 2C and 2D is further discussed below.

[0033] In addition to dividing each track into plural segments, the entire recording area of optical disk 4 is divided into plural concentric zones, also known as bands, and each zone includes plural concentric recording tracks. Fig. 4 schematically illustrates optical disk 4 divided into various zones including, from the outer periphery to the inner periphery of the disk, a Gray code part (GCP) band, a control (CTL) region (i.e., band), a test (TEST) region, a first band (BAND 0) through a fifteenth band (BAND 15), and another test (TEST) region, control (CTL) region and Gray code part (GCP) band.

[0034] Generally, each of the GCP bands includes da-

ta which identifies the type of the disk and the address or location of each of the zones on the disk, and includes a pit pattern formed of a Gray code. The GCP bands further are arranged so that they can be reproduced when optical block 8 in the optical disk drive crosses the various tracks on optical disk 4. Each of the CTL regions generally includes data which identifies the type of record medium and the TEST regions are utilized for testing purposes. BAND 0 through BAND 15 are known as user zones (e.g., video data, audio data, etc.) on which user data is recorded.

[0035] Fig. 5 is a table which identifies the starting and ending radial positions of each of the zones of optical disk 4 and the clock frequency at which data is recorded in each of those zones. As shown, the clock frequency at which data is recorded is the same for each of the first three zones nearest the outer periphery (24.192 MHz) and is the same for each of the three zones nearest the inner periphery (12.096 MHz). In addition, the data clock frequency increases with each band 15 through band 0 as the outer periphery is approached. Bands 0-14 have the same data recording capacity since the data clock rates are selected to correspond to the starting and ending radial positions of those bands. The data clock rate is generated in the optical disk drive shown in Fig. 1 from a servo clock which is derived from the wobble pits in the servo patterns in each of the segments, to be further described. The servo clock additionally is utilized for producing sampling pulses for purposes of proper focusing, tracking and detecting of address codes. It is noted that within each zone, the angular recording density is constant and, therefore, the timing of the sampling pulses also is constant and not dependent on the radial position of a track.

[0036] In addition to the above-described data structure, each track further is divided into plural sectors which store the same amount of data (e.g., 2 kilobytes). Each sector is comprised of plural segments. Since the amount of data recorded in each segment in a track decreases when the respective track approaches the inner periphery of the optical disk, the number of segments included in each sector of a track increases as the respective track approaches the inner periphery of the optical disk. Fig. 3B schematically illustrates the relationship between each of the sectors in the various tracks and the number of segments contained in those sectors. As shown, sector 0 on a track located in zone 13 includes less address segments (and, therefore, less total segments) than sector 0 on a track located in zone 15. Furthermore, it is shown that each sector does not necessarily include only entire frames of data (i.e., each and every one of the 14 segments of a frame). Rather, the beginning of a sector may coincide with the beginning of any of the segments in a frame, to be further discussed.

[0037] Referring now to Fig. 6, a block diagram of drive controller 2 shown in Fig. 1 is shown. Drive controller 2 is comprised of input/output (I/O) circuits 31, 47 and 52, a D/A convertor 32, a select/clamping circuit 33, A/D convertors 34 and 46, a data clock generating circuit 35, a data timing generating circuit 36, a data phase controller 37, a read/write (R/W) circuit 38, a servo clock generating circuit 39, a servo timing generating circuit 40, a selector 41, an address decoder 42, a bus 43, a controller 44, a multiplexer 45, a pulse width modulating (PWM) circuit 48, drivers 49, 50, 51, and a digital signal processing circuit 53.

[0038] When optical disk 4 is loaded by loading mechanism 5 on spindle motor 6, or when an automatic "spin-up" mode is initiated after optical disk 4 is loaded, host computer 3 controls via controller 44 digital signal processing circuit 53 to initiate the rotation of spindle motor 6. Digital signal processing circuit 53 supplies via bus 43, I/O circuit 52 and terminal 2io a control signal to driver 7 which drives spindle motor 6 to rotate optical disk 4. When the rotational speed of spindle motor 6 reaches a predetermined velocity, driver 7 supplies via I/O circuit 52 a "lock" signal back to digital signal processing circuit 53. Digital signal processing circuit 53 also supplies during this time a control signal to PWM circuit 48 which modulates the control signal and which supplies a drive signal to driver 50 which via terminal 2o5 drives galvano-motor 11 to position the laser beam from laser diode 13 outside the user area of optical disk 4. Digital signal processing circuit 53 further provides via PWM circuit 48 to driver 51 a control signal to move optical block 8 to the outer or inner periphery of optical disk 4. Since the focusing of laser light may affect data recorded in the user area of optical disk 4, this undesirable effect is prevented by focusing the laser light initially outside the user area of the disk.

[0039] When spindle motor 6 obtains a predetermined constant velocity and optical block 8 has moved to, for example, the outer periphery of the disk, digital signal processing circuit 53 sets the bias current of laser diode 13 by supplying a bias control signal and a laser diode on/off signal to driver 14 via I/O circuit 31, D/A circuit 32 and terminal 202, and via servo timing generating circuit 40 and terminal 2o3, respectively. Driver 14 then drives laser diode 13 to emit laser light. The laser light (i.e., laser beam) emitted from laser diode 13 is reflected from disk 4 to photo detector 15 in optical block 8 which converts the laser light into an electric signal and which supplies the electric signal to I-V/matrix amplifier 16. When the laser beam is incident on the ALPC area of an address segment of a track (see Fig. 3A), photo detector 15 produces an electric signal proportional thereto. I-V/matrix amplifier 16, in response to the electric signal, supplies an ALPC signal, a focus error signal, and a pull-in signal to multiplexer 45 via terminals 1o3 and 2i3, 1o4 and 2i4, and 1o5 and 2i5, respectively. Multiplexer 45 multiplexes, in a time division manner, the received signals and supplies the ALPC signal (among others) to A/D converter 46 which digitizes the signal and which supplies the digitized ALPC signal via I/O circuit 47 and bus 43 to digital signal processing circuit 53. Digital signal

processing circuit 53 ascertains from the digitized ALPC signal the amount of light emitted from laser diode 13 and adjusts that amount of light by varying the control signal which is supplied to I/O circuit 31. That is, based on a calculation by a digital filter (not shown), the signal supplied via I/O circuit 31 and D/A converter 32 to driver 14 is adjusted until the laser diode power output is at an appropriate and constant level.

[0040] At this time, digital signal processing circuit 53 controls PWM circuit 48 to drive via driver 49 and terminal 2o4 focus actuator 12 to enter a focus search mode which drives focus actuator 12 in the upper and lower directions (e.g., toward and away from disk 4). In the focus search mode, focus actuator 12 changes the focus of the laser beam onto optical disk 4; the reflection of the beam being incident on the light-receiving surface of photo detector 15 which converts the incident light into an electric signal. In response to the electric signal, I-V/matrix amplifier 16 generates and supplies via terminals 1o4 and 2i4 the focus error signal to multiplexer 45 which supplies the focus error signal (among other signals) to A/D converter 46. A/D converter 46 digitizes the focus error signal and supplies the digitized signal through I/O circuit 47 to digital signal processing circuit 53 which, in response thereto, adjusts the focus control signal supplied to driver 49.

[0041] Upon stable and proper focusing, I-V/matrix amplifier 16 produces an RF signal which has a substantially constant amplitude (produced from the signal supplied from photo detector 15) that is supplied to selector/clamp circuit 33 via terminal 2i1. The selector/clamp circuit selects and clamps the RF signal and supplies the clamped RF signal to A/D converter 34.

[0042] Servo clock generating circuit 39 operates in a "free-run mode" to supply a clock signal, having a free-run frequency, which is supplied as a timing pulse to servo timing generator 40. The free-run frequency is divided by a predetermined value and coupled to selector/clamping circuit 33 to provide proper clamping of the RF signal. A/D converter 34 supplies the digitized RF signal to servo clock generating circuit 39 which detects the pit-pattern formed (during manufacture) on optical disk 4 by measuring the difference in amplitudes of the digitized RF signal. Clock generating circuit 39 determines whether the detected pit-pattern in the digitized RF signal corresponds to a pit-pattern of one of the servo areas, and upon detection of a servo area pit-pattern, clock generating circuit 39 controls clock selector 41 to "open" a time window corresponding to the position in the RF signal at which the next servo area pit-pattern is expected to occur. When servo clock generating circuit 39 detects this servo area pit-pattern a predetermined number of times, servo clock generating circuit 39 is considered to be "locked" to the servo area pit-pattern of optical disk 4. In addition, phase information is generated from the amplitude difference of each of the wobble bits (WB) (see Figs. 2A-2D) at both edges thereof and the summed total of the amplitude differences provides correct tracking information so as to ensure proper tracking during reproduction.

[0043] When servo clock generating circuit 39 is locked to the servo area pit-pattern, the position of the various marks and flags (i.e., marks SM, AM and flags SF1, SF2) in the reproduced servo area is determined by ascertaining at which one of four predetermined positions, AR1, AR2, AR3 and AR4, the RF signal amplitude is maximum. When the RF signal is a maximum at position AR1, the mark is an address mark AM and the reproduced servo area is in an address segment. Since each frame begins with an address segment, frame synchronization is achieved by resetting a frame counter in servo clock generating circuit 39 at each detection of a mark at position AR1. Once servo clock generating circuit 39 continuously detects the address mark in the servo area of each address segment, frame synchronization is considered to be "locked." Servo clock generating circuit 39 then controls selector 41 to open a time window at each of the fourteen segments of each frame.

[0044] When frame synchronization is accomplished, the address data AD in the address area of each of the address segments is reproduced and supplied to address decoder 42 which decodes the reproduced data (which is stored in the form of pit-patterns in the address area) by comparing the pattern, which is formed as a Gray code at every four bits, with a Gray code table. The comparison is made with an inverted table depending on whether the least significant bit (LSB) of the upper four bits is a "1" or a "0."

[0045] The frame code, which is included in the address data, is stored in a frame counter in address decoder 42 which is incremented by one on each detection of an address segment, and the value in the frame counter is compared to the frame code reproduced from the address data of each of the address segments to ensure coincidence therebetween. Upon frame count synchronization, the frame code stored in the frame counter is supplied to digital signal processing circuit 53, for example by way of bus 43.

[0046] Digital signal processing circuit 53 ascertains the velocity of optical block 8 from the track addresses and controls slide motor 10 by supplying a control signal to driver 51 through PWM circuit 48 in order to move optical block 8 to a desired track on the optical disk, at which point, proper tracking is accomplished as follows.

[0047] A tracking data signal is produced from the difference between the amplitude values of the RF signals corresponding to each of the wobble points in a servo area. Digital signal processing circuit 53 supplies a tracking control signal via PWM circuit 48 to driver 50 which drives galvano-motor 11 of optical block 8. Here, fluctuations of low frequency components in the RF signal are controlled to effectively provide tracking control of the laser beam so that it is positioned at the central portion of a track on optical disk 4.

[0048] Referring again to Figs. 2A to 2D, when servo clock generating circuit 39 detects a segment mark at

position AR2 (sector flag 1 in Fig. 2C) in the servo area of a segment, i.e., when the RF signal amplitude is maximum at position AR2, the reproduced segment is determined to be a data segment that is located at the beginning of a sector. If the segment mark is located at position AR3 (sector flag 2 in Fig. 2D), the reproduced segment is determined to be a data segment that is located adjacent and prior to the first segment of a sector. Host computer 3 is operable to determine whether a particular segment is the first or last segment of a sector utilizing the address data of each segment and, therefore, it is possible to identify the first segment of each sector even when a sector mark (or segment mark) in a particular segment cannot be reproduced. Finally, if the segment mark is located at position AR4 (the segment mark SM in Fig. 2A), the reproduced segment is determined to be neither a first nor a last segment of a sector.

[0049] Data clock generating circuit 35 generates a data clock signal having a frequency a multiple number of times greater than the frequency of the servo clock signal which is produced by servo clock generating circuit 39. The data clock signal is supplied to data timing generating circuit 36 and read/write circuit 38. Read/write circuit 38 also is supplied with recording data from host computer 3 via controller 44 during a recording operation. Read/write circuit 39 scrambles each set of sector data to be recorded by adding (e.g., by means of an exclusive-OR function), for example, a random number of 127 periods in accordance with the equation $y = x^7 + x + 1$ so as to modulate the scrambled recording data to data of an RZI series in synchronism with the data clock. The value initially is set to "0" at each segment of data and a modulated signal is supplied via driver 18 to magnetic head 17 from data phase controller 37 (via terminal 201).

[0050] During a recording operation, magnetic head 17 generates a magnetic field in response to the modulated signal which is applied to the data area of a segment on optical disk 4. The data area is heated to a Curie temperature by the laser beam in order to record the data of the NRZI series.

[0051] During a reproduction operation, data reproduced from each data area, which is produced by photodetector 15 and I-V/matrix amplifier 16, is clamped at a predetermined potential in selector/clamping circuit 33. The clamped signal is digitized in A/D converter 34 and supplied to read/write circuit 38 which, in a digital filter therein, processes the digitized signal by performing Viterbi coding on the data of the NRZI series. The read/write circuit 38 further converts the data of the NRZI series into an NRZ system whose basic unit is a segment, descrambles the data to provide sector data, and converts the sector data into reproduced data. The reproduced data is supplied through controller 44 to host computer 3.

[0052] Referring now to Fig. 7, a block diagram of controller 44 shown in Fig. 6 is illustrated. Controller 44 is comprised of a central processing unit (CPU) 60, a bus 61, a read-only memory (ROM) 62, a random-access memory (RAM) 63, an input/output (I/O) port 64, switches 66, 69, an LDC/ECC decoder 67, an LDC/ECC encoder 68, a buffer 70 and an interface (IF) circuit 71. ROM 62 stores program data, parameter data, etc. and RAM 63 is utilized as a temporary work area for CPU 60. Each of LDC/ECC decoder 67 and LDC/ECC encoder 68 is comprised of a random access memory (RAM) 67a, 68a, respectively, each having a capacity to store two sectors' worth of data, and a RAM controller 67b, 68b, respectively.

[0053] A description of the operation of controller 44 when data is recorded on a writable magneto-optical disk or on a writable region of a partial (hybrid) disk will first be described. During a recording operation, host computer 3 supplies to CPU 60 a control signal by way of terminal io1, IF circuit 71, I/O port 64 and bus 61. In response to the control signal, CPU 60 supplies via I/O port 64 a switching control signal to switches 66 and 69 which connect their respective contacts b and c in response thereto. Data to be recorded is supplied from host computer 3 to buffer 70 which temporally stores the data therein. The data are transferred from buffer 70 through contacts b and c of switch 69 to LDC/ECC encoder 60 which adds error detection and error correction code. LDC/ECC encoder 68 supplies through contacts b and c of switch 66 and terminal 65 the data along with the error detection/correction code to read/write circuit 38 (Fig. 6). The data subsequently is recorded on optical disk 4, as previously discussed.

[0054] When data is supplied to LDC/ECC encoder 68, the encoder adds parity data to one of the two sectors supplied thereto and which are stored in RAM 68a. Upon completion of recording a sector, LDC/ECC encoder 68 supplies to CPU 60 via I/O port 64 a signal that indicates that the sector data is output therefrom. At this point, CPU 60 controls buffer 70, IF circuit 71 and read/write circuit 38 to process the data in the next sector.

[0055] When data is reproduced from optical disk 4, host computer 3 supplies a control signal to CPU 60 which in response thereto supplies a switching control signal via I/O port 64 to switches 66 and 69 which connect their respective contacts a and c. The reproduced data is supplied from read/write circuit 38 through terminal 65 and switch 66 to LDC/ECC decoder 67. When data is reproduced from a writable disk or from a writable region of a hybrid disk, LDC/ECC decoder 67 does not rearrange (to be described) the data and only performs error detection and correction on the reproduced data prior to supplying through switch 69 the error corrected data through switch 69 to buffer 70.

[0056] On the other hand, when data is reproduced from a read-only disk or from a read-only region of a hybrid disk, LDC/ECC decoder 67 rearranges the reproduced data in a manner to be described prior to performing error detection and error correction thereon.

[0057] As described above, LDC/ECC decoder 67 performs a converse function as that performed by LDC/

ECC encoder 68 when data is reproduced from a writable disk or from a writable region of a hybrid disk. However, LDC/ECC decoder 67 performs the additional function of rearranging data reproduced from a read-only disk or from a read-only region of a hybrid disk. In the latter case, data contained in two sectors, which are reproduced and stored in RAM 67a, are rearranged (or "shifted") by RAM controller 67b to produce a single sector's worth of data, which is referred to as a "rearranged" sector. LDC/ECC decoder 67 performs error detection and correction on the rearranged sector using parity data contained therein and the error corrected and rearranged sector is supplied to buffer 70. At this time, LCD/ECC decoder 67 supplies to CPU 60 a signal that indicates that a sector is supplied thereout. CPU 60 then controls read/write circuit 38 and the accompanying circuits in the disk drive to reproduce and supply to LDC/ECC decoder 67 the next sector stored on optical disk 4. LDC/ECC decoder 67 stores in RAM 67a the reproduced sector with the sector already stored in RAM 67a (i.e., that sector that was previously reproduced) and repeats the above rearranging and error detecting/correcting process to produce another rearranged sector.

[0058] Figs. 8 and 9 illustrate an exemplary data structure of a sector in accordance with the present invention wherein "i" represents a code word, "j" represents a byte of data such that each code word includes 16 bytes of data, and the horizontal arrow indicates the order in which data is recorded. As shown, each sector includes 2048 bytes of data (D0 to D2047), 40 undefined bytes (U.D.), 8 bytes of CRC code (CRC1 to CRC8) and 256 bytes of Reed-Solomon code (E1,1, E2,1,... E16,16), for a total of 2352 bytes per sector. The CRC code represents parity for detecting errors in the entire data region which includes all of the data bytes D0 through D2047 and the undefined bytes, whereas the Reed-Solomon code in each column provides error detection/correction of data located in the respective column. That is, parities (E1,1), (E1, 2)...(E1, 16) correspond to data D0, D16, D32...D2032 and the three undefined bytes corresponding to positions (j=0, i=2), (j=0, i=1) and (j=0, i=0); parities (E2,1), (E2, 2)...(E2, 16) correspond to data D1, D17, D33... D2033 and the three undefined bytes corresponding to positions (j=1, i=2), (j=1, i=1) and (j=1, i=0), etc.

[0059] In the above exemplary data structure, each of the columns (j=0, 1...15) shown in Figs. 8 and 9 is comprised of 147 bytes wherein the data portion for producing the Reed-Solomon code (e.g., (E1,1), (E1,2)... (E1,16)) is generated from the data portion of the column (e.g., D0, D16, D32...D2032, UD(i=2, j=0), UD(i=1, j=0), UD(i=0, j=0)) which has a length of 131 bytes and the parity length of the Reed-Solomon code of each column is 16 bytes. Therefore, the minimum distance is 17 to provide a Reed-Solomon code of (147, 131, 17).

[0060] Fig. 10 illustrates the data structure of adjacent sectors recorded in a writable region of an optical disk in accordance with the present invention. As shown, a recorded sector, e.g., sector S_n, located in a writable region of an optical disk includes data Da1(n), Da2(n)... Dam(n) that represent data D0, D1...D2047 shown in Figs. 8 and 9, undefined data UD(n) that represents both the undefined data (UD) and CRC parities CRC1 through CRC8, and a long distance code LDC(n) that represents parities (E1, 1)...(E16, 16). Similarly, another sector S_{n-1} recorded on a writable region of an optical disk includes all of the data, Da1(n-1), Da2(n-1)...Dam (n-1), UD(n-1) and LDC(n-1). In other words, sector data is recorded in the same order (i.e., arrangement) in which it is supplied from the host computer. Of course, parity data is added to each sector in LDC/ECC encoder 68, previously discussed. In addition, data in adjacent sectors S_{n-1}, S_n and S_{n+1} shown in Fig. 10 are recorded in adjacent sectors in a writable region of optical disk 4.

[0061] Referring now to Fig. 11, a diagram of the data structure of adjacent sectors stored in a read-only area of an optical disk in accordance with the present invention is illustrated. As previously discussed, upon reproduction of data stored on a read-only disk or on a read-only region of a hybrid disk, LDC/ECC decoder 67 (shown in Fig. 7) reproduces (i.e., restores) a sector of data by rearranging data from two of the reproduced sectors. Fig. 11 illustrates the data structure of "arranged" sectors stored on the optical disk. As shown, sectors S_{n-2}, S_{n-1}, S_n, S_{n+1} and S_{n+2} represent five consecutive sectors stored on a read-only region of an optical disk wherein each of these sectors is comprised of data from two original "pre-arranged" sectors. That is, a particular sector, e.g., sector S_n, includes data that originally was included in that sector, e.g., data Da1(n), Da3 (n), Da5(n)...Dam-1(n), UD(n) and LDC(n), and data originally included in the preceding sector, e.g., data Da2(n-1), Da4(n-1)...Dam(n-1). Hence, for a particular sector S_n, both the long distance code LDC(n) and the CRC parity data UD(n) corresponds to that data stored in sector S_n on the optical disk that originally was contained in ("pre-arranged") sector S_n and to that data stored in sector S_{n+1} on the optical disk that also originally was contained in ("pre-arranged") sector S_n.

[0062] Furthermore, a first sector S_{n-2} located in a group of sectors S_{n-2} to S_{n+2} stored on an optical disk includes data originally from that sector, i.e., Da1(n-2), Da3(n-2)... Dam-1(n-2), UD(n-2) and LDC(n-2), and dummy data which is located at those positions in sector S_{n-2} whose data is stored in the following adjacent sector S_{n-1}. That is, since sector S_{n-2} represents a first or "head" sector, there is no data that is shifted into that sector during arrangement of the data prior to recording the arranged sectors in a read-only area of an optical disk during manufacture thereof, and therefore, dummy data is supplied to fill in the "gaps."

[0063] Furthermore, an additional or "new" sector is created during arrangement of the sectors when some of the data in the original last sector, for example, sector S_{n+1}, is "shifted" out of that sector. That is, when data from sector S_{n+1} is moved, as shown in Fig. 11, a new

sector S_{n+2} is formed and dummy data is stored in the gaps. In addition, Data LDC(n+2) in sector S_{n+2} represents dummy data or may contain data that identifies this sector as a last one of the "arranged" sectors in a group, to be discussed.

[0064] Identification data that identifies the presence of a "head" sector of a group of sectors is stored as the undefined bytes in the undefined region UD(n-2) of sector S_{n-2}, and identification data that identifies the presence of a "last" sector of a group of arranged sectors is stored as the undefined bytes in the undefined region UD(n+2) of sector S_{n+2}. As a result of the stored identification data, a reproducing apparatus does not have to "guess" when a group of sectors begins and ends. That is, since it may not be possible during a recording process (i.e., a manufacture process) to record continuous or contiguous sectors, and data of two adjacent sectors are required to produce data of one sector during reproduction thereof, it is important to be able to determine the locations of the first and last sectors of a group of "arranged" sectors. Hence, a group can be comprised of any number of plural sectors.

[0065] Referring back to Fig. 10, it is shown that data D0 to D2027 (Figs. 8-9) in an original "pre-arranged" sector, for example, sector S_n, is represented by data Da1(n), Da2(n), Da3(n) .... Dam(n). Each of the data units Da1, Da2, Da3...Dam in each of the sectors can represent any predetermined number of bytes. Then, and consistent with the above description of the present invention, when "pre-arranged" sectors are arranged, by a recording device during manufacture of a read-only disk or a hybrid disk, each of the even-numbered data units Da2, Da4, Da6 ..., etc., are "shifted" to a successively adjacent sector, as shown in Fig. 11, before each of the sectors is recorded on the read-only disk or on the read-only region of a hybrid disk. Of course, the shifting of the even-numbered data units Da2(n+1), Da4 (n+1) from the last original sector S_{n+1} creates a new sector S_{n+2} which also is recorded on the optical disk.

[0066] Fig. 12 illustrates the data structure of adjacent sectors in read-only areas of a disk when each of the data units Da1, Da2, etc., shown in Fig. 11 is comprised of 128 bytes of data. As previously discussed, there are 128 lines (i=3 to i=130 shown in Figs. 8-9) of non-parity data in a sector and 16 bytes of data per line. Hence, each data unit includes 8 lines of data. For example, data unit Da1 includes bytes D0 to D127 (lines i=123 to i=130), data unit Da2 includes bytes D128 to D255 (lines i=115 to i=122), ..., and data unit Dam includes bytes D1920 to D2047. When sectors S_{n-1}, S_n and S_{n+1} are arranged in the manner described above, bytes D128 to D255, bytes D384 to D511, ..., and bytes D1920 to D2047 are shifted in each sector to the succeeding sector, and the data shifted from the original last sector form a new sector, e.g., sector S_{n+2} (not shown in Fig. 12). Therefore, sector S_{n+1} stored on a read-only area of an optical disk includes data D0-127(n+1), D128-255(n), D256-383(n+1), D384-511(n), D512-639(n+1)... D1792-1919(n+1) and D1920-2047(n). Similarly, stored sectors S_{n-1} and S_n respectively include data from their own sector and the preceding sector as shown.

[0067] As described, sectors reproduced from a read-only optical disk or from a read-only area of a hybrid optical disk actually are produced from the data that is stored in two sectors adjacent one another on the optical disk. When a burst error occurs, it is possible that a relatively substantial amount of data in a particular sector cannot be reproduced. Generally, by means of performing error detection and error correction using the parity data contained in a sector, some or all of the unreproducable data can be restored. However, when sectors are arranged in accordance with the present invention, a burst error will affect approximately only half of the amount of data in a particular sector as would be affected if the sectors were not arranged as described. Since each arranged sector contains approximately half the amount of data as contained in that sector "rearranged" (or "pre-arranged"), because the other half of the data in the sector "belongs" to a different rearranged sector, the affect of a burst error on that sector is reduced substantially. Therefore, the need for error detection/correction is reduced; this however simply may be thought of as an increase in the error detection/correction capability. Furthermore, the improvement gained against burst errors does not increase the amount of error correction/detection data and does not require a substantial increase in processing time.

[0068] Figs. 13 - 15 are flow charts of the operation of controller 2 to record to and reproduce from a record medium, as carried out by the optical disk drive shown in Fig. 1. The process begins when loading mechanism 5 loads an optical disk 4 into the optical disk drive at instruction s1. Upon loading, various servo processes are carried out at instruction s2 including the driving of spindle motor 6, drive motor 10, galvano motor 11 and focus actuator 12. When the optical disk reaches synchronized speed, as discussed above, one of the control tracks CTL (Fig. 4) on optical disk 4 is reproduced at instruction s3 in order to identify the type of recording medium of optical disk 4, to identify the various address information including the locations of the writable regions if the optical disk is a hybrid disk, etc., and if it is determined, at inquiry s4, that the record medium is a read-only optical disk (i.e., a ROM), then the process proceeds to instruction s5 whereat a ROM flag is generated and stored in a memory in the optical disk drive (e.g., in RAM 63 shown in Fig. 7). On the other hand, if the record medium is not a read-only type memory, then it is determined at inquiry s7 whether the optical disk is a random access memory (RAM), that is, a writable optical disk such as a magneto-optical disk. If the optical disk is a RAM type device, then a RAM flag is generated and stored in memory at instruction s8. However, if the optical disk is not a RAM type device, then it is determined at inquiry s9 whether the optical disk is a hybrid (partial) disk which has both writable regions and read-

only regions. If the optical disk is a hybrid disk, then a "partial" flag is generated and stored in memory at instruction s10. On the other hand, if it is determined at inquiry s9 that the optical disk is not a hybrid disk, an error message is generated in CPU 60, supplied to host computer 3 and displayed to the user at instruction s11 and the process is terminated. An exemplary error message that may be displayed is "Disk Type Read Error. Please Insert the Disk Again or Use Another Disk."

[0069] Upon generating and storing one of the above flags pursuant to instructions S5, S8 or S10, the process proceeds to inquiry s6 whereat CPU 60 waits until it receives a disk access command. Upon receipt of a disk access command, the stored flag is read from the optical disk drive memory at instruction s12 (Fig. 14). If it is determined at inquiry s13 based on the reproduced flag that the optical disk is a read-only type record medium, the process proceeds to instruction s14 whereat two sectors are reproduced from the read-only type optical disk. If, however, a reproduced sector still resides in LDC/ECC decoder 67, only one sector need be reproduced from the optical disk. The two sectors (i.e., the two sectors that are reproduced or the single sector that is reproduced together with the sector still resident in the LDC/ECC decoder) are rearranged in the manner described above with reference to Figs. 11 and 12 and error corrected using the CRC parity data and long distance codes stored therein. It is noted that any dummy data stored in a sector is either ignored or removed by CPU 60. Upon completion of the reproduction process, as determined at inquiry s15, the process returns to inquiry s6.

[0070] However, if it is determined at inquiry s13, based on the reproduced flag, that the optical disk is not a read-only type record medium, inquiry s16 inquires whether the optical disk is a random-access type memory (e.g., a magneto-optical disk). If the optical disk is a random-access type memory, the process proceeds to instruction s17 whereat a sector either is recorded on optical disk 4 or reproduced from optical disk 4 depending on the instruction from host computer 3. During a recording operation, error detection/correction data is added to a sector prior to its being recorded on the optical disk. Conversely, during a reproducing operation, a reproduced sector is error corrected and supplied out. No "arranging" or "rearranging" of data in a sector is carried out when the optical disk is a type (i.e., writable) record medium. Furthermore, since there is no dummy data stored in a sector recorded on or reproduced from a writable record medium, no processing thereof is required. Upon completion of the above recording or reproducing of a sector to or from a writable record medium, as determined at inquiry s18, the process returns to inquiry s6.

[0071] If it is determined at inquiry s16, based on the reproduced flag, that the optical disk is not a random-access type memory, the process proceeds to inquiry s19 (Fig. 15) where it is determined whether the optical disk is a partial (or hybrid) type memory which has both writable regions and read-only regions, and if so, it is determined at inquiry s20 whether the sector to be accessed is located in a read-only region of the optical disk. If the sector on the disk to be accessed is in a read-only region, the process proceeds to instruction s14 whereat that region is reproduced in a manner similar to that described above with respect to the reproduction of a sector from a read-only type optical disk.

[0072] If the sector on the disk to be accessed is not in a read-only region, then it is determined at inquiry s21 whether the sector to be accessed is located in a random-access (writable) region of the optical disk. If the sector on the disk to be accessed is in the writable RAM region, the process proceeds to instruction s17 whereat data is either recorded on or reproduced from that region in a manner similar to that described above with respect to the recording and reproduction of data to and from a random-access type record medium. However, if it is determined at inquiry s21 that the sector to be accessed is not located in a random-access (writable) region of the optical disk, the process proceeds to instruction s11 whereat the error message is generated and displayed to the user. Furthermore, if it is determined that the optical disk is not a partial (or hybrid) type memory at inquiry S19, the error message is generated and displayed at instruction s11.

[0073] In another embodiment of the present invention, LDC/ECC decoder 67 shown in Fig. 7 stores in its RAM 67 data contained in two reproduced sectors in a particular manner which incorporates the rearranging process previously discussed. Here, when data of two sectors, for example, sector S_{n-2} and sector S_{n-1} (shown in Fig. 11), are reproduced from a read-only optical disk or from a read-only area of a hybrid optical disk, the data corresponding to (rearranged) sector S_{n-2} which is contained in reproduced sector S_{n-2}, for example, data Da1(n-2), Da3(n-2), etc., is stored at a location corresponding to a first sector in RAM 67a. In addition, data corresponding to rearranged sector S_{n-2} which is contained in reproduced sector S_{n-1}, for example, data Da2(n-2), Da4(n-2), etc., is stored at a location also corresponding to the first sector in RAM 67a , and data corresponding to rearranged sector S_{n-1} which is contained in reproduced sector S_{n-1}, for example, data Da1(n-1), Da3(n-1), etc., is stored at a location corresponding to a second sector in RAM 67a.

[0074] In this embodiment, the two sectors stored in RAM 67a do not undergo a rearranging or shifting process per se, and instead, such shifting of data already is accomplished by directing the reproduced data of each sector to the appropriate address in RAM 67a. Error detection and error correction then is performed in the same manner as previously discussed. Of course, when the next sector S_n is reproduced, the data corresponding to rearranged sector S_{n-1} which is contained in reproduced sector S_n, e.g., data Da2(n-1), Da4(n-1), etc., is stored at a location corresponding to the second sec-

tor in RAM 67a and data corresponding to rearranged sector S_n which is contained in reproduced sector S_n, e.g., data Da1(n), Da3(n), etc., is stored at a location corresponding to the "first" or other sector in RAM 67a. Hence, data of each reproduced sector is stored in alternating locations of RAM 67a so that a formal shifting of data already stored therein is unnecessary.

[0075] In a further embodiment of the present invention, Fig. 16 illustrates the data structure of adjacent sectors stored in a read-only optical disk or in a read-only area of an optical disk wherein the data in the undefined regions of each sector also are moved or shifted to an adjacent sector. As shown, a particular sector, for example, sector S_n, includes data Da1(n), Da3(n), Da5 (n)...Dam(n) and LDC(n) that originally was included in that sector (i.e., the pre-arranged sector S_n), and includes data Da2(n-1), Da4(n-1)...Dam-1(n-1) and UD (n-1) that originally was included in the preceding sector (i.e., the pre-arranged sector S_{n-1}). Hence, parity data (e.g., CRC1 - CRC8) pertaining to a particular sector S_n still is reproducible when a burst error causes the undefined region of sector S_n, which actually contains the undefined region for section S_{n-1}, to become unreproducable. In addition, data in the undefined region UD(n-2) in sector S_{n-1} can contain data that identifies this sector as a first one of the arranged sectors in a group, as previously discussed.

[0076] Fig. 17 illustrates the data structure of adjacent sectors in read-only areas of a disk in accordance with another embodiment of the present invention in which each of the data units Da1, Da2, etc., (see Fig. 11) is comprised of 7 lines (Figs. 8-9) or 112 bytes of data. As shown, data unit Da1 in each sector includes bytes D0 to D111 (lines i=124 to i=130), data unit Da2 includes bytes D112 to D223 (lines i=117 to i=123), ..., data unit Dam-1 includes bytes D1904 to D2015 (lines i=5 to i=11), and data unit Dam includes the remaining data bytes D2016 to D2047 (lines i=3 and i=4). Furthermore, when sectors S_{n-1}, S_n and S_{n+1} are arranged in the manner described above, bytes D112 to D223, bytes D336 to D477, ..., and bytes D2016 to D2047 are shifted in each sector to the succeeding sector, and the data shifted from the original last sector, e.g., sector S_{n+1}, form a new sector S_{n+2} (not shown in Fig. 12). Therefore, sector S_{n+1} stores on a read-only area of an optical disk bytes D0-111(n+1), D112-223(n), D224-335(n+1), D336-447(n), D448-559(n+1)... D1904-2015(n+1) and D2016-2047(n), as well as UD(n+1) and LDC(n+1). Each of stored sectors S_{n-1} and S_n similarly includes data from its own sector and the preceding sector as shown.

[0077] In still another embodiment of the present invention, each of the sectors having the data structure shown in Fig. 17 may have its respective undefined regions moved or shifted to the succeeding sector. Such sectors have the data structure shown in Fig. 16 except each data unit is comprised of 7 lines or 112 bytes of data. In this instance, a sector S_n includes data D0 to D111(n), D112 to D223(n-1)...D2016 to D2047(n-1), and further includes data in an undefined region UD(n-1) from the preceding sector S_{n-1}, as well as the long distance code LDC(n) from sector S_n. Hence, parity data (e.g., CRC1 - CRC8) pertaining to a particular sector S_n still is reproducible when a burst error causes the undefined region of sector S_n, which actually contains the undefined region for sector S_{n-1}, to become unreproducable. Similarly, the other sectors, e.g., sectors S_{n-1} and S_{n+1} each includes data in the undefined region from the respective preceding sector S_{n-2} and S_n. Of course, if sector S_{n-1} is the first sector in the group, dummy data or identification data may be included in the undefined region UD(n-2) in sector S_{n-1}.

[0078] Fig. 18 illustrates the data structure of adjacent sectors stored in a read-only area of an optical disk in accordance with another embodiment of the present invention. As previously discussed, two sectors are reproduced from the optical disk and stored in RAM 67a in LDC/ECC decoder 67 (shown in Fig. 7). In this embodiment, two "rearranged" or original sectors (as opposed to one sector in the above embodiments) can be produced from only the two "arranged" sectors stored in RAM 67a, as described below. As shown in Fig. 18, the sectors stored on an optical disk are "paired" together wherein each pair of sectors is comprised of an odd-numbered sector and an even-numbered sector, and the respective odd and even-numbered sectors in each pair contain data of both thereof. That is, odd-numbered sector S_{2n-1} includes data that originally was included in that sector, e.g., data Da1(2n-1), Da3(2n-1), Da5(2n-1)...Dam(2n-1), UD(2n-1) and LDC(2n-1), and data originally included in the even-numbered sector of the pair, e.g., data Da2(2n), Da4(2n)...Dam-1(2n). Similarly, odd-numbered sector S_{2n+1} includes data that originally was included in that sector, e.g., data Da1(2n+1), Da3 (2n+1), Da5(2n+1)...Dam(2n+1), UD(2n+1) and LDC (2n+1), and data originally included in the odd-numbered sector of the pair, e.g., data Da2(2n+2), Da4 (2n+2)...Dam-1(2n+2).

[0079] Hence, LDC/ECC decoder 67 produces two rearranged sectors by swapping the appropriate data in one sector stored in RAM 67a with data in the other sector stored in RAM 67a. In addition, since no "new" sectors are created when the sectors are arranged (during, for example, manufacture of the optical disk) and since there are no gaps created in the first sector upon arranging thereof, there is no need to add dummy data to any of the arranged sectors.

[0080] Fig. 19 illustrates the data structure of paired sectors (Fig. 18) in a read-only area of a disk in accordance with another embodiment of the present invention in which each of the data units Da1, Da2, etc., of each sector in the pair is comprised of 8 lines (see Figs. 8-9) or 128 bytes of data. As shown, data unit Da1 in each sector (e.g., sector S_{2n-1} or sector S_{2n}) includes bytes D0 to D127 (lines i=123 to i=130), data unit Da2 includes bytes D128 to D255 (lines i=115 to i=122), etc. Each of

the paired sectors S_{2n-1} and S_{2n} is arranged in the manner described above with reference to Fig. 18, and thus, bytes D128 to D255, bytes D384 to D511, etc., in each sector are moved to the other sector in the pair. Therefore, sector S_{2n-1} stored on a read-only area of an optical disk includes data D0-127(2n-1), D128-255(2n)... D1920-2047(2n), UD(2n-1) and LDC(2n-1). Stored sector S_{2n} includes the other data of sectors S_{2n-1} and S_{2n}. Alternatively, the undefined region (e.g., UD(2n-1), UD (2n)) of each sector is located in the other sector in the pair in a manner similar to that shown in Fig. 16.

[0081] Fig. 20 illustrates the data structure of paired sectors (Fig. 18) in a read-only area of a disk in accordance with a further embodiment of the present invention in which each of the data units Da1, Da2, etc., is comprised of 7 lines (Figs. 8-9) or 112 bytes of data. As shown, data unit Da1 in each sector includes bytes D0 to D111 (lines i=124 to i=130), data unit Da2 includes bytes D112 to D223 (lines i=117 to i=123), etc. Each of the paired sectors S_{2n-1} and S_{2n} is arranged in the manner described above with reference to Fig. 18, and thus, bytes D112 to D223, bytes D336 to D477, etc., in each sector are moved to the other sector in the pair. Therefore, sector S_{2n-1} stored on a read-only area of an optical disk includes data D0-111(2n-1), D112-223(2n), D224-335(2n-1), D336-447(2n),...D2016-2047(2n), UD (2n-1) and LDC(2n-1). Stored sector S_{2n} includes the other data of the sectors S_{2n-1} and S_{2n}. Alternatively, the undefined region (e.g., UD(2n-1), UD(2n)) of each sector is located in the other sector in the pair in a manner similar to that shown in Fig. 16.

[0082] In yet another embodiment of the present invention, each sector stored on the optical disk is comprised of data units which contain different numbers of lines of data (i.e,. different numbers of bytes of data). For example, data units Da1, Da2, Da3 ...Dam shown in Fig. 11 or shown in Fig. 18 may include 7 lines of data, 8 lines of data, 7 lines of data, ..., 8 lines of data, respectively. The number of lines in each data unit may alternate between 7 and 8 lines of data or alternate between other numbers of lines of data.

[0083] While the present invention has been particularly shown and described in conjunction with preferred embodiments thereof, it will be readily appreciated by those of ordinary skill in the art that various changes may be made without departing from the spirit and scope of the invention.

Claims

1. A method of recording data elements each having a plurality of sequentially numbered information data units (Da_{ij}; i=1, ..., m; j=n-2, ... n+2) consisting of a plurality of odd-numbered and a plurality of even-numbered information data units on a record medium (4) comprising the steps of

   - successively receiving data elements (S_j; j=n-2, ..., n+2),
   - adding error detection and error correction data (LDC) derived from the information data units (Da_{ij}) of the respective data element (S_j)
   - recording said data elements on said record medium (4),

   characterised in that

   - either each of the plurality of odd-numbered or each of the plurality of even-numbered information data units (Da_{ij}) of the succession of information data units in a respective one of said data elements (S_j) are transferred to one other different data element (S_j) and this transfer is repeated within at least one predetermined group (S_{n-2}, ..., S_{n+2}) of data elements (S_j) of all received data elements (S_j) such that the transferred information data units of the one data element replace the transferred information data units in said other data element (S_j), thus forming arranged data elements (S_j) each having newly arranged information data units (Da_{ij}), wherein identification data in data elements indicate a head data element (S_{n-2}) of said group and a last data element (S_{n+2}) of said group (S_{n-2}, ..., S_{n+2}) and wherein each of said arranged data elements (S_j) is recorded in a respective different region of said record medium (4).

2. The method of claim 1, wherein each arranged data element (S_j) is formed of information data units (Da_{ij}) derived from two received data elements (S_j).

3. The method of anyone of claims 1 to 2, wherein said transferred information data units (Da_{ij}) in a respective data element (S_j) are transferred to a respectively adjacent data element (S_j).

4. The method of anyone of claims 1 to 3, wherein said last data element (S_{n-2}) is a new data element which includes only information data units (Da_{ij}) received from one other, different data element (S_j).

5. The method of claim 4, further comprising the step of adding dummy data to locations in said new data element which do not receive information data units (Da_{ij}).

6. The method of claim 4 or 5, further comprising the step of adding identification data to said new data element for identifying the new data element as said last data element (S_{n-2}) of said group (S_{n-2},..., S_{n+2}).

7. A method of recording data elements each having

a plurality of sequentially numbered information data units (Da_{ij}; i=1, ..., m; j= 2n-1, ..., 2n+2) consisting of a plurality of odd-numbered and a plurality of even-numbered information data units on a record medium (4) comprising the steps of

- successively receiving data elements (S_j; $j=2_{n-1}$, ..., 2_{n+2})
- adding error detection and error correction data (LDC) derived from the information data units (Da_{ij}) of the respective data element (S_j),
- recording said data elements on said record medium (4),

characterised in that

- said data elements (S_j) are received in pairs, each pair including an odd-numbered data element (S_{2n-1}; S_{2n+1}) and an even-numbered data element (S_{2n}; S_{2n+2}), wherein either each of the plurality of odd-numbered or each of the plurality of even-numbered information data units of the succession of information data units in one of said data elements is transferred by swapping said information data units to the other data element of said pair, and this transfer is repeated for each of said pairs, thus forming arranged data elements each having newly arranged information data units, wherein each of said arranged data elements (S_j)is recorded in a respective different region of said record medium (4)

8. The method of claim 7, wherein said error detection and error correction data (LDC) in a respective data element (S_j) are not transferred, such that said error detection and error correction data (LDC) in each of said arranged data elements (S_j) are derived from the information data units (Da_{ij}) that had been transferred as well as from the data that remained in said data element (S_j).

9. The method of anyone of claims 7 to 8, wherein approximately half of the error detection and error correction data (LDC) in said respective data element (S_j) are transferred to said other, different data element (S_j).

10. The method of claim 9, wherein said error detection and error correction data (LDC) includes cyclic redundancy code data and Reed-Solomon codes, and the transferred error detection and error correction data (LDC) comprises only said cyclic redundancy code data.

11. The method of anyone of claims land 10, wherein said record medium (4) includes a read-only area having a plurality of regions; and wherein each of the arranged data elements (S_j) is recorded in a respectively different region of the read-only area of said record medium (4).

12. A method of reproducing successive data elements recorded as arranged data elements on a record medium (4),
comprising the steps of:

successively reproducing data elements (S_j, j=n-2,..., n+2) from said record medium (4), each of said reproduced data element (S_j) having a plurality of sequentially numbered information data units (Da_{ij}, i=1,..., m; j=n-2,..., n+1) consisting of a plurality of odd-numbered and a plurality of even-numbered information data units and error detection and error correction data (LDC),
detecting and correcting errors of information data units (Da_{ij}) in each of said data elements (S_j) in accordance with said error detection and error correction data (LDC),

characterized by the steps of:

detecting identification data in said data elements (S_j) which identification data indicate a head data element (S_{n-2}) of at least one predetermined group (S_{n-2},...,S_{n+2}) of data elements (S_j) for all said received data elements (S_j) and a last data element (S_{n+2}) of said group (S_{n-2},..., S_{n+2}),
reversibly transferring either each of the plurality of odd-numbered or each of the plurality of even-numbered information data units (Da_{ij}) of the succession of information data units in a respective one of said data elements (S_j) to one other, different data element (S_j) and repeating this transfer within said group (S_{n-2}+,...,+S_{n+2}), thus forming rearranged data elements (S_j) each having newly arranged information data units (Da_{ij}),
detecting and correcting errors of information data units (Da_{ij}) in each of said rearranged data elements in accordance with said error detection and error correction data (LDC) in said rearranged data element (S_j) and
supplying the error corrected rearranged data elements (S_j) as unarranged data elements (S_j).

13. The method of claim 12, wherein said information data units Da_{ij}) in said respective arranged data element (S_j) are transferred to corresponding locations in said different arranged data elements (S_j) to produce said rearranged data elements (S_j).

14. The method of claim 12 or 13, wherein each rear-

ranged data element (S_j) is formed of information data units (Da_{ij}) derived from two arranged data elements (S_j).

15. The method of anyone of claims 12 to 14, wherein said information data units (Da_{ij}) in a respective arranged data element (S_j) are transferred to a respectively adjacent arranged data element (S_j).

16. The method of anyone of claims 12 to 15, wherein said last data element (S_{n-2}) is a new data element which includes only information data units (Da_{ij}) received from one other, different data element (S_j); and wherein for producing rearranged data elements (S_j) the information data units (Da_{ij}) in said new data element are transferred to said different data element (S_j).

17. The method of claim 16, wherein said new data element includes dummy data at locations which have not received information data units (Da_{ij}); and further comprising the step of removing the dummy data from said new data element so that only rearranged data elements (S_j) are produced from said group ($S_{n-2},...,S_{n+2}$).

18. The method of anyone of claims 12 to 15, wherein the data elements (S_j) reproduced from the record medium (4) are comprised of pairs of arranged data elements (S_j) each pair including an odd-numbered arranged data element and an even-numbered arranged data element; and the step of reversibly transferring some but not all information data units (Da_{ij}) is carried out by swapping said information data units (Da_{ij}) in the respective odd-numbered and even-numbered arranged data elements (S_j) in each said pair of arranged data elements (S_j).

19. The method of anyone of claims 12 to 18, wherein each of the reproduced arranged data elements (S_j) is comprised of a succession of data units; and wherein alternate data units in a respective arranged data element (S_j) are transferred to said different arranged data element (S_j).

20. The method of claim 19, wherein each alternate data unit in a respective arranged data element (S_j) is transferred to a corresponding location in said different arranged data element (S_j).

21. The method of anyone of claims 12 to 20, wherein said error detection and error correction data (LDC) in a respective arranged data element (S_j) are not transferred, such that said error detection and error correction data (LDC) in each of said arranged data elements (S_j) are derived from the data that had been transferred as well as from the information data units (Da_{ij}) that remained in that arranged data element (S_j).

22. The method of anyone of claims 12 to 20, wherein approximately half of said error detection and error correction data (LDC) in said respective arranged data element (S_j) are transferred to said other, different data element (S_j).

23. The method of claim 22, wherein said error detection and error correction data (LDC) includes cyclic redundancy code data and Reed-Solomon codes, and the transferred error detection and error correction data (LDC) comprises only said cyclic redundancy code data.

24. The method of claim 15, wherein said record medium (4) includes a plurality of sectors; and wherein each of the arranged data elements (S_j) is reproduced from a different sector on said record medium (4).

25. The method of claim 12, further comprising the steps of

identifying in each of the reproduced arranged data elements (S_j) information data (Da_{ij}) therein which is associated with a single rearranged data element (S_j), said rearranged data element (S_j) containing information data units (Da_{ij}) derived from both reproduced arranged data elements (S_j);

storing in a memory data included in a reproduced arranged data element (S_j) which has been identified as being associated with said single rearranged data element (S_j) and generating therefrom said single rearranged data element (S_j); and

supplying the error corrected single rearranged data element (S_j) as an output.

26. The method of anyone of claims 12 to 24, further comprising the steps of

identifying the record medium (4) as a read-only record medium, a writable record medium or a hybrid record medium, the latter having both read-only and writable regions;

identifying the read-only regions and the writable regions of said record medium (4) when said record medium (4) is identified as a hybrid record medium;

transferring some but not all information data units (Da_{ij}) in a reproduced arranged data element (S_j) to a different arranged data element (S_j) to produce rearranged data elements (S_j) when said data elements (S_j) are reproduced from said read-only region;

providing each of said arranged data elements (S_j) as said rearranged data elements (S_j) when said data elements (S_j) are reproduced from said writable region.

27. A record medium (4) having recorded thereon successive data, the record medium (4) comprising a plurality of sectors (S_j, j=n-2,..., n+2) having stored therein sequentially numbered information data units (Da_{ij}, i=1,..., m; j=n-2,..., n+1) consisting of a plurality of odd-numbered and a plurality of even-numbered information data units and error detection and error correction data (LDC) derived from the information data units (Da_{ij}, i=1,..., m; j=n-2,..., n+1),

characterized in that

within at least one predetermined group (S_{n-2},...,S_{n+2}) of sectors (S_j) either each of the plurality of odd-numbered or each of the plurality of even-numbered information data units (Da_{ij}) of the succession of information data units in a respective one of said sector is transferred to one other, different sector (S_j), thus forming rearranged sectors (S_j) each having newly arranged information data units (Da_{ij}), wherein

identification data in said sectors (S_j) indicate a head sector (S_{n-2}) of said group (S_{n-2},...,S_{n+2}) and a last sector (S_{n+2}) of said group (S_{n-2},..,S_{n+2}).

28. The record medium of claim 27, wherein said last sector (S_{n+2}) includes only information data units (Da_{ij}) received from one other, different data sector (S_j); and locations in said the last sector (S_{n+2}) which have not received information data units (Da_{ij}) include dummy data.

29. The record medium of claim 27, wherein each pair of adjacent sectors (S_j) comprises an odd-numbered sector (S_j) and an even-numbered sector (S_j); and information data units (Da_{ij}) in each of the odd-numbered and even-numbered sectors (S_j) include information data units (Da_{ij}) derived from both the odd-numbered and the even-numbered sector in said pair.

30. The record medium of claim 27 or 28, having a read-only area at which said information data units (Da_{ij}) are stored, said read-only area including a plurality of sectors (S_j) each sector (S_j) having stored therein said information data units (Da, UD) and said error detection and error correction data (LDC), wherein each of said sector (S_j) comprises a first group of information data units (Da_{ij}) and a second group of information data units (Da_{ij}) and wherein said error detection and error correction data (LDC) in each respective sector (S_j) are derived from the data of one of said groups in this sector (S_j) and from the information data units (Da_{ij}) of the respective other of said groups in a respective distinct other, different sector (S_j).

31. The record medium of claim 30, wherein said information data units (Da_{ij}) in said other sector are derived from an adjacent sector on said record medium (4).

Patentansprüche

1. Verfahren zur Aufzeichnung von Datenelementen, die jeweils eine Vielzahl von sequentiell nummerierten Informationsdateneinheiten (Da_{ij}; i=1, ...,m; j=n-2, ...n+2) aufweisen, bestehend aus einer Vielzahl von ungeradzahligen und einer Vielzahl von geradzahligen Informationsdateneinheiten auf einem Aufzeichnungsträger (4),
umfassend die Schritte

- aufeinanderfolgendes Empfangen von Datenelementen (S_j; j=n-2,...,n+2),
- Hinzufügen von Fehlerdetektier- und Fehlerkorrekturdaten (LDC), die aus den Informationsdateneinheiten (Da_{ij}) des jeweiligen Datenelements (S_j) abgeleitet sind,
- Aufzeichnen der betreffenden Datenelemente auf dem genannten Aufzeichnungsträger (4),

dadurch gekennzeichnet,

- **dass** entweder jede der Vielzahl von ungeradzahligen oder jede der Vielzahl von geradzahligen Informationsdateneinheiten (Da_{ij}) der Folge von Informationsdateneinheiten in einem entsprechenden Datenelement der genannten Datenelemente (S_j) zu einem anderen unterschiedlichen Datenelement (S_j) übertragen wird und dass diese Übertragung innerhalb zumindest einer bestimmten Gruppe (S_{n-2}, ... , S_{n+2}) von Datenelementen (S_j) sämtlicher empfangener Datenelemente (S_j) derart wiederholt wird, dass die übertragenen Informationsdateneinheiten des einen Datenelements die übertragenen Informationsdateneinheiten in dem anderen Datenelement (S_j) ersetzen, womit geordnete Datenelemente (S_j) gebildet werden, deren jedes neu geordnete Informationsdateneinheiten (Da_{ij}) aufweist,

wobei Identifikationsdaten in Datenelementen ein Kopfdatenelement (S_{n-2}) der betreffenden Gruppe und ein letztes Datenelement (S_{n+2}) der betreffenden Gruppe (S_{n-2},..., S_{n+2}) anzeigen
und wobei jedes der genannten geordneten Datenelemente (S_j) in einem entsprechenden unterschiedlichen Bereich des genannten Aufzeichnungsträgers (4) aufgezeichnet wird.

2. Verfahren nach Anspruch 1, wobei jedes geordnete Datenelement (S_j) aus Informationsdateneinheiten (Da_{ij}) gebildet wird, die aus zwei empfangenen Datenelementen (S_j) abgeleitet sind.

3. Verfahren nach Anspruch 1 oder 2, wobei die genannten übertragenen Informationsdateneinheiten (Da_{ij}) in einem entsprechenden Datenelement (S_j) zu einem entsprechenden benachbarten Datenelement (S_j) übertragen werden.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei das genannte letzte Datenelement (S_{n-2}) ein neues Datenelement ist, welches lediglich Informationsdateneinheiten (Da_{ij}) enthält, die von einem anderen unterschiedlichen Datenelement (S_j) empfangen sind.

5. Verfahren nach Anspruch 4, ferner umfassend den Schritt der Hinzufügung von Blinddaten an Stellen in dem genannten neuen Datenelement, die keine Informationsdateneinheiten (Da_{ij}) erhalten.

6. Verfahren nach Anspruch 4 oder 5, ferner umfassend den Schritt der Hinzufügung von Identifikationsdaten zu dem genannten neuen Datenelement zur Identifizierung des neuen Datenelements als das genannte letzte Datenelement (S_{n-2}) der betreffenden Gruppe (S_{n-2}, ...,S_{n+2}).

7. Verfahren zur Aufzeichnung von Datenelementen, die jeweils eine Vielzahl von sequentiell nummerierten Informationsdateneinheiten (Da_{ij}; i=1,...,m; j=2n-1,...,2n+2) aufweisen, bestehend aus einer Vielzahl von ungeradzahligen und einer Vielzahl von geradzahligen Informationsdateneinheiten auf einem Aufzeichnungsträger (4), umfassend die Schritte

- aufeinanderfolgendes Empfangen von Datenelementen (S_j; j=2_{n-1}, ...,2_{n+2}),
- Hinzufügen von Fehlerdetektier- und Fehlerkorrekturdaten (LDC), die aus den Informationdateneinheiten (Da_{ij}) des betreffenden Datenelements (S_j) abgeleitet sind,
- Aufzeichnen der genannten Datenelemente auf dem betreffenden Aufzeichnungsträger (4),

dadurch gekennzeichnet,

- **dass** die genannten Datenelemente paarweise empfangen werden, dass jedes Paar ein ungeradzahliges Datenelement (S_{2n-1}; S_{2n+1}) und ein geradzahliges Datenelement (S_{2n}; S_{2n+2}) enthält, wobei entweder jede der Vielzahl von ungeradzahligen oder jede der Vielzahl von geradzahligen Informationsdateneinheiten der Folge von Informationsdateneinheiten in einem der genannten Datenelemente durch Austauschen der betreffenden Informationsdateneinheiten mit dem anderen Datenelement des genannten Paares übertragen wird

und wobei diese Übertragung für jedes Paar der genannten Paare wiederholt wird, derart, dass so geordnete Datenelemente gebildet werden, die jeweils neu geordnete Informationsdateneinheiten aufweisen, wobei jedes der betreffenden geordneten Datenelemente (S_j) in einem entsprechenden unterschiedlichen Bereich des genannten Aufzeichnungsträgers (4) aufgezeichnet wird.

8. Verfahren nach Anspruch 7, wobei die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in einem entsprechenden Datenelement (S_j) nicht übertragen werden, derart, dass die betreffenden Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in jedem der genannten geordneten Datenelemente (S_j) aus den Informationsdateneinheiten (Da_{ij}) abgeleitet werden, die übertragen worden sind, sowie aus den Daten, die in dem genannten Datenelement (S_j) verblieben sind.

9. Verfahren nach einem der Ansprüche 7 bis 8, wobei etwa die Hälfte der Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in dem jeweiligen Datenelement (S_j) zu dem genannten anderen unterschiedlichen Datenelement (S_j) übertragen wird.

10. Verfahren nach Anspruch 9, wobei die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) zyklische Redundanzcodedaten und Reed-Solomon-Codes enthalten und wobei die übertragenen Fehlerdetektier- und Fehlerkorrekturdaten (LDC) lediglich die genannten zyklischen Redundanzcodedaten umfassen.

11. Verfahren nach einem der Ansprüche 1 und 10, wobei der genannte Aufzeichnungsträger (4) einen Festwertspeicherbereich enthält, der eine Vielzahl von Bereichen aufweist, und wobei jedes der geordneten Datenelemente (S_j) in einem entsprechenden unterschiedlichen Bereich des Festwertspeicherbereichs des genannten Aufzeichnungsträgers (4) aufgezeichnet wird.

12. Verfahren zur Wiedergabe von aufeinanderfolgenden Datenelementen, die als geordnete Datenelemente auf einem Aufzeichnungsträger (4) aufgezeichnet sind, umfassend die Schritte: aufeinanderfolgendes Wiedergeben von Datenelementen (S_j, j=n-2,...,n+2) von dem genannten Aufzeichnungsträger (4), wobei jedes genannte wiedergegebene Datenelement (S_j) eine Vielzahl von sequentiell nummerierten Informationsdateneinheiten (Da_{ij}, i=1,...,m; j=n-2,...,n+1) aufweist, bestehend aus einer Vielzahl von ungeradzahligen und einer Vielzahl von geradzahligen Informationsdateneinheiten und Fehlerdetektier- und Fehlerkorrekturdaten (LDC),
Ermitteln und Korrigieren von Fehlern der Informa-

tionsdateneinheiten (Da_{ij}) in jedem der genannten Datenelemente (Sj) entsprechend den genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC), **gekennzeichnet durch** die Schritte:

Ermitteln von Identifikationsdaten in den genannten Datenelementen (S_j), wobei die betreffenden Identifikationsdaten ein Kopfdatenelement (S_{n-2}) zumindest einer bestimmten Gruppe (S_{n-2},...,S_{n+2}) von Datenelementen (S_j) für sämtliche der genannten empfangenen Datenelemente (S_j) und ein letztes Datenelement (S_{n+2}) der betreffenden Gruppe (S_{n-2},...,S_{n+2}) anzeigen, reversibles Übertragen entweder jede der Vielzahl von ungeradzahligen oder jede der Vielzahl von geradzahligen Informationsdateneinheiten (Da_{ij}) der Folge von Informationsdateneinheiten in einem entsprechenden Element der genannten Datenelemente (S_j) zu einem anderen unterschiedlichen Datenelement (S_j) und Wiederholen dieser Übertragung innerhalb der genannten Gruppe (S_{n-2}+,..., +S_{n+2}), derart, dass so neu geordnete Datenelemente (S_j) gebildet werden, die jeweils neu geordnete Informationsdateneinheiten (Da_{ij}) aufweisen,
Ermitteln und Korrigieren von Fehlern der Informationsdateneinheiten (Da_{ij}) in jedem der betreffenden neu geordneten Datenelemente entsprechend den genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in dem genannten neu geordneten Datenelement (S_j) und
Lieferung der fehlerkorrigierten neu geordneten Datenelemente (S_j) als ungeordnete Datenelemente (S_j).

13. Verfahren nach Anspruch 12, wobei die genannten Informationsdateneinheiten (Da_{ij}) in dem genannten jeweiligen geordneten Datenelement (S_j) zu entsprechenden Stellen in den genannten unterschiedlichen geordneten Datenelementen (S_j) übertragen werden, um die genannten neu geordneten Datenelemente (S_j) zu erzeugen.

14. Verfahren nach Anspruch 12 oder 13, wobei jedes neu geordnete Datenelement (S_j) aus Informationsdateneinheiten (Da_{ij}) gebildet wird, die aus zwei geordneten Datenelementen (S_j) abgeleitet werden.

15. Verfahren nach einem der Ansprüche 12 bis 14, wobei die genannten Informationsdateneinheiten (Da_{ij}) in einem entsprechenden geordneten Datenelement (S_j) zu einem entsprechenden benachbarten geordneten Datenelement (S_j) übertragen werden.

16. Verfahren nach einem der Ansprüche 12 bis 15, wobei das genannte letzte Datenelement (S_{n-2}) ein neues Datenelement ist, welches lediglich Informationsdateneinheiten (Da_{ij}) enthält, die von einem anderen, unterschiedlichen Datenelement (S_j) erhalten sind,
und wobei zur Erzeugung von neu geordneten Datenelementen (S_j) die Informationsdateneinheiten (Da_{ij}) in dem genannten neuen Datenelement zu dem genannten unterschiedlichen Datenelement (S_j) übertragen werden.

17. Verfahren nach Anspruch 16, wobei das genannte neue Datenelement Blinddaten an Stellen enthält, die keine Informationsdateneinheiten (Da_{ij}) erhalten haben,
und ferner umfassend den Schritt der Beseitigung der Blinddaten aus dem neuen Datenelement, derart, dass lediglich neu geordnete Datenelemente (S_j) aus der genannten Gruppe (S_{n-2},...,S_{n+2}) erzeugt werden.

18. Verfahren nach einem der Ansprüche 12 bis 15, wobei die von dem Aufzeichnungsträger (4) wiedergegebenen Datenelemente (S_j) Paare von geordneten Datenelementen (S_j) umfassen, wobei jedes Paar ein ungeradzahliges geordnetes Datenelement und ein geradzahliges geordnetes Datenelement enthält,
und wobei der Schritt der reversiblen Übertragung einiger, jedoch nicht sämtlicher Informationsdateneinheiten (Da_{ij}) dadurch ausgeführt wird, dass die genannten Informationsdateneinheiten (Da_{ij}) in den entsprechenden ungeradzahligen und geradzahligen geordneten Datenelementen (S_j) in jedem Paar der geordneten Datenelemente (S_j) ausgetauscht werden.

19. Verfahren nach einem der Ansprüche 12 bis 18, wobei jedes der wiedergegebenen geordneten Datenelemente (S_j) aus einer Folge von Dateneinheiten besteht und wobei abwechselnde Dateneinheiten in einem entsprechenden geordneten Datenelement (S_j) zu dem anderen geordneten Datenelement (S_j) übertragen werden.

20. Verfahren nach Anspruch 19, wobei jede abwechselnde Dateneinheit in einem jeweiligen geordneten Datenelement (S_j) zu einer entsprechenden Stelle in dem genannten anderen geordneten Datenelement (S_j) übertragen wird.

21. Verfahren nach einem der Ansprüche 12 bis 20, wobei die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in einem geordneten Datenelement (S_j) nicht übertragen werden, derart, dass die betreffenden Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in jedem der betreffenden geordneten Datenelemente (S_j) aus den Daten abgeleitet werden, die übertragen worden sind, sowie aus den In-

formationsdateneinheiten (Da_{ij}), die in dem betreffenden geordneten Datenelement (S_j) verblieben sind.

22. Verfahren nach einem der Ansprüche 12 bis 20, wobei etwa die Hälfte der genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) in dem genannten geordneten Datenelement (S_j) zu dem anderen, unterschiedlichen Datenelement (S_j) übertragen wird.

23. Verfahren nach Anspruch 22, wobei die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) zyklische Redundanzcodedaten und Reed-Solomon-Codes enthalten und wobei die übertragenen Fehlerdetektier- und Fehlerkorrekturdaten (LDC) lediglich die genannten zyklischen Redundanzcodedaten umfassen.

24. Verfahren nach Anspruch 15, wobei der genannte Aufzeichnungsträger (4) eine Vielzahl von Sektoren aufweist und wobei jedes der geordneten Datenelemente (S_j) aus einem anderen bzw. unterschiedlichen Sektor auf dem genannten Aufzeichnungsträger (4) wiedergegeben wird.

25. Verfahren nach Anspruch 12, ferner umfassend die Schritte: Identifizieren in jedem der wiedergegebenen geordneten Datenelemente (S_j) Informationsdaten (Da_{ij}), die einem einzelnen neu geordneten Datenelement (S_j) zugeordnet sind,
wobei das betreffende neu geordnete Datenelement (S_j) Informationsdateneinheiten (Da_{ij}) enthält, die aus beiden wiedergegebenen geordneten Datenelementen (S_j) abgeleitet sind, Speichern von Daten in einem Speicher, die in einem wiedergegebenen geordneten Datenelement (S_j) enthalten sind, welches als dem genannten einzelnen neu geordneten Datenelement (S_j) zugeordnet identifiziert worden ist, und Erzeugen daraus das betreffende einzelne neu geordnete Datenelement (S_j),
und Liefern des fehlerkorrigierten einzelnen neu geordneten Datenelements (S_j) als Ausgangssignal.

26. Verfahren nach einem der Ansprüche 12 bis 24, ferner umfassend die Schritte:

Identifizieren des Aufzeichnungsträgers (4) als Festwertspeichermedium, als beschreibbares Aufzeichnungsmedium oder als hybrides Aufzeichnungsmedium, wobei letzteres sowohl Festwertspeicherbereiche als auch beschreibbare Bereiche aufweist, Identifizieren der Festwertspeicherbereiche und der beschreibbaren Bereiche des genannten Aufzeichnungsträgers (4), wenn der betreffende Aufzeichnungsträger (4) als hybrides Aufzeichnungsmedium identifiziert ist,
Übertragen von einigen, nicht jedoch sämtlichen Informationsdateneinheiten (Da_{ij}) in einem wiedergegebenen geordneten Datenelement (S_j) zu einem unterschiedlichen geordneten Datenelement (S_j) zur Erzeugung von neu geordneten Datenelementen (S_j), wenn die betreffenden Datenelemente (S_j) aus dem genannten Festwertspeicherbereich wiedergegeben werden, Bereitstellen jedes der genannten geordneten Datenelemente (S_j) als die genannten neu geordneten Datenelemente (S_j), wenn die betreffenden Datenelemente (S_j) aus dem genannten beschreibbaren Bereich wiedergegeben sind.

27. Aufzeichnungsträger (4), auf dem aufeinanderfolgende Daten aufgezeichnet sind, wobei der Aufzeichnungsträger (4) eine Vielzahl von Sektoren (S_j, j=n-2,...,n+2) aufweist, in denen sequentiell nummerierte Informationsdateneinheiten (Da_{ij}, i=1,...,m; j=n-2,...,n+1) gespeichert sind, die eine Vielzahl von ungeradzahligen und eine Vielzahl von geradzahligen Informationsdateneinheiten und Fehlerdetektier- und Fehlerkorrekturdaten (LDC) enthalten, welche aus den Informationsdateneinheiten (Da_{ij}, i=1,...,m; j=n-2,...n+1) abgeleitet sind, **dadurch gekennzeichnet, dass** innerhalb zumindest einer bestimmten Gruppe ($S_{n-2},...,S_{n+2}$) von Sektoren (S_j) entweder jede der Vielzahl von ungeradzahligen oder jede der Vielzahl von geradzahligen Informationsdateneinheiten (Da_{ij}) der Folge von Informationsdateneinheiten in einem der Sektoren zu einem anderen, unterschiedlichen Sektor (S_j) übertragen ist, derart, dass so neu geordnete Sektoren (S_j) gebildet sind, die jeweils neu geordnete Informationsdateneinheiten (Da_{ij}) aufweisen,
wobei Identifikationsdaten in den genannten Sektoren (S_j) einen Kopfsektor (S_{n-2}) der betreffenden Gruppe ($S_{n-2},...,S_{n+2}$) und einen letzten Sektor (S_{n+2}) der genannten Gruppe ($S_{n-2},...S_{n+2}$) bezeichnen.

28. Aufzeichnungsträger nach Anspruch 27, wobei der genannte letzte Sektor (S_{n+2}) lediglich Informationsdateneinheiten (Da_{ij}) enthält, die von einem anderen unterschiedlichen Datensektor (S_j) erhalten sind,
und wobei Stellen in dem betreffenden letzten Sektor (S_{n+2}), die keine Informationsdateneinheiten (Da_{ij}) erhalten haben, Blinddaten aufweisen.

29. Aufzeichnungsträger nach Anspruch 27, wobei jedes Paar von benachbarten Sektoren (S_j) einen ungeradzahligen Sektor (S_j) und einen geradzahligen Sektor (S_j) aufweist
und wobei Informationsdateneinheiten (Da_{ij}) in jedem der ungeradzahligen und geradzahligen Sektoren (S_j) Informationsdateneinheiten (Da_{ij}) enthält, die von beiden ungeradzahligen und geradzahligen

Sektoren in dem genannten Paar abgeleitet sind.

30. Aufzeichnungsträger nach Anspruch 27 oder 28, mit einem Festwertspeicherbereich, in welchem die genannten Informationsdateneinheiten (Da_{ij}) gespeichert sind und der eine Vielzahl von Sektoren (S_j) aufweist,
wobei in jedem Sektor (S_j) die genannten Informationsdateneinheiten (Da, UD) und die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) gespeichert sind,
wobei jeder Sektor (S_j) eine erste Gruppe von Informationsdateneinheiten (Da_{ij}) und eine zweite Gruppe von Informationsdateneinheiten (Da_{ij}) umfasst und wobei die genannten Fehlerdetektier- und Fehlerkorrekturdaten (LDC) im jeweiligen Sektor (S_j) aus den Daten einer der betreffenden Gruppen in diesem Sektor (S_j) und aus den Informationsdateneinheiten (Da_{ij}) der anderen Gruppe der betreffenden Gruppen in einem gesonderten anderen unterschiedlichen Sektor (S_j) abgeleitet sind.

31. Aufzeichnungsträger nach Anspruch 30, wobei die genannten Informationsdateneinheiten (Da_{ij}) in dem genannten anderen Sektor aus einem benachbarten Sektor auf dem betreffenden Aufzeichnungsträger (4) abgeleitet sind.

Revendications

1. Un procédé pour enregistrer sur un support d'enregistrement (4) des éléments de données ayant chacun une multiplicité d'unités de données d'information numérotées séquentiellement (Da_{ij}; i = 1, ..., m; j = n-2, ... n+2), consistant en une multiplicité d'unités de données d'information de numéros impairs et une multiplicité d'unités de données d'information de numéros pairs, comprenant les étapes suivantes :

- on reçoit successivement des éléments de données (S_j, j = n-2, ..., n+2),
- on ajoute des données de détection d'erreur et de correction d'erreur (LDC) obtenues à partir des unités de données d'information (Da_{ij}) de l'élément de données respectif (S_j)
- on enregistre ces éléments de données sur le support d'enregistrement (4),

caractérisé en ce que

- chacune de la multiplicité d'unités de données d'information de numéros impairs ou chacune de la multiplicité d'unités de données d'information de numéros pairs (Da_{ij}) de la succession d'unités de données d'information dans l'un respectif des éléments de données (S_j) est transférée vers un autre élément de données différent (S_j) et ce transfert est répété à l'intérieur d'au moins un groupe prédéterminé (S_{n-2}, ..., S_{n+2}) d'éléments de données (S_j) de tous les éléments de données reçus (S_j), de façon que les unités de données d'information transférées de l'élément de données remplacent les unités de données d'information transférées dans l'autre élément de données (S_j), pour former ainsi des éléments de données (S_j) arrangés, ayant chacun des unités de données d'information (Da_{ij}) nouvellement arrangées, dans lequel des données d'identification dans des éléments de données indiquent un élément de données de tête (S_{n-2}) du groupe, et un dernier élément de données (S_{n+2}) du groupe (S_{n-2}, ..., S_{n+2}), et dans lequel chacun des éléments de données (S_j) arrangé est enregistré dans une région différente respective du support d'enregistrement (4).

2. Le procédé de la revendication 1, dans lequel chaque élément de données (S_j) arrangé est formé d'unités de données d'information (Da_{ij}) obtenues à partir de deux éléments de données (S_j) reçus.

3. Le procédé de l'une quelconque des revendications 1 ou 2, dans lequel les unités de données d'information (Da_{ij}) transférées dans un élément de données respectif (S_j) sont transférées vers un élément de données (S_j) respectivement adjacent.

4. Le procédé de l'une quelconque des revendications 1 à 3, dans lequel le dernier élément de données ((S_{n-2}) est un nouvel élément de données qui contient seulement des unités de données d'information (Da_{ij}) reçues à partir d'un autre élément de données (S_j) différent.

5. Le procédé de la revendication 4, comprenant en outre l'étape d'ajout de données fictives à des positions dans le nouvel élément de données qui ne reçoivent pas des unités de données d'information (Da_{ij}).

6. Le procédé de la revendication 4 ou 5, comprenant en outre l'étape d'ajout de données d'identification au nouvel élément de données, pour identifier le nouvel élément de données comme étant le dernier élément de données (S_{n-2}) du groupe (S_{n-2}, ..., S_{n+2}).

7. Un procédé pour enregistrer sur un support d'enregistrement (4) des éléments de données ayant chacun une multiplicité d'unités de données d'information numérotées séquentiellement (Da_{ij}; i = 1, ..., m; j = 2n-1, ... 2n+2), consistant en une multiplicité d'unités de données d'information de numéros im-

pairs et une multiplicité d'unités de données d'information de numéros pairs, comprenant les étapes suivantes :

- on reçoit successivement des éléments de données (S_j; j = 2n-1, ..., 2n+2),
- on ajoute des données de détection d'erreur et de correction d'erreur (LDC) obtenues à partir des unités de données d'information (Da_{ij}) de l'élément de données respectif (S_j)
- on enregistre ces éléments de données sur le support d'enregistrement (4),

caractérisé en ce que

- les éléments de données (S_j) sont reçus par paires, chaque paire incluant un élément de données de numéro impair (S_{2n-1}; S_{2n+1}) et un élément de données de numéro pair (S_{2n}; S_{2n+2}), dans lequel chacune de la multiplicité d'unités de données d'information de numéros impairs, ou chacune de la multiplicité d'unités de données d'information de numéro pair, de la succession d'unités de données d'information dans l'un des éléments de données, est transférée en échangeant les unités de données d'information avec l'autre élément de données de la paire, et ce transfert est répété pour chacune des paires, pour former ainsi des éléments de données arrangés ayant chacun des unités de données d'information nouvellement arrangées, chacun des éléments de données (S_j) arrangés étant enregistré dans une région respective différente du support d'enregistrement (4).

8. Le procédé de la revendication 7, dans lequel les données de détection d'erreur et de correction d'erreur (LDC) dans un élément de données respectif (S_j) ne sont pas transférées, de façon que ces données de détection d'erreur et de correction d'erreur (LDC) dans chacun des éléments de données (S_j) arrangés soient obtenues à partir des unités de données d'information (Da_{ij}) qui ont été transférées, ainsi qu'à partir des données qui sont restées dans l'élément de données (S_j).

9. Le procédé de l'une quelconque des revendications 7 ou 8, dans lequel approximativement la moitié des données de détection d'erreur et de correction d'erreur (LDC) dans l'élément de données respectif (S_j) est transférée vers l'autre élément de données (S_j) différent.

10. Le procédé de la revendication 9, dans lequel les données de détection d'erreur et de correction d'erreur (LDC) comprennent des données de code à redondance cyclique et des codes de Reed-Solomon, et les données de détecteur d'erreur et de correction d'erreur (LDC) transférées comprennent seulement les données de code à redondance cyclique.

11. Le procédé de l'une quelconque des revendications 1 et 10, dans lequel le support d'enregistrement (4) comprend une zone fonctionnant seulement en lecture ayant une multiplicité de régions; et dans lequel chacun des éléments de données (S_j) arrangé est enregistré dans une région respectivement différente de la zone fonctionnant seulement en lecture, sur le support d'enregistrement (4).

12. Un procédé de reproduction d'éléments de données successifs enregistrés sous la forme d'éléments de données arrangés sur un support d'enregistrement (4),
comprenant les étapes suivantes :

on reproduit successivement des éléments de données (S_j; j = n-2, ..., n+2) à partir du support d'enregistrement (4), chaque élément de données (S_j) reproduit ayant une multiplicité d'unités de données d'information numérotés séquentiellement (Da_{ij}, i = 1, ..., m; j = n-2, ..., n+1), consistant en une multiplicité d'unités de données d'information de numéros impairs et une multiplicité d'unités de données d'information de numéros pairs, et en données de détection d'erreur et de correction d'erreur (LDC),

on détecte et on corrige des erreurs d'unités de données d'information (Da_{ij}) dans chacun des éléments de données (S_j), conformément aux données de détection et de correction d'erreur (LDC),
caractérisé par les étapes suivantes :

on détecte des données d'identification dans les éléments de données (S_j), ces données d'identification indiquant un élément de données de tête (S_{n-2}) d'au moins un groupe prédéterminé (S_{n-2}, ..., S_{n+2}) d'éléments de données (S_j), pour tous les éléments de données (S_j) reçus (S_j) et un dernier élément de données (S_{n+2}) du groups (S_{n-2}, ..., S_{n+2}),

on transfère de façon réversible soit chacune de la multiplicité d'unités de données d'information de numéros impairs, soit chacune de la multiplicité d'unités de données d'information de numéros pairs (Da_{ij}), de la succession d'unités de données d'information dans l'un respectif des éléments de données (S_j), vers l'autre élément de données (S_j), différent, et on répète ce transfert à l'intérieur du groupe (S_{n-2}+, ..., +S_{n+2}), pour former ainsi des éléments de données (S_j) réarrangés ayant chacun des unités de données d'information (Da_{ij}) nouvellement arrangées,

on détecte et on corrige des erreurs d'unités de données d'information (Da_{ij}) dans chacun des éléments de données réarrangés, conformément aux données de détection d'erreur et de correction

d'erreur (LDC) dans l'élément de données (S_j) réarrangé, et

on fournit les éléments de données (S_j) réarrangés, avec les erreurs corrigées, en tant qu'éléments de données (S_j) non arrangés.

13. Le procédé de la revendication 12, dans lequel les unités de données d'information (Da_{ij}) dans l'élément de données (S_j) arrangé respectif sont transférées vers des positions correspondantes dans les éléments de données (S_j) arrangés différents, pour produire les éléments de données (S_j) réarrangés.

14. Le procédé de la revendication 12 ou 13, dans lequel chaque élément de données (S_j) réarrangé est formé d'unités de données d'information (Da_{ij}) obtenues à partir de deux éléments de données (S_j) arrangés.

15. Le procédé de l'une quelconque des revendications 12 à 14, dans lequel les unités de données d'information (Da_{ij}) dans un élément de données (S_j) arrangé respectif sont transférées vers un élément de données (S_j) arrangé respectivement adjacent.

16. Le procédé de l'une quelconque des revendications 12 à 15, dans lequel le dernier élément de données (S_{n-2}) est un nouvel élément de données qui contient seulement des unités de données d'information (Da_{ij}) reçues d'un autre élément de données (S_j) différent; et dans lequel pour produire des éléments de données (S_j) réarrangés, les unités de données d'information (Da_{ij}) dans ce nouvel élément de données sont transférées vers l'élément de données (S_j) différent.

17. Le procédé de la revendication 16, dans lequel le nouvel élément de données contient des données fictives à des positions qui n'ont pas reçu des unités de données d'information (Da_{ij}); et comprenant en outre l'étape de suppression des données fictives du nouvel élément de données, de façon que seuls des éléments de données (S_j) réarrangés soient produits à partir dudit groupe (S_{n-2}, ..., S_{n+2}).

18. Le procédé de l'une quelconque des revendications 12 à 15, dans lequel les éléments de données (S_j) reproduits à partir du support d'enregistrement (4) sont constitués de paires d'éléments de données (S_j) arrangés, chaque paire incluant un élément de données arrangé de numéro impair et un élément de données arrangé de numéro pair; et l'étape consistant à transférer de façon réversible certaines mais non la totalité des unités de données d'information (Da_{ij}) est accomplie en échangeant les unités de données d'information (Da_{ij}) dans les éléments de données (S_j) arrangés de numéro pair et de numéro impair respectifs, dans chaque paire d'éléments de données (S_j) arrangés.

19. Le procédé de l'une quelconque des revendications 12 à 18, dans lequel chacun des éléments de données (S_j) arrangés reproduits est constitué d'une succession d'unités de données; et dans lequel des unités de données alternées dans un élément de données (S_j) arrangé respectif sont transférées vers l'élément de données (S_j) arrangé différent.

20. Le procédé de la revendication 19, dans lequel chaque unité de données alternée dans un élément de données (S_j) arrangé respectif est transférée vers une position correspondante dans l'élément de données (S_j) arrangé différent.

21. Le procédé de l'une quelconque des revendications 12 à 20, dans lequel les données de détection d'erreur et de correction d'erreur (LDC) dans un élément de données (S_j) arrangé respectif ne sont pas transférées, de façon que les données de détection d'erreur et de correction d'erreur (LDC) dans chacun des éléments de données (S_j) arrangés soient obtenues à partir des données qui ont été transférées ainsi qu'à partir des unités de données d'information (Da_{ij}) qui sont restées dans cet élément de données (S_j) arrangé.

22. Le procédé de l'une quelconque des revendications 12 à 20, dans lequel approximativement la moitié des données de détection d'erreur et de correction d'erreur (LDC) dans l'élément de données (S_j) arrangé respectif sont transférées vers l'autre élément de données (Sj) différent.

23. Le procédé de la revendication 22, dans lequel les données de détection d'erreur et de correction d'erreur (LDC) comprennent des données de code à redondance cyclique et des codes de Reed-Solomon, et les données de détection d'erreur et de correction d'erreur (LDC) transférées comprennent seulement les données de code à redondance cyclique.

24. Le procédé selon la revendication 15, dans lequel le support d'enregistrement (4) comprend une multiplicité de secteurs; et dans lequel chacun des éléments de données (S_j) arrangé est reproduit à partir d'un secteur différent sur le support d'enregistrement (4).

25. Le procédé de la revendication 12, comprenant en outre les étapes suivantes :

on identifie dans chacun des éléments de données (S_j) arrangés reproduits des données d'information (Da_{ij}) contenues à l'intérieur qui sont associées à un seul élément de données (S_j)

réarrangé, cet élément de données (S_j) réarrangé contenant des unités de données d'information (Da_{ij}) obtenues à partir des deux éléments de données (S_j) arrangés reproduits;
on stocke dans une mémoire des données incluses dans un élément de données (S_j) arrangé reproduit qui ont été identifiées comme étant associées à l'élément de données (S_j) réarrangé unique, et on génère à partir d'elles l'élément de données (S_j) réarrangé unique; et
on fournit comme une information de sortie l'élément de données (Sj) réarrangé unique sur lequel la correction d'erreur a été effectuée.

26. Le procédé de l'une quelconque des revendications 12 à 24, comprenant en outre les étapes suivantes :

on identifie le support d'enregistrement (4) comme un support d'enregistrement permettant seulement la lecture, un support d'enregistrement permettant l'écriture ou un support d'enregistrement hybride, ce dernier ayant à la fois des régions permettant seulement la lecture et des régions permettant l'écriture;
on identifie les régions permettant seulement la lecture et les régions permettant l'écriture dans le support d'enregistrement (4), lorsque ce support d'enregistrement (4) est identifié comme un support d'enregistrement hybride;
on transfère certaines, mais non la totalité, des unités de données d'information (Da_{ij}) dans un élément de données (S_j) arrangé reproduit, vers un élément de données (S_j) arrangé différent, pour produire des éléments de données (S_j) réarrangés, lorsque les éléments de données (S_j) sont reproduits à partir de la région permettant seulement la lecture;
on fournit chacun des éléments de données (S_j) arrangés comme les éléments de données (S_j) réarrangés, lorsque les éléments de données (S_j) sont reproduits à partir de la région permettant l'écriture.

27. Un support d'enregistrement (4) sur lequel des données successives sont enregistrées, le support d'enregistrement (4) comprenant une multiplicité de secteurs (S_j, j = n-2, ..., n+2) dans lesquels sont stockées des unités de données d'information numérotées séquentiellement (Da_{ij}; i = 1, ..., m; j = n-2, ... n+1) consistant en une multiplicité d'unités de données d'information de numéros impairs et en une multiplicité d'unités de données d'information de numéros pairs, et des données de détection d'erreur et de correction d'erreur (LDC) obtenues à partir des unités de données d'information (Da_{ij}; i = 1, ..., m; j = n-2, ... n+1),
caractérisé en ce que
à l'intérieur d'au moins un groupe prédéterminé (S_{n-2}, ..., S_{n+2}) de secteurs (S_j), chacune de la multiplicité d'unités de données d'information de numéros impairs ou chacune de la multiplicité d'unités de données d'information de numéros pairs (Da_{ij}) de la succession d'unités de données d'information dans l'un respectif des secteurs est transférée vers un autre secteur (S_j) différent, pour former ainsi des secteurs (S_j) réarrangés ayant chacun des unités de données d'information (Da_{ij}) nouvellement arrangées, dans lequel
des données d'identification dans les secteurs (S_j) indiquent un secteur de tête (S_{n-2}) du groupe (S_{n-2}, ..., S_{n+2}) et un dernier secteur (S_{n+2}) du groupe (S_{n-2}, ..., S_{n+2}).

28. Le support d'enregistrement de la revendication 27, dans lequel le dernier secteur (S_{n+2}) contient seulement des unités de données d'information (Da_{ij}) reçues de l'autre secteur de données (S_j) différent; et des emplacements dans le dernier secteur (S_{n+2}) qui n'ont pas reçu d'unités de données d'information (Da_{ij}) contiennent des données fictives.

29. Le support d'enregistrement de la revendication 27, dans lequel chaque paire de secteurs (S_j) adjacents comprend un secteur (S_j) de numéro impair et un secteur (S_j) de numéro pair; et des unités de données d'information (Da_{ij}) dans chacun des secteurs (S_j) de numéro impair et de numéro pair contiennent des unités de données d'information (Da_{ij}) obtenues à la fois à partir du secteur de numéro impair et du secteur de numéro pair dans la paire.

30. Le support d'enregistrement de la revendication 27 ou 28, ayant une zone permettant seulement la lecture dans laquelle les unités de données d'information (Da_{ij}) sont stockées, cette zone permettant seulement la lecture incluant une multiplicité de secteurs (S_j), chaque secteur (S_j) stockant à l'intérieur les unités de données d'information (Da, UD) et les données de détection d'erreur et de correction d'erreur (LDC), dans lequel chacun des secteurs (S_j) comprend un premier groupe d'unités de données d'information (Da_{ij}) et un second groupe d'unités de données d'information (Da_{ij}), et dans lequel les données de détection d'erreur et de correction d'erreur (LDC) dans chaque secteur respectif (S_j) sont obtenues à partir des données de l'un des groupes dans ce secteur (S_j) et à partir des unités de données d'information (Da_{ij}) de l'autre respectif des groupes dans un autre secteur (S_j) différent, distinct, respectif.

31. Le support d'enregistrement de la revendication 30, dans lequel les unités de données d'information (Da_{ij}) dans l'autre secteur sont obtenues à partir d'un secteur adjacent sur le support d'enregistrement (4).

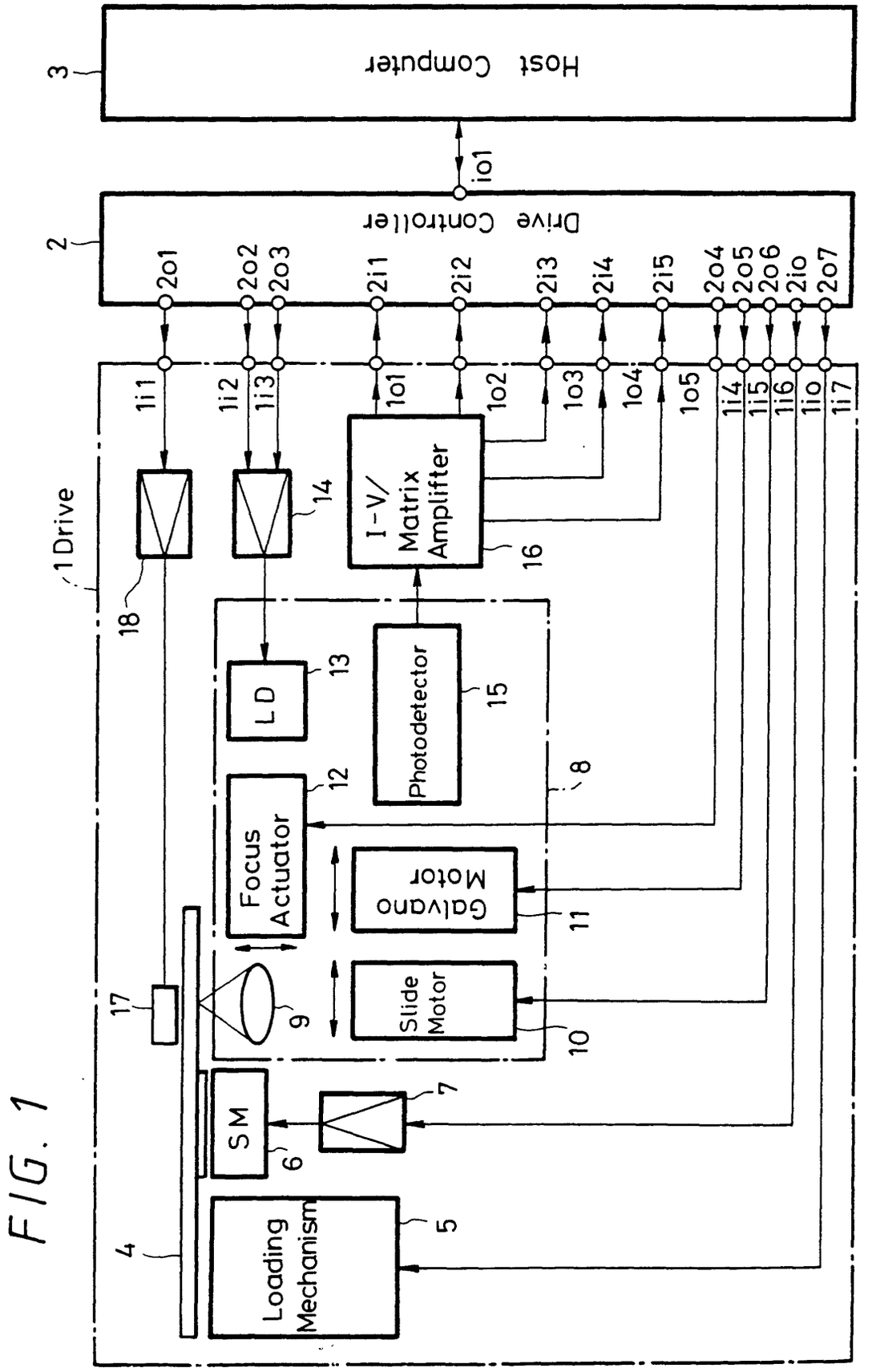

Host Computer
3
io1
Drive Controller
2
2o1
2o2
2o3
2i1
2i2
2i3
2i4
2i5
2o4
2o5
2o6
2io
2o7
1i1
1i2
1i3
1o1
1o2
1o3
1o4
1o5
1i4
1i5
1i6
1io
1i7
1 Drive
I-V/ Matrix Amplifter
16
14
18
LD
13
Photodetector
15
8
12
Focus Actuator
Galvano Motor
11
17
9
Slide Motor
10
7
SM
6
4
Loading Mechanism
5

FIG. 1

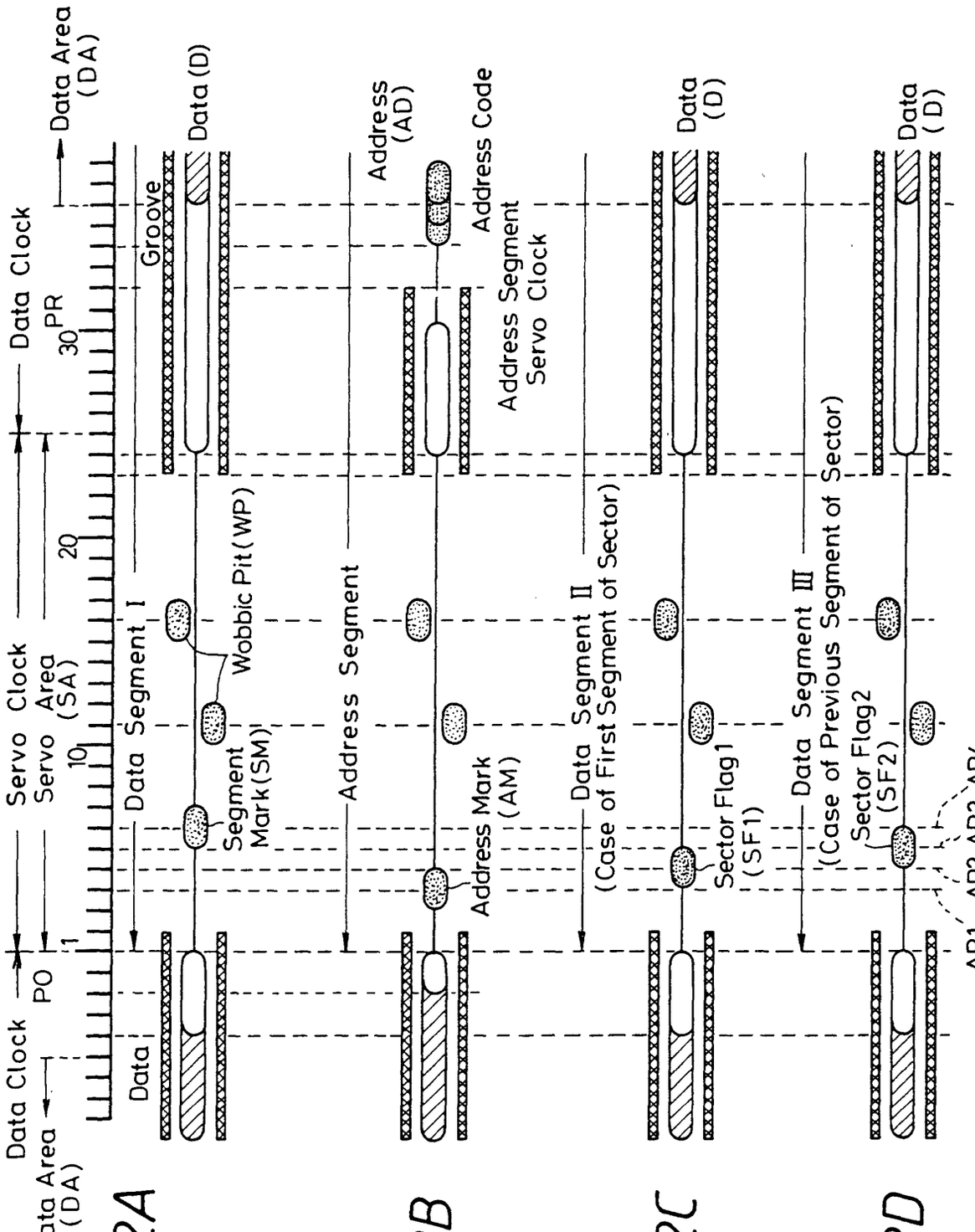


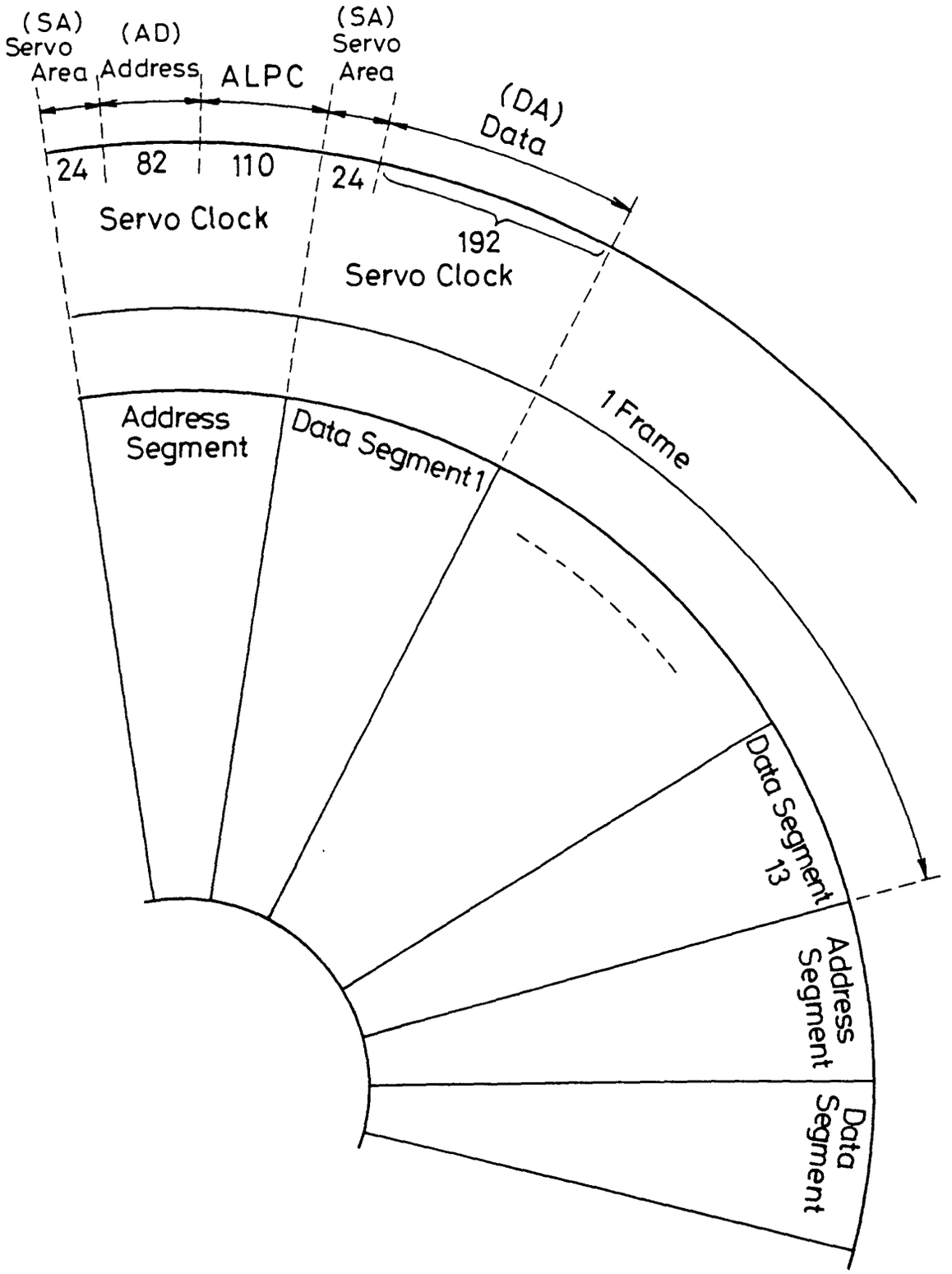
FIG. 2A

FIG. 2B

FIG. 2C

FIG. 2D

FIG. 3A


(SA) Servo Area
(AD) Address
ALPC
(SA) Servo Area
(DA) Data
24
82
110
24
192
Servo Clock
Servo Clock
1 Frame
Address Segment
Data Segment 1
Data Segment 13
Address Segment
Data Segment

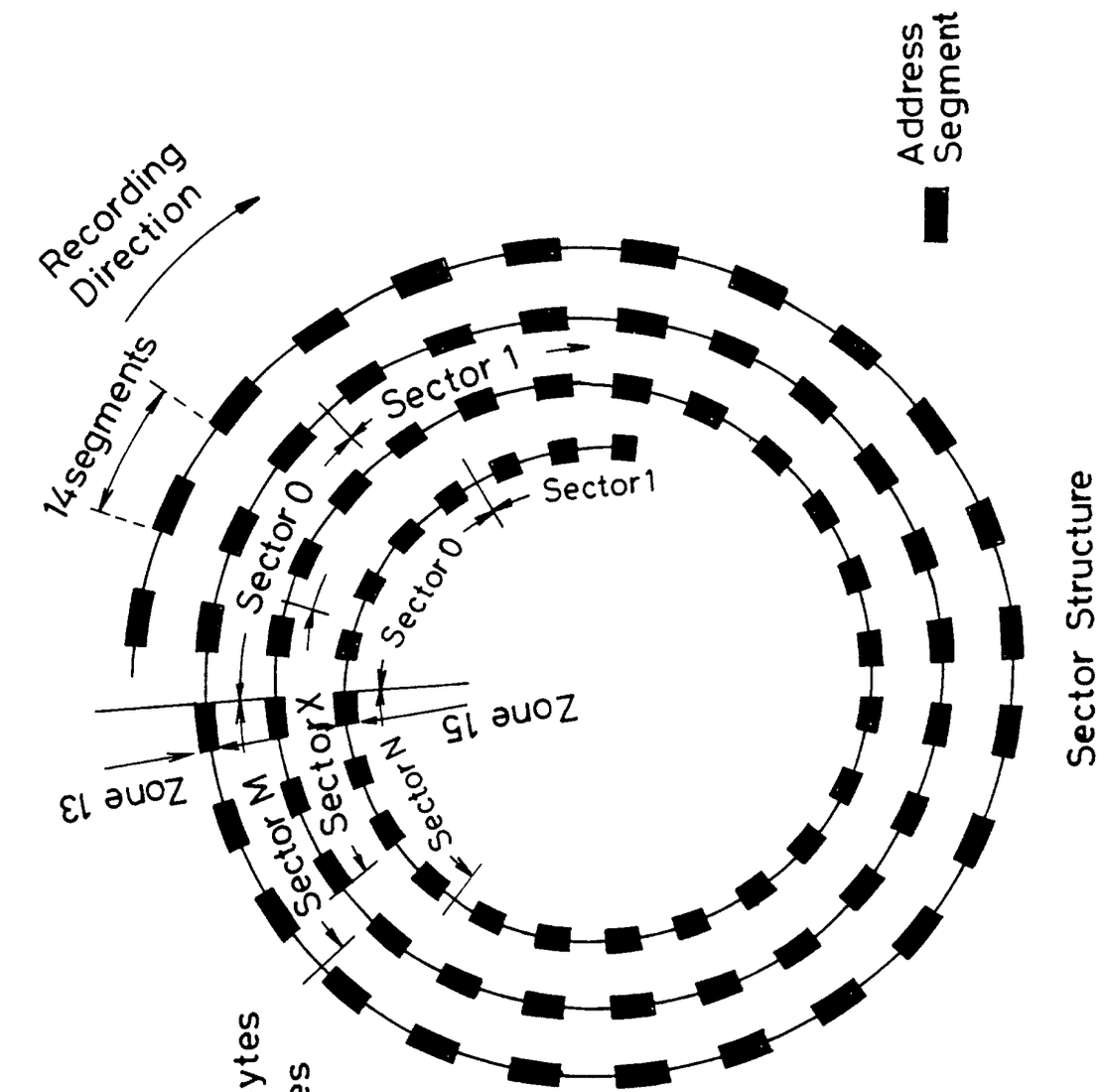


FIG. 3B

Segment/Track 1400
Address/Track 100
Sector Size 2048bytes
16interleaves
16degrees
Zone Number16

FIG. 4

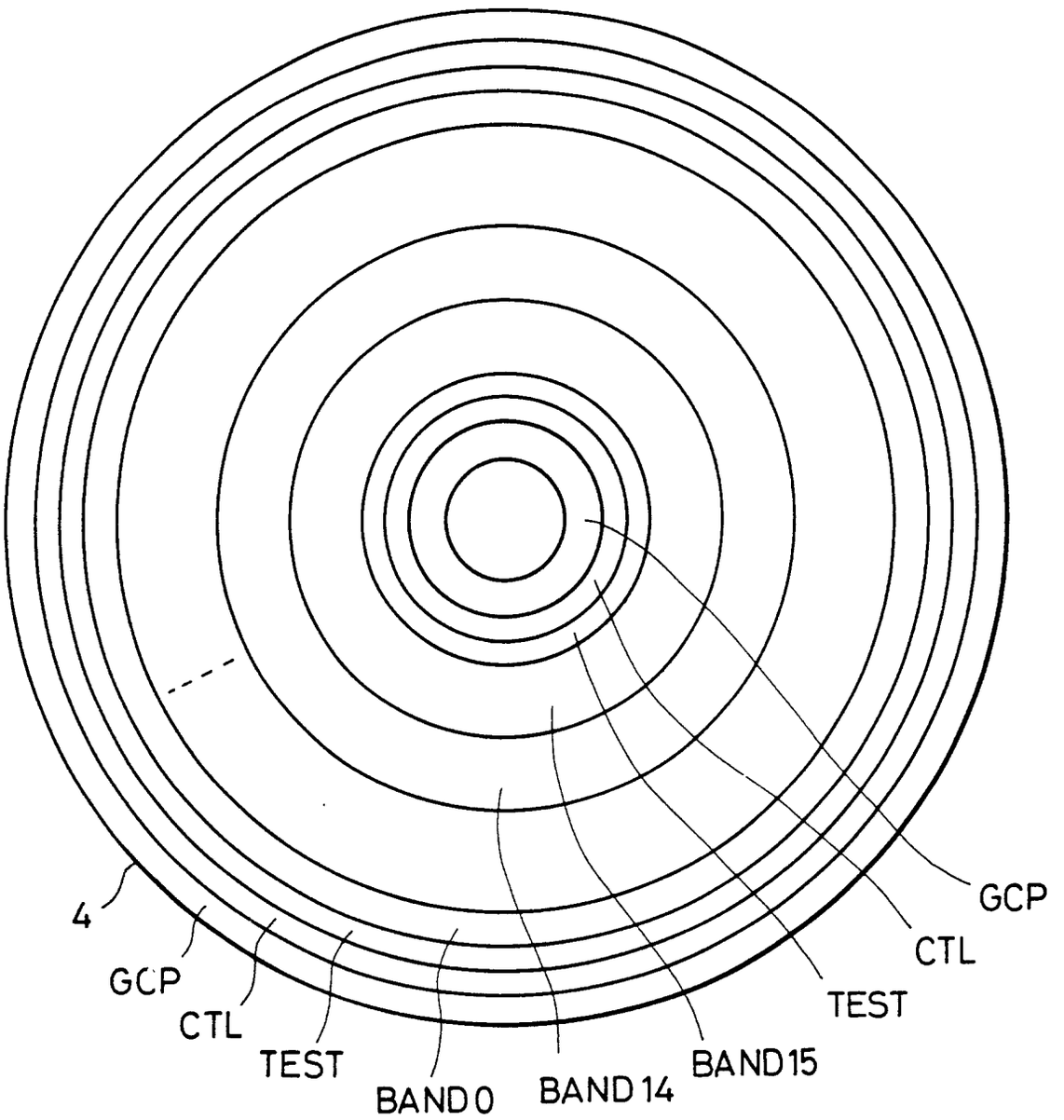


FIG. 5

	Name of Region	Starting Radius	Ending Radius	Data Clock
GCP Region		41.9980	41.2180	24.192MHz
Control Region		41.2144	41.2096	24.192MHz
Test Region		41.2060	41.2012	24.192MHz
Band 0		41.2000	41.1836	24.192MHz
Band 1		39.1824	39.1468	23.688MHz
Band 2		38.1456	38.0908	23.184MHz
Band 3		37.0896	36.9964	22.680MHz
Band 4		36.9952	35.8636	21.672MHz
Band 5		35.8624	34.6924	21.168MHz
Band 6		34.6912	33.4636	20.160MHz
Band 7		33.4624	32.1964	19.656MHz
Band 8		32.1952	30.8524	18.648MHz
Band 9		30.8512	29.4316	17.640MHz
Band 10		29.4304	27.9724	17.136MHz
Band 11		27.9712	26.4172	16.128MHz
Band 12		26.4160	24.7468	15.120MHz
Band 13		24.7456	22.9612	14.112MHz
Band 14		22.9600	20.9260	12.600MHz
Band 15		20.9248	20.0020	12.096MHz
Test Region		20.0008	19.9960	12.096MHz
Control Region		19.9924	19.9876	12.096MHz
GCP Region		19.9840	19.0000	12.096MHz

FIG. 6

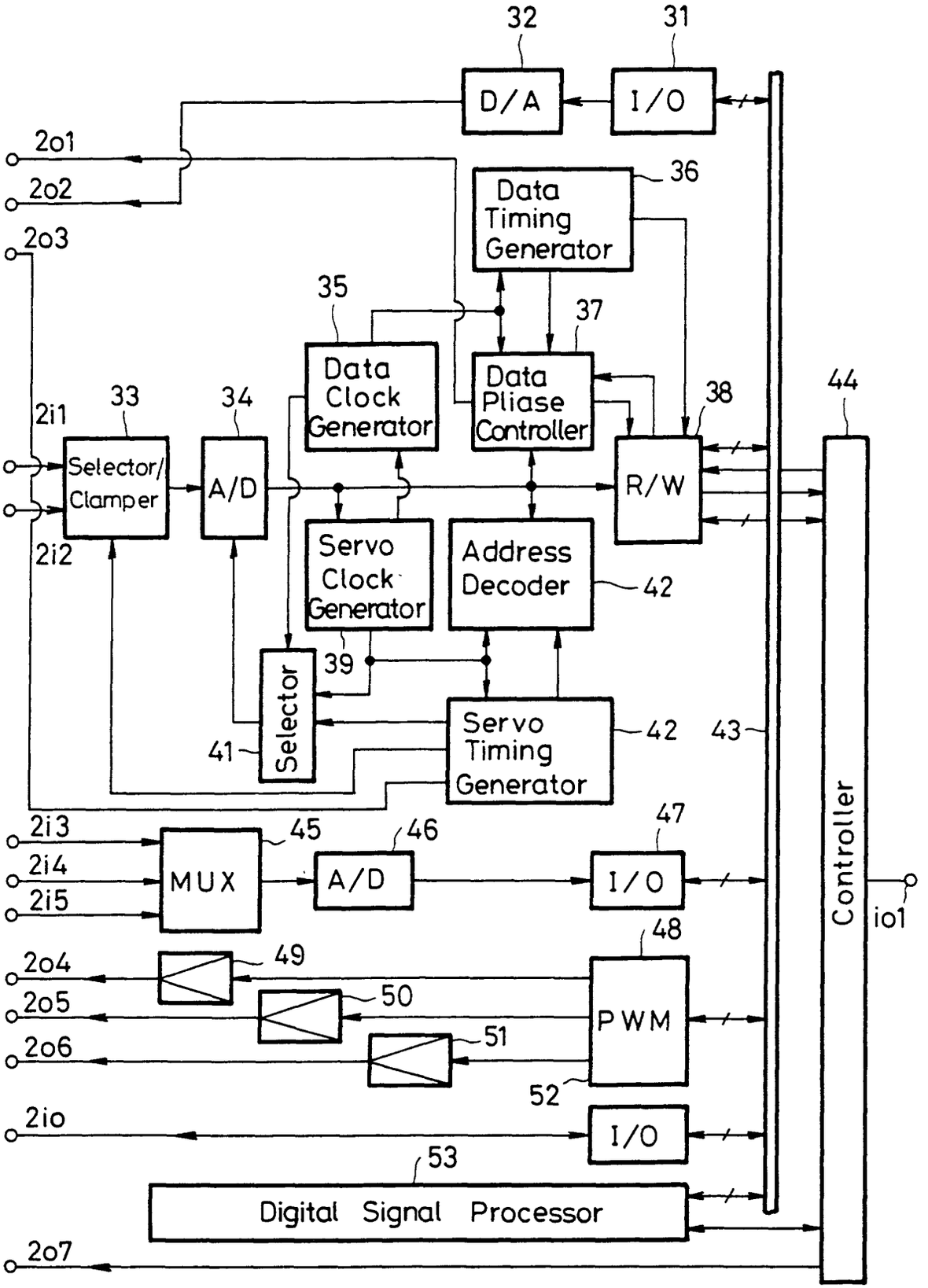

32
31
D/A
I/O
2o1
2o2
2o3
Data Timing Generator
36
35
37
Data Clock Generator
Data Pliase Controller
38
44
2i1
33
34
Selector/ Clamper
A/D
R/W
2i2
Servo Clock Generator
Address Decoder
42
39
Selector
41
Servo Timing Generator
42
43
2i3
2i4
2i5
MUX
45
46
A/D
47
I/O
Controller
io1
48
2o4
49
2o5
50
PWM
2o6
51
52
2io
I/O
53
Digital Signal Processor
2o7

FIG. 7

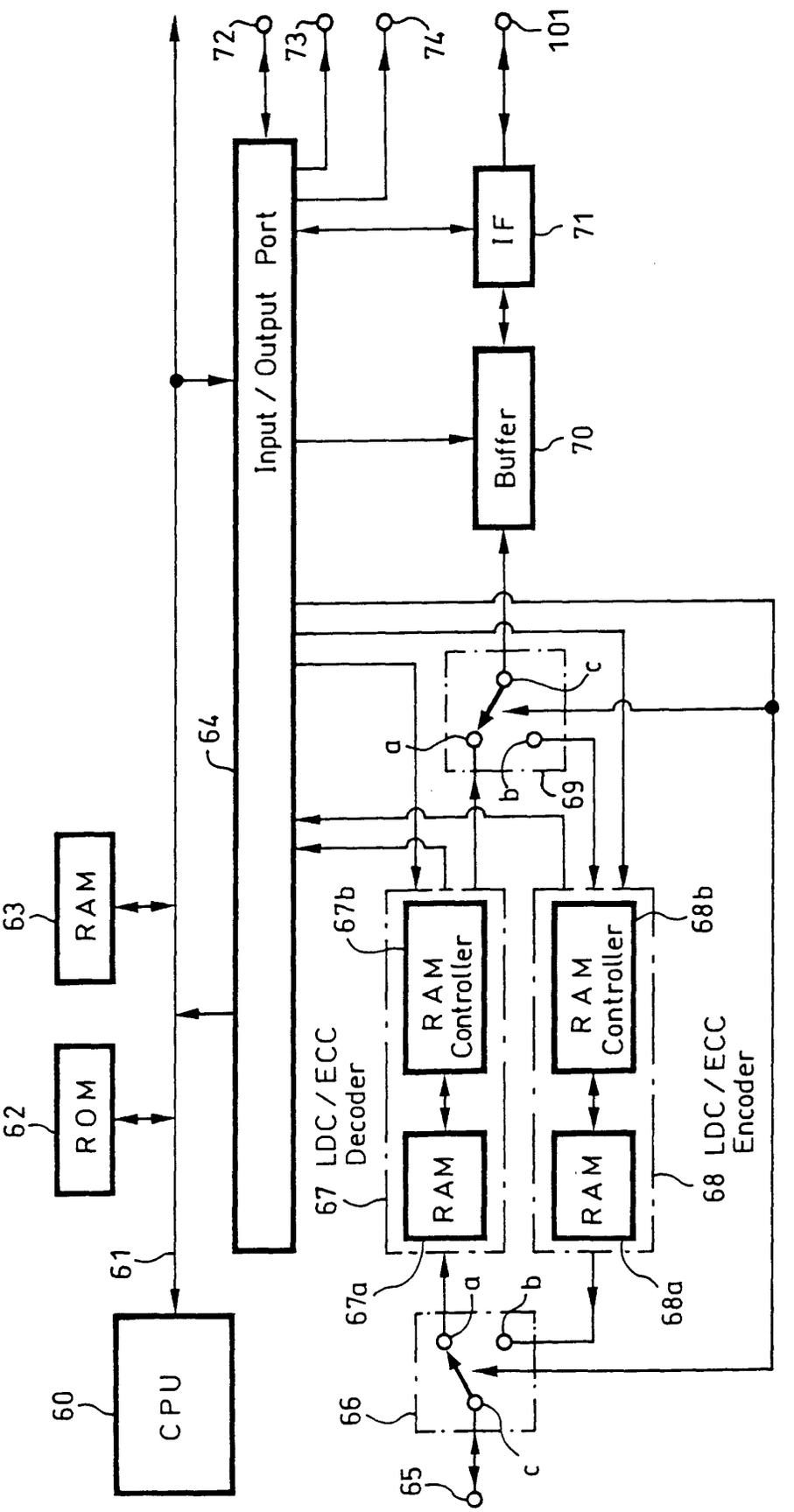

72
73
74
101
Input / Output Port
IF
71
Buffer
70
64
63
RAM
62
ROM
61
60
CPU
67 LDC / ECC Decoder
67b
RAM Controller
RAM
67a
68 LDC / ECC Encoder
68b
RAM Controller
RAM
68a
66
65
69
a
b
c

FIG. 8

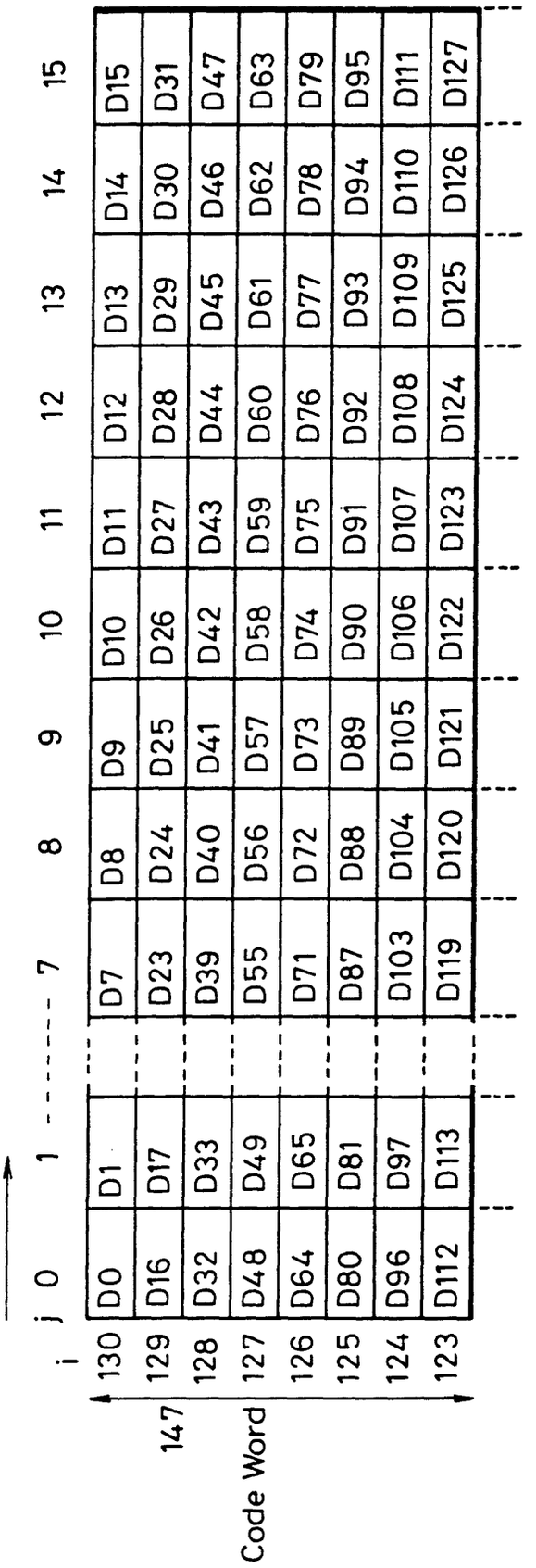

j
0
1
7
8
9
10
11
12
13
14
15
i
130
129
128
127
126
125
124
123
147
Code Word
D0 D1 D7 D8 D9 D10 D11 D12 D13 D14 D15
D16 D17 D23 D24 D25 D26 D27 D28 D29 D30 D31
D32 D33 D39 D40 D41 D42 D43 D44 D45 D46 D47
D48 D49 D55 D56 D57 D58 D59 D60 D61 D62 D63
D64 D65 D71 D72 D73 D74 D75 D76 D77 D78 D79
D80 D81 D87 D88 D89 D90 D91 D92 D93 D94 D95
D96 D97 D103 D104 D105 D106 D107 D108 D109 D110 D111
D112 D113 D119 D120 D121 D122 D123 D124 D125 D126 D127

FIG. 9

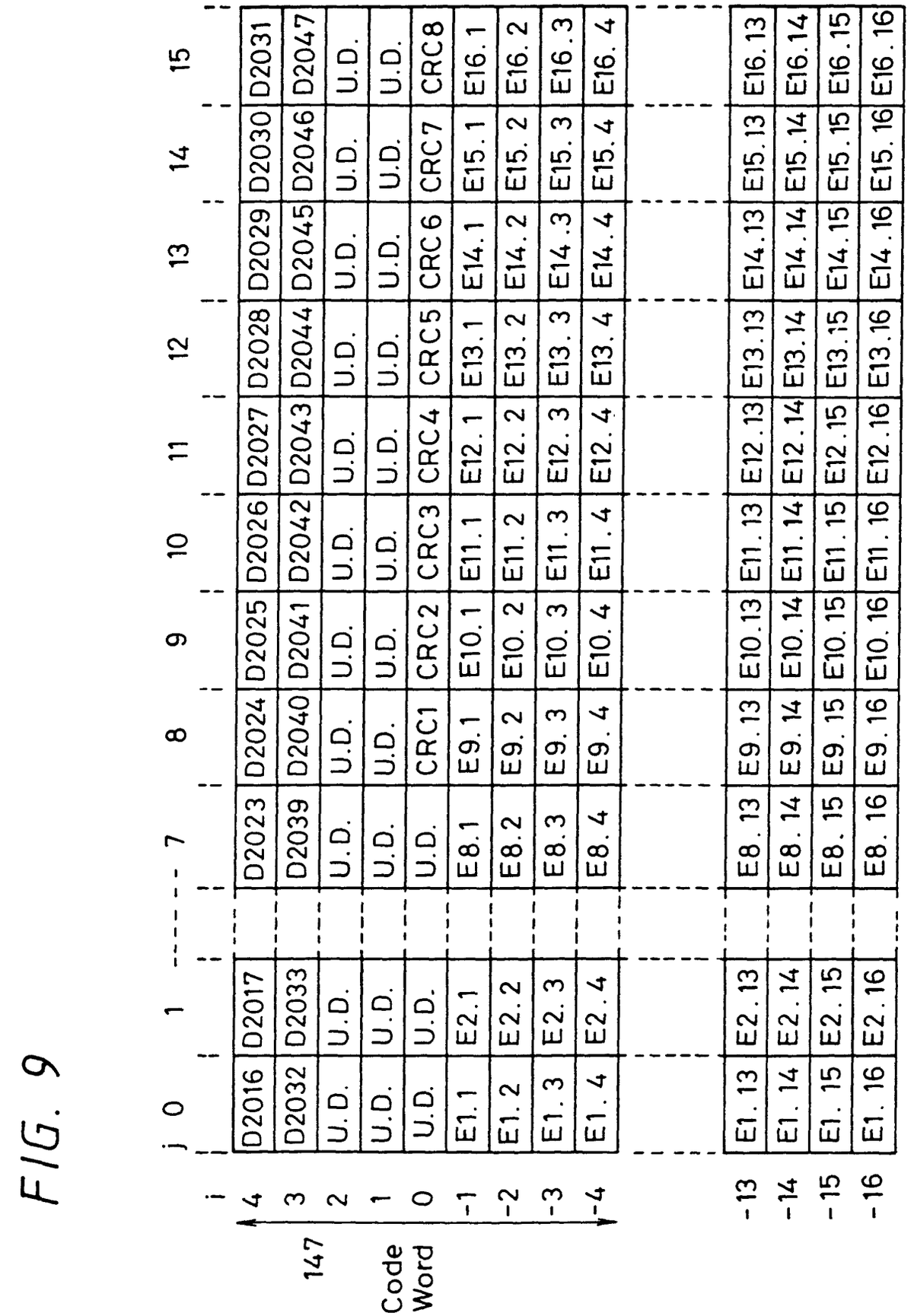

j 0 1 7 8 9 10 11 12 13 14 15
i
4 D2016 D2017 D2023 D2024 D2025 D2026 D2027 D2028 D2029 D2030 D2031
3 D2032 D2033 D2039 D2040 D2041 D2042 D2043 D2044 D2045 D2046 D2047
2 U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D.
1 U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D. U.D.
0 U.D. U.D. U.D. CRC1 CRC2 CRC3 CRC4 CRC5 CRC6 CRC7 CRC8
-1 E1.1 E2.1 E8.1 E9.1 E10.1 E11.1 E12.1 E13.1 E14.1 E15.1 E16.1
-2 E1.2 E2.2 E8.2 E9.2 E10.2 E11.2 E12.2 E13.2 E14.2 E15.2 E16.2
-3 E1.3 E2.3 E8.3 E9.3 E10.3 E11.3 E12.3 E13.3 E14.3 E15.3 E16.3
-4 E1.4 E2.4 E8.4 E9.4 E10.4 E11.4 E12.4 E13.4 E14.4 E15.4 E16.4
-13 E1.13 E2.13 E8.13 E9.13 E10.13 E11.13 E12.13 E13.13 E14.13 E15.13 E16.13
-14 E1.14 E2.14 E8.14 E9.14 E10.14 E11.14 E12.14 E13.14 E14.14 E15.14 E16.14
-15 E1.15 E2.15 E8.15 E9.15 E10.15 E11.15 E12.15 E13.15 E14.15 E15.15 E16.15
-16 E1.16 E2.16 E8.16 E9.16 E10.16 E11.16 E12.16 E13.16 E14.16 E15.16 E16.16
147 Code Word

FIG. 10

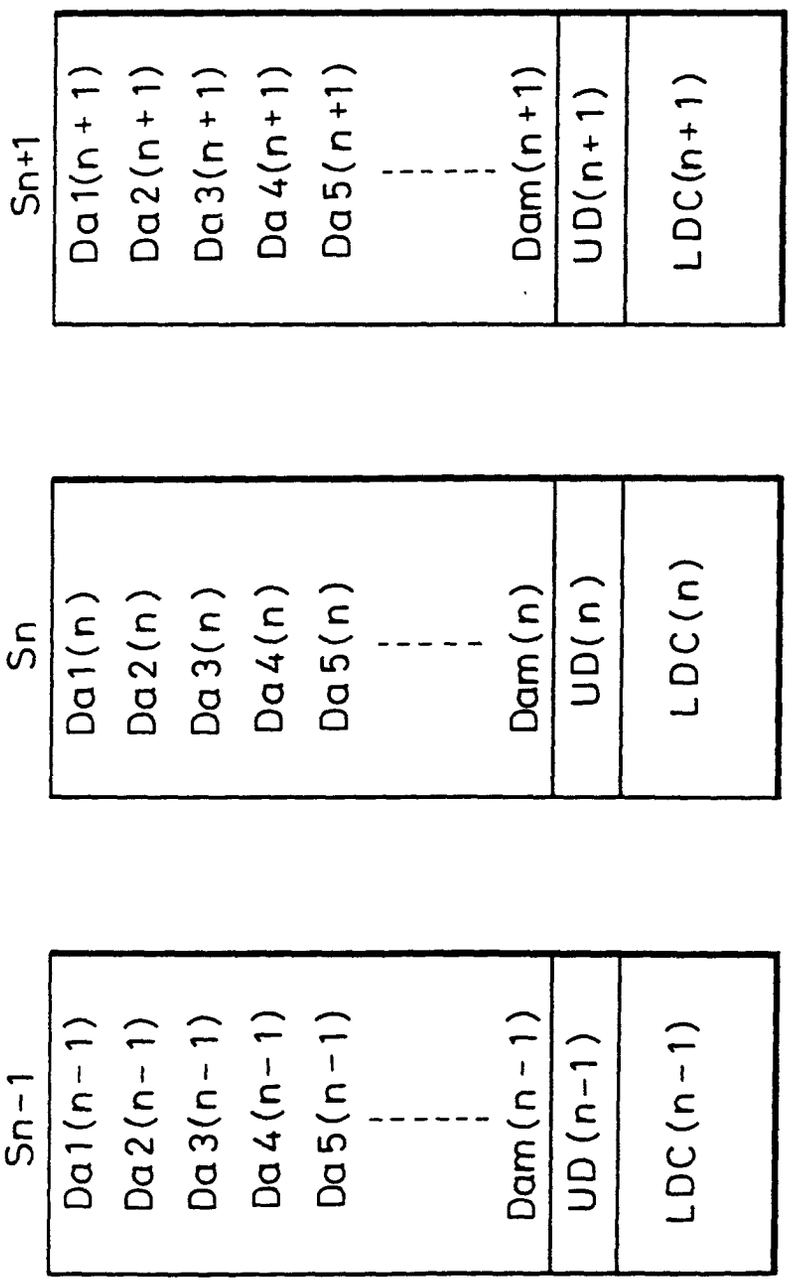

Sn-1
Da1(n-1)
Da2(n-1)
Da3(n-1)
Da4(n-1)
Da5(n-1)
Dam(n-1)
UD(n-1)
LDC(n-1)
Sn
Da1(n)
Da2(n)
Da3(n)
Da4(n)
Da5(n)
Dam(n)
UD(n)
LDC(n)
Sn+1
Da1(n+1)
Da2(n+1)
Da3(n+1)
Da4(n+1)
Da5(n+1)
Dam(n+1)
UD(n+1)
LDC(n+1)

FIG. 11

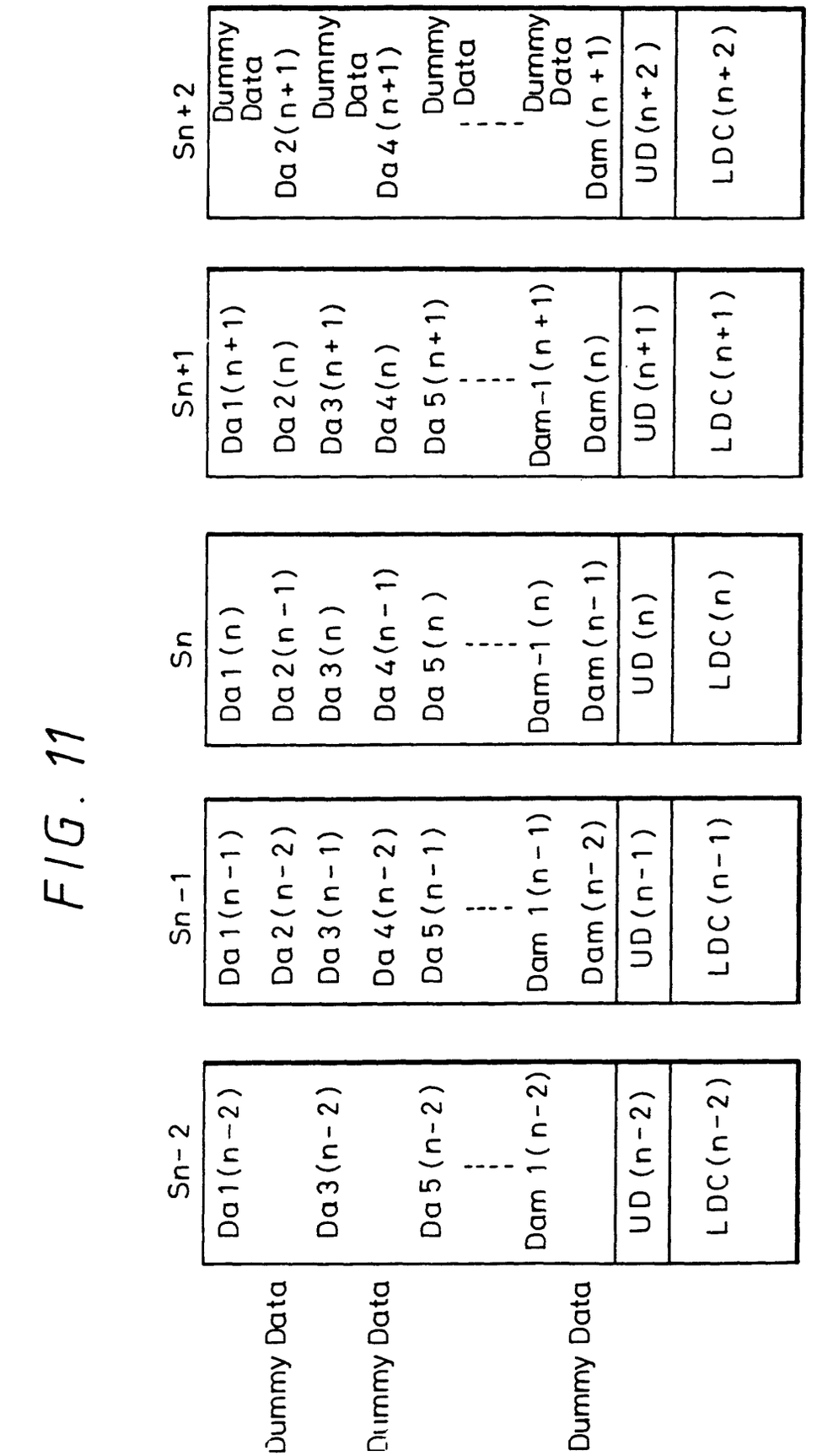

Sn-2
Sn-1
Sn
Sn+1
Sn+2
Da1(n-2)
Da3(n-2)
Da5(n-2)
Dam1(n-2)
Da1(n-1)
Da2(n-2)
Da3(n-1)
Da4(n-2)
Da5(n-1)
Dam1(n-1)
Dam(n-2)
Da1(n)
Da2(n-1)
Da3(n)
Da4(n-1)
Da5(n)
Dam-1(n)
Dam(n-1)
Da1(n+1)
Da2(n)
Da3(n+1)
Da4(n)
Da5(n+1)
Dam-1(n+1)
Dam(n)
Dummy Data
Da2(n+1)
Dummy Data
Da4(n+1)
Dummy Data
Dummy Data
Dam(n+1)
UD(n-2)
UD(n-1)
UD(n)
UD(n+1)
UD(n+2)
LDC(n-2)
LDC(n-1)
LDC(n)
LDC(n+1)
LDC(n+2)
Dummy Data
Dummy Data
Dummy Data

FIG. 12

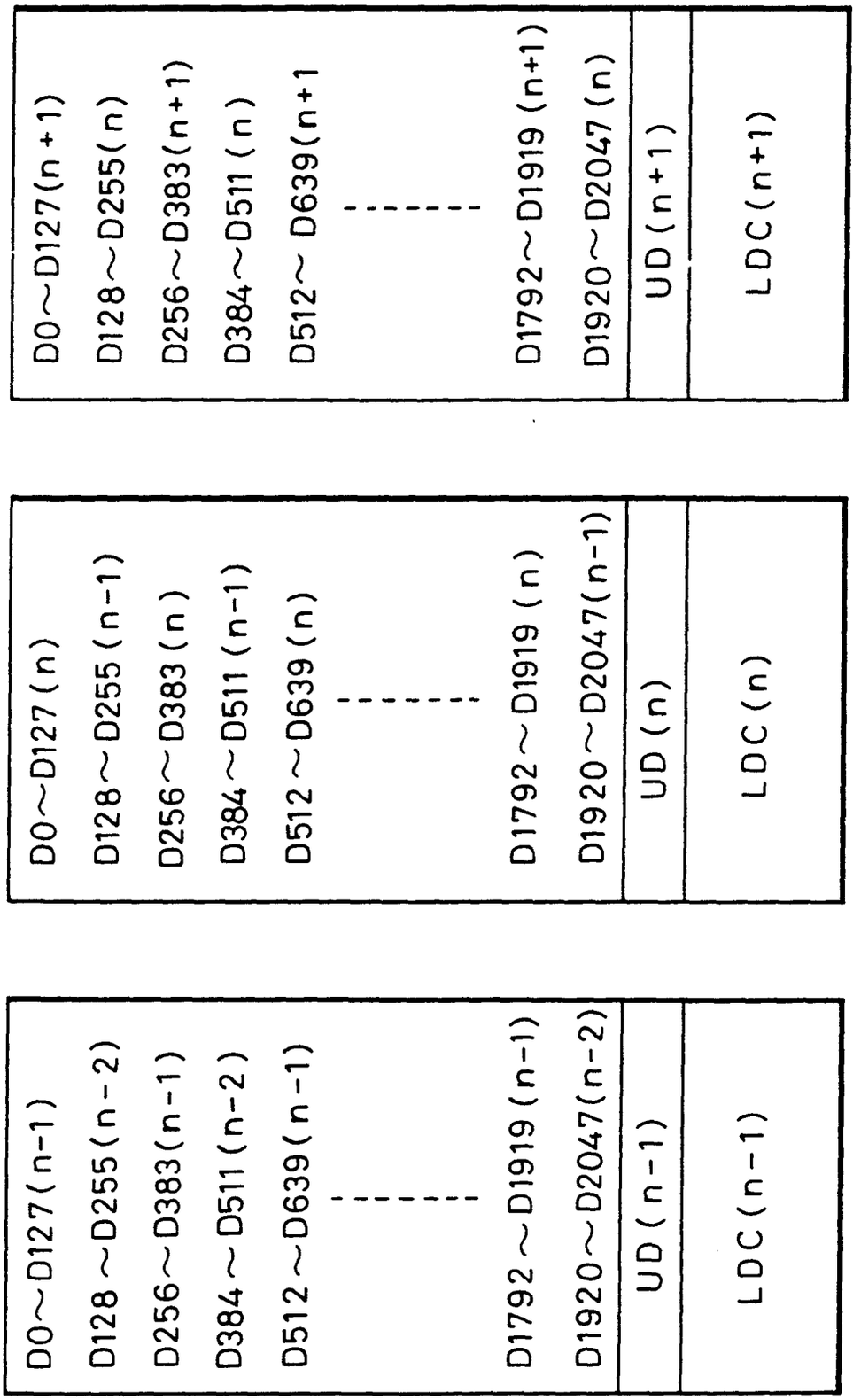

Sn-1
D0～D127(n-1)
D128～D255(n-2)
D256～D383(n-1)
D384～D511(n-2)
D512～D639(n-1)
D1792～D1919(n-1)
D1920～D2047(n-2)
UD(n-1)
LDC(n-1)
Sn
D0～D127(n)
D128～D255(n-1)
D256～D383(n)
D384～D511(n-1)
D512～D639(n)
D1792～D1919(n)
D1920～D2047(n-1)
UD(n)
LDC(n)
Sn+1
D0～D127(n+1)
D128～D255(n)
D256～D383(n+1)
D384～D511(n)
D512～D639(n+1)
D1792～D1919(n+1)
D1920～D2047(n)
UD(n+1)
LDC(n+1)

FIG. 13

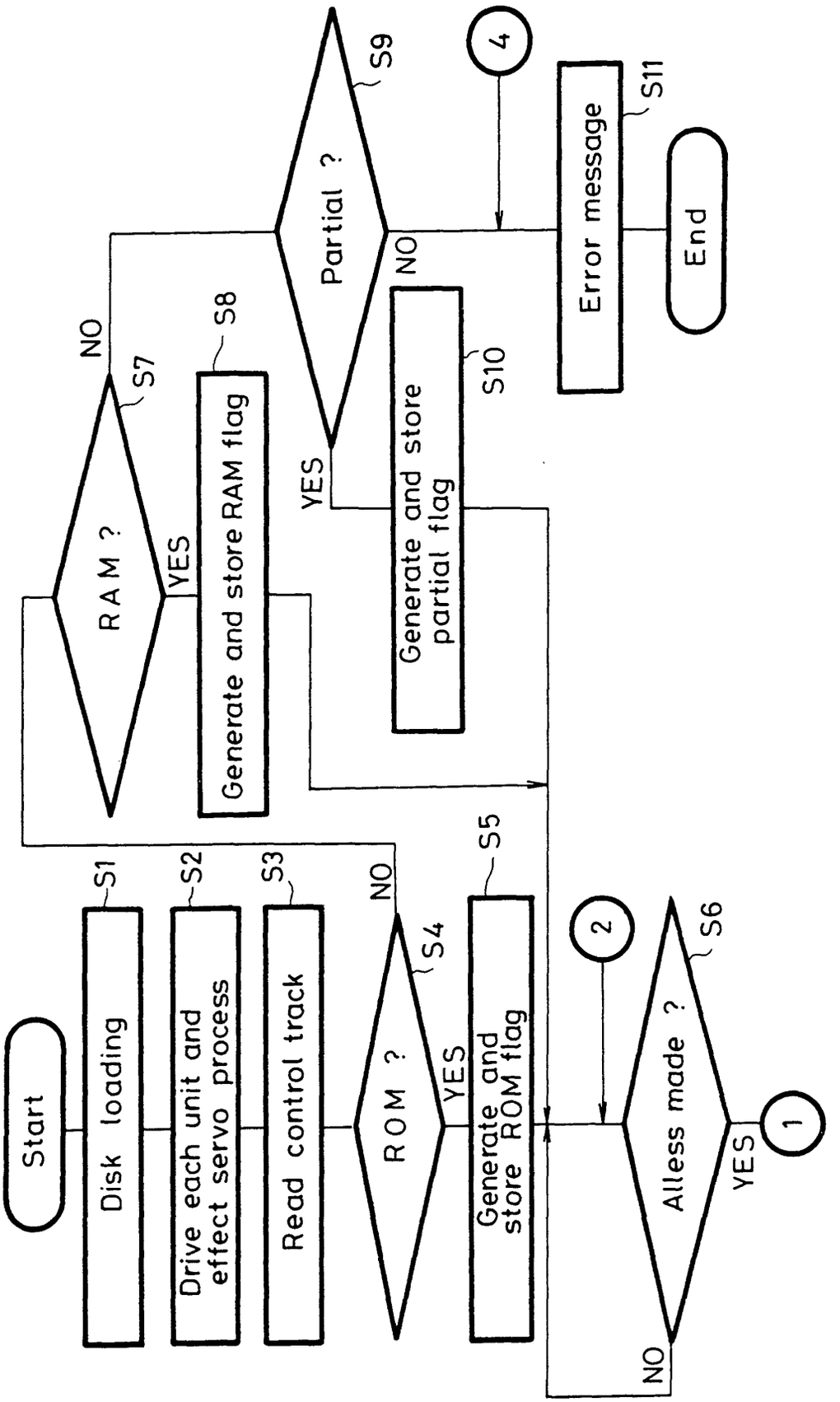

Start
Disk loading
S1
Drive each unit and effect servo process
S2
Read control track
S3
ROM ?
S4
NO
YES
Generate and store ROM flag
S5
2
Alless made ?
S6
NO
YES
1
RAM ?
S7
NO
YES
Generate and store RAM flag
S8
Partial ?
S9
YES
NO
Generate and store partial flag
S10
4
Error message
S11
End

FIG. 14

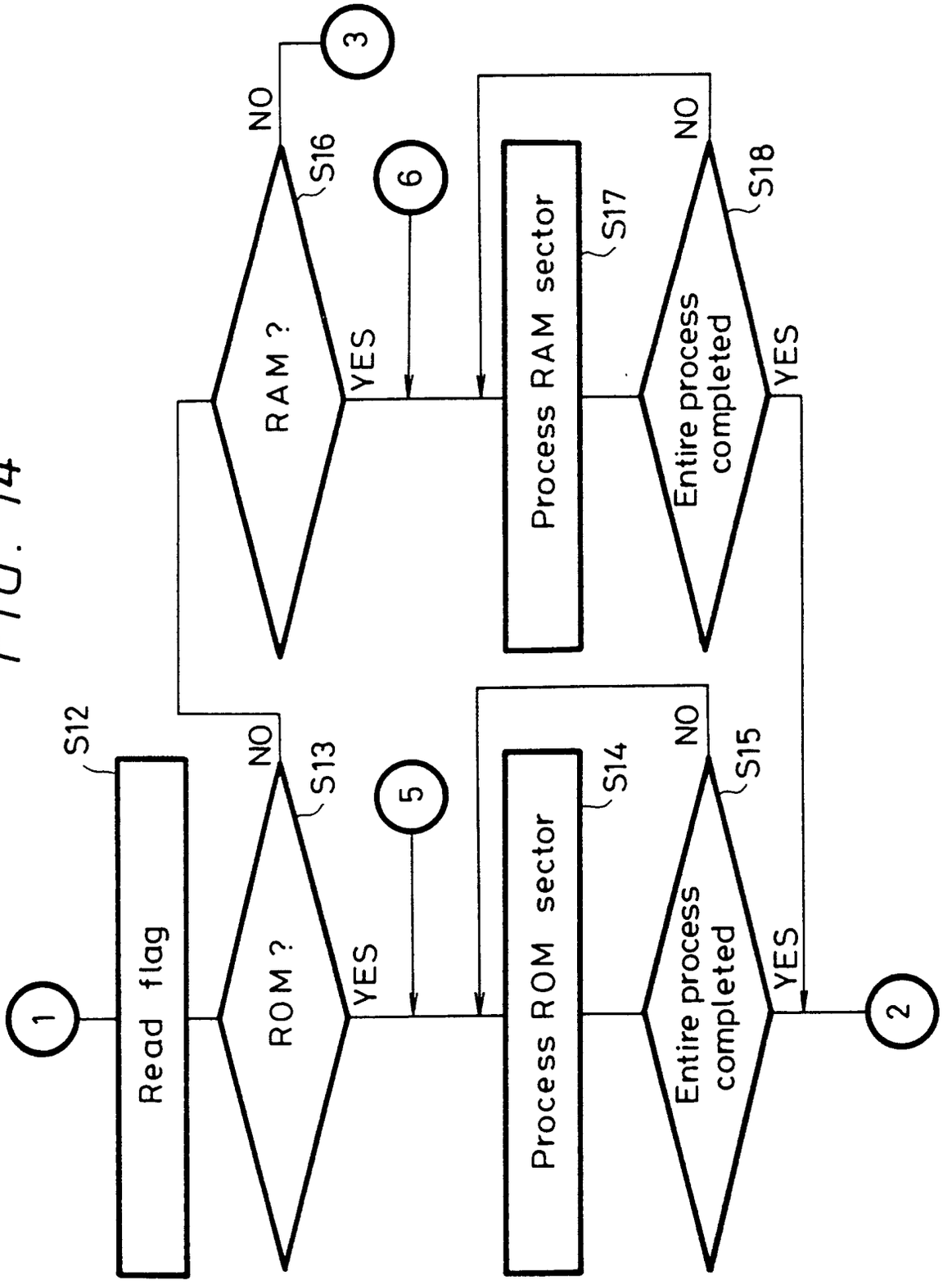

1
Read flag
S12
ROM ?
NO
S13
YES
5
Process ROM sector
S14
Entire process completed
NO
S15
YES
2
RAM ?
NO
S16
YES
6
Process RAM sector
S17
Entire process completed
NO
S18
YES
3

FIG. 15

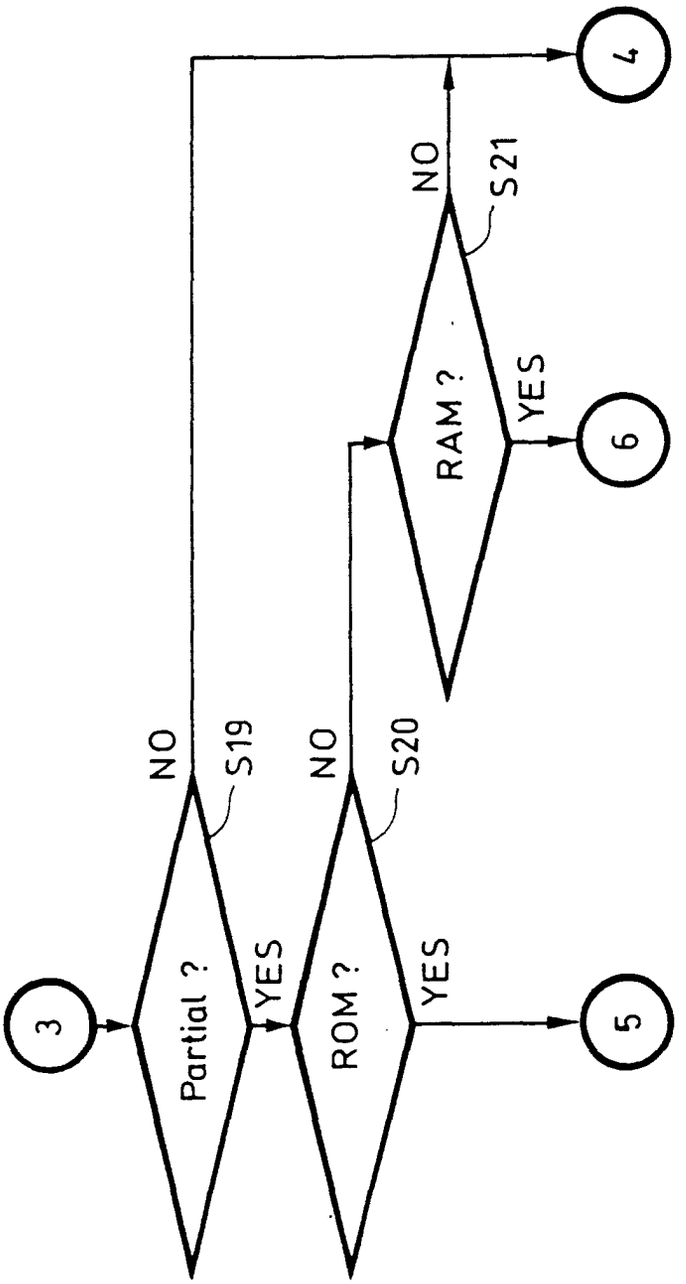


FIG. 16

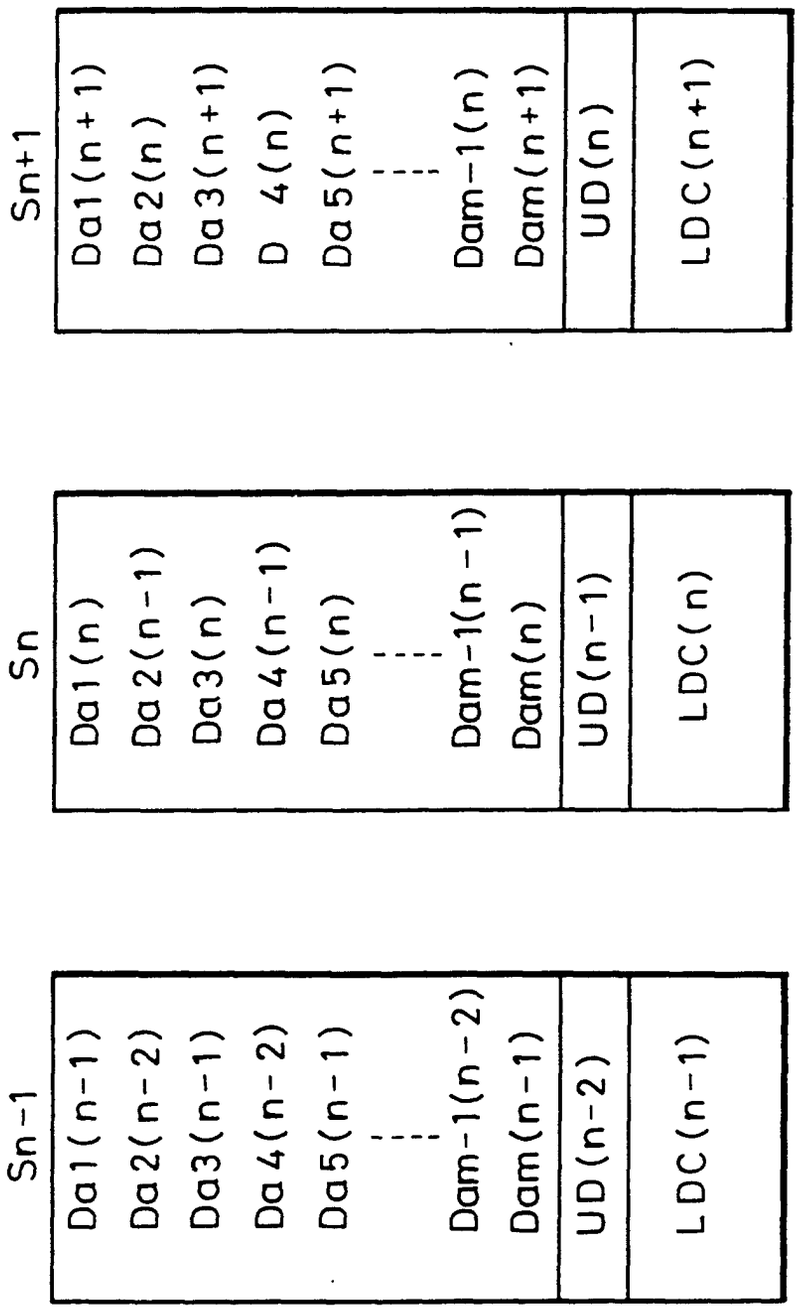

Sn-1
Da1(n-1)
Da2(n-2)
Da3(n-1)
Da4(n-2)
Da5(n-1)
Dam-1(n-2)
Dam(n-1)
UD(n-2)
LDC(n-1)
Sn
Da1(n)
Da2(n-1)
Da3(n)
Da4(n-1)
Da5(n)
Dam-1(n-1)
Dam(n)
UD(n-1)
LDC(n)
Sn+1
Da1(n+1)
Da2(n)
Da3(n+1)
D 4(n)
Da5(n+1)
Dam-1(n)
Dam(n+1)
UD(n)
LDC(n+1)

FIG. 17

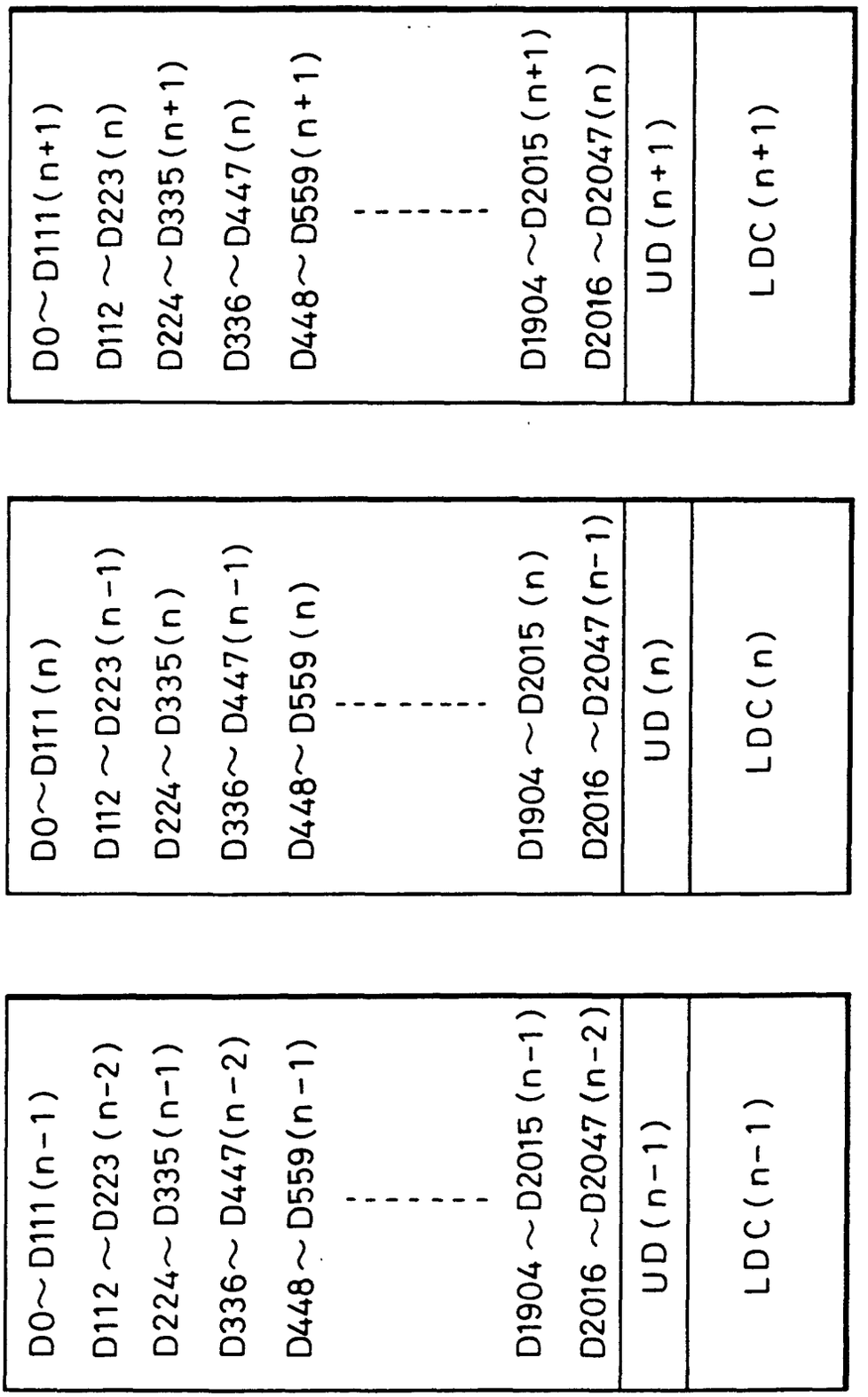

Sn-1
D0～D111(n-1)
D112～D223(n-2)
D224～D335(n-1)
D336～D447(n-2)
D448～D559(n-1)
D1904～D2015(n-1)
D2016～D2047(n-2)
UD(n-1)
LDC(n-1)
Sn
D0～D111(n)
D112～D223(n-1)
D224～D335(n)
D336～D447(n-1)
D448～D559(n)
D1904～D2015(n)
D2016～D2047(n-1)
UD(n)
LDC(n)
Sn+1
D0～D111(n+1)
D112～D223(n)
D224～D335(n+1)
D336～D447(n)
D448～D559(n+1)
D1904～D2015(n+1)
D2016～D2047(n)
UD(n+1)
LDC(n+1)

FIG. 18

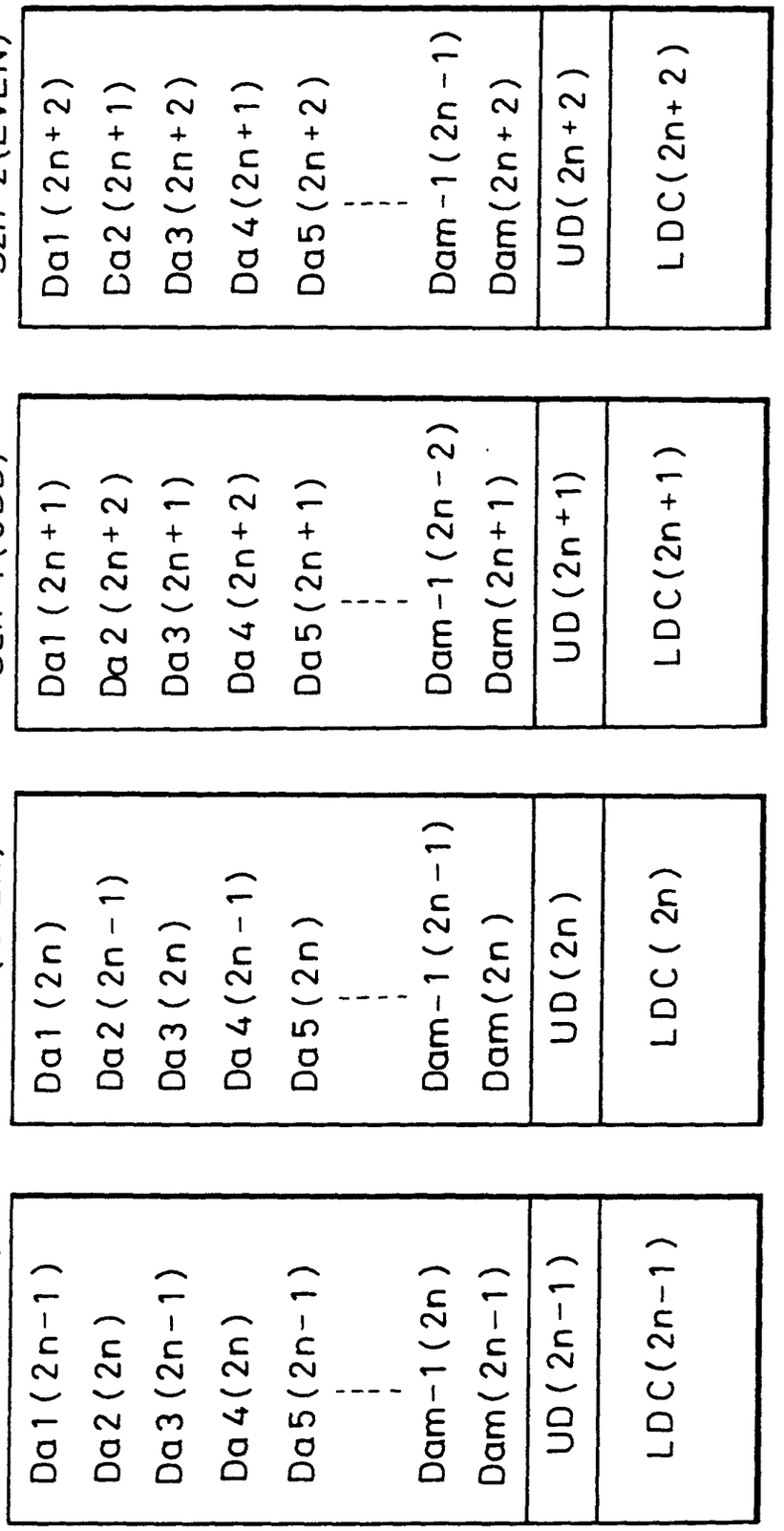

S2n-1(ODD)
Da1(2n-1)
Da2(2n)
Da3(2n-1)
Da4(2n)
Da5(2n-1)
Dam-1(2n)
Dam(2n-1)
UD(2n-1)
LDC(2n-1)
S2n(EVEN)
Da1(2n)
Da2(2n-1)
Da3(2n)
Da4(2n-1)
Da5(2n)
Dam-1(2n-1)
Dam(2n)
UD(2n)
LDC(2n)
S2n+1(ODD)
Da1(2n+1)
Da2(2n+2)
Da3(2n+1)
Da4(2n+2)
Da5(2n+1)
Dam-1(2n-2)
Dam(2n+1)
UD(2n+1)
LDC(2n+1)
S2n+2(EVEN)
Da1(2n+2)
Ca2(2n+1)
Da3(2n+2)
Da4(2n+1)
Da5(2n+2)
Dam-1(2n-1)
Dam(2n+2)
UD(2n+2)
LDC(2n+2)

FIG. 19

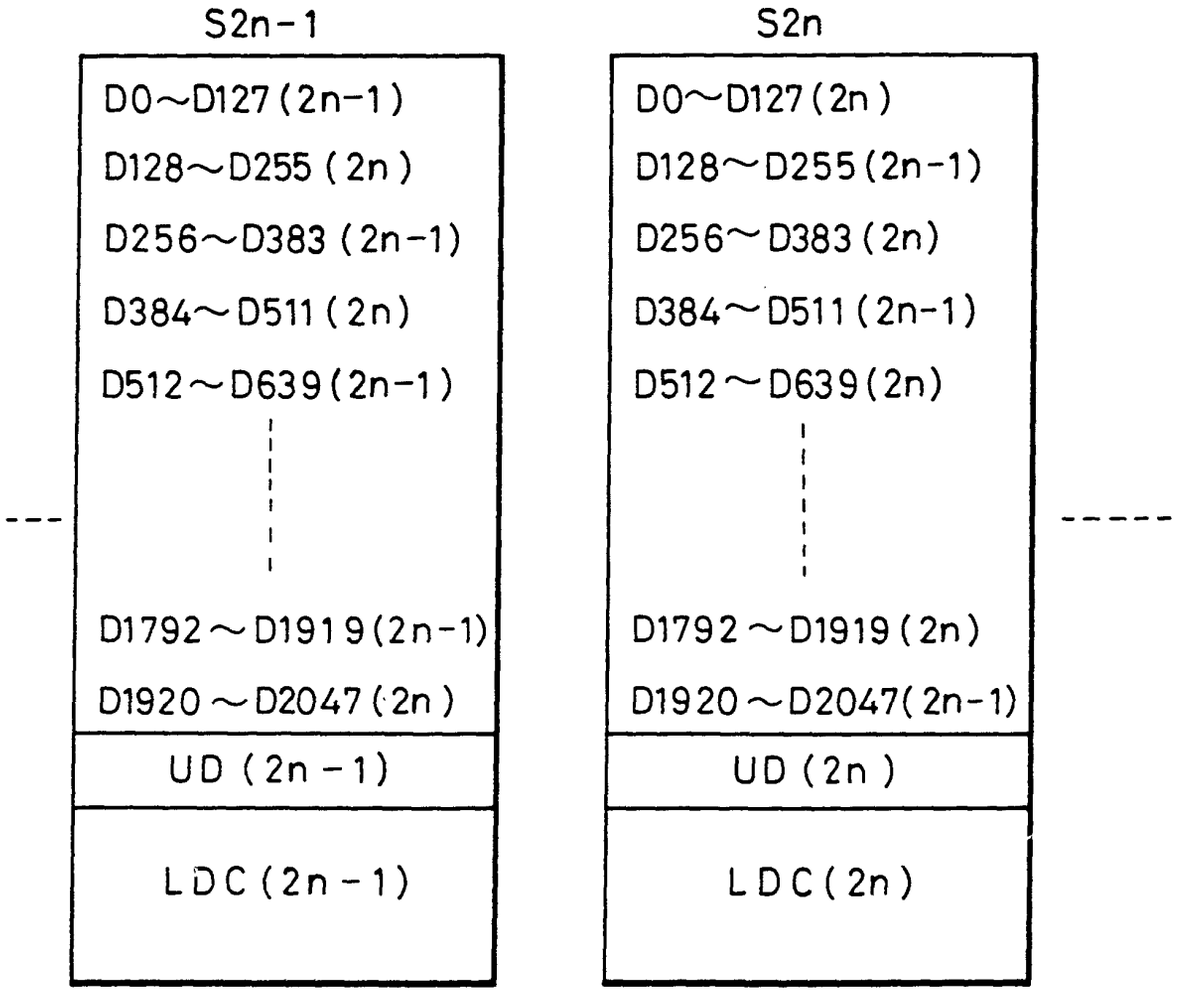
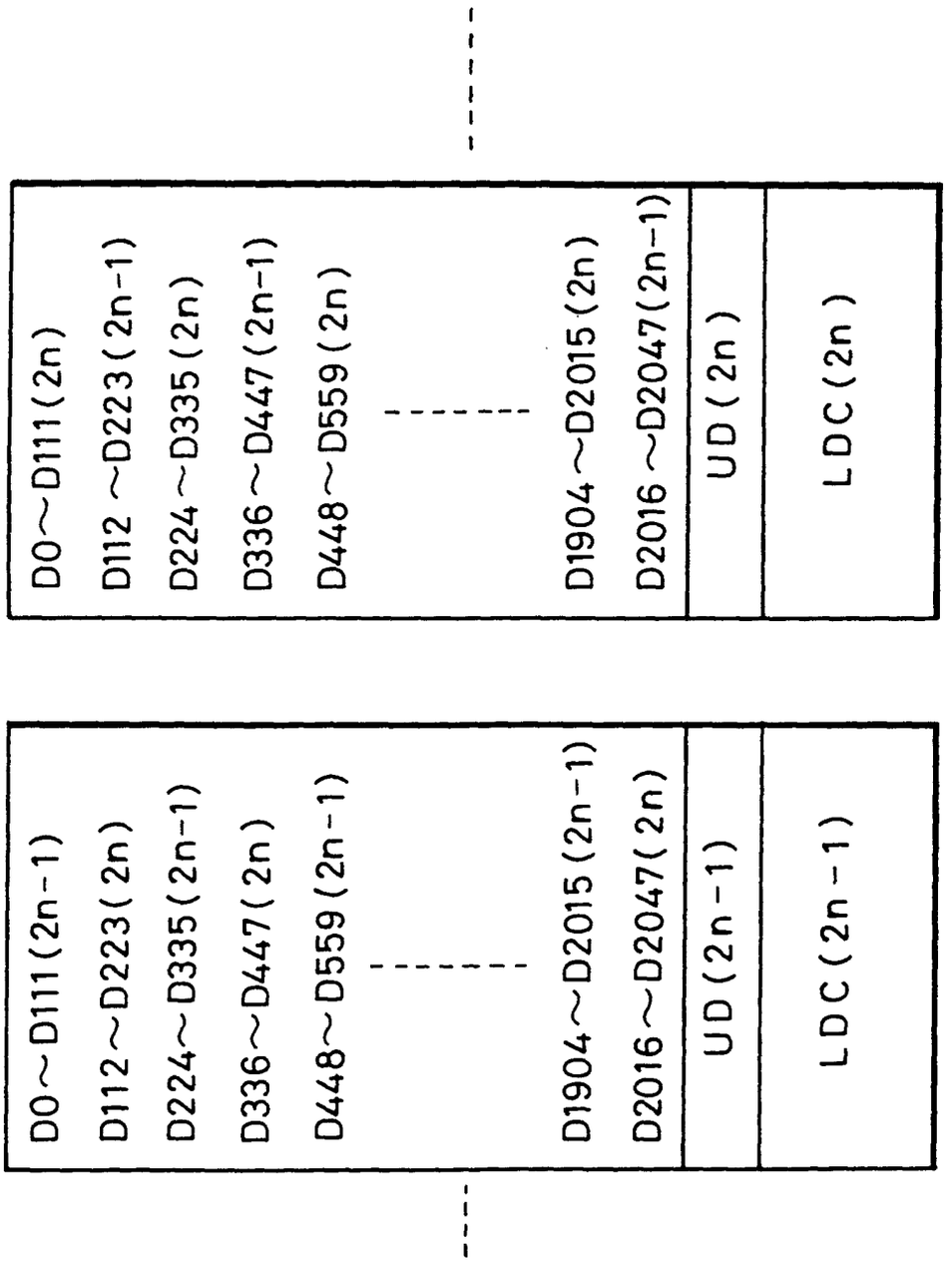

S2n-1
D0～D127(2n-1)
D128～D255(2n)
D256～D383(2n-1)
D384～D511(2n)
D512～D639(2n-1)
D1792～D1919(2n-1)
D1920～D2047(2n)
UD(2n-1)
LDC(2n-1)
S2n
D0～D127(2n)
D128～D255(2n-1)
D256～D383(2n)
D384～D511(2n-1)
D512～D639(2n)
D1792～D1919(2n)
D1920～D2047(2n-1)
UD(2n)
LDC(2n)

FIG. 20


S2n-1
D0～D111(2n-1)
D112～D223(2n)
D224～D335(2n-1)
D336～D447(2n)
D448～D559(2n-1)
D1904～D2015(2n-1)
D2016～D2047(2n)
UD(2n-1)
LDC(2n-1)
S2n
D0～D111(2n)
D112～D223(2n-1)
D224～D335(2n)
D336～D447(2n-1)
D448～D559(2n)
D1904～D2015(2n)
D2016～D2047(2n-1)
UD(2n)
LDC(2n)