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PATENT REQUEST: STANDARD PATENT

I/We, the Applicant(s)/Nominated Person(s) specified below, request I/We be granted a patent for the invention disclosed in the accompanying standard complete specification.

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[54] Invention Title:

Write Once Type Information Recording Medium, Method and Apparatus for Formatting the Same, and Method and Apparatus for Writing Data To or Reading Data From the Same

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NOTICE OF ENTITLEMENT

I, John Gordon Hinde, of Spruson & Ferguson, St Martins Tower, 31 Market Street, Sydney, New South Wales 2000, Australia, being the patent attorney for the Applicant(s)/Nominated Person(s) in respect of Application No 59024/94 state the following:-

The Applicant(s)/Nominated Person(s) has/have entitlement from the actual inventor(s) as follows:-

The Applicant(s)/Nominated Person(s) is/are the assignee(s) of the actual inventor(s).

The Applicant(s)/Nominated Person(s) is/are the applicant(s) of the basic application(s) listed on the Patent Request. The basic application(s) listed on the Patent Request is/are the first application(s) made in a Convention Country in respect of the invention.

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.....,.....  
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WRITE ONCE TYPE INFORMATION RECORDING MEDIUM, METHOD AND APPARATUS FOR  
FORMATTING THE SAME, AND METHOD AND APPARATUS FOR WRITING DATA TO OR READING  
DATA FROM THE SAME

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(57) Claim

1. A write once type information recording medium having a format that includes a plurality of sectors, each of said sectors including x p-bit frames, each of said p-bit frames comprising an f-bit synchronisation signal region; and a d-bit data region;

said recording medium further comprising a data recording format wherein the respective bits of an x-bit packet in which a v-bit error correction code has been added to u-bit data are distributed to said data regions of said x p-bit frames; and

where x, p, f, d, u and v are positive integers.

7. A data writing apparatus for writing data into a write once type recording medium having a format that includes sectors, each of the sectors including x p-bit frames, each of the frames containing an f-bit synchronization signal region and a d-bit data region, said data writing method comprising:

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a ROM (Read-Only-Memory) for previously storing a program to execute an initiating process of said data writing apparatus when a power supply of said data writing apparatus is turned ON;

a memory for storing at least one x-bit packet in which a v-bit error correction code has been added to u-bit data;

data writing means for writing the respective bits of said packet read out from said memory into said data regions of said x frames; and

output means for outputting a completion of said data writing operations after said data has been written; and where x, p, f, d, u and v are positive integers.

The present invention generally relates to a write once type information recording medium such as an optical memory card. More specifically, the present invention is 5 directed to a method and apparatus which is capable of formatting a write once type information recording medium with increasing storage efficiency, and which has the capability of correcting burst errors, to a write once type information recording medium formatted in accordance 10 with the above-mentioned format, and to a method and apparatus for writing data to or reading data from such a write once type information recording medium.

The need has been arisen to increase a data recording 15 density in view of an economical point when data are recorded on an information recording medium. However, when the data recording density is increased, errors occurring in the reproduced data can be increased because of, for instance, defects in the recording medium.

20 In general, to reduce errors in the reproduced data, an error correction code is added to the data during a data recording operation so as to perform the error correction. There are typically two different types of errors occurring in the reproduced data, namely, random errors occurring at random, and burst errors occurring in 25 a continuous manner. Once a burst error occurs, it can hardly be corrected owing to a large continuous errors included therein.

To make error correction feasible, interleaving is 30 carried out in a conventional information recording

system. That is, a series of data is subdivided into a large number of data segments which will then be distributed into the recording medium. In this case, even if positionally continuous errors occur on the recording 5 medium due to defects thereof, the errors are not continued on the reproduced data. As a result, these errors can be corrected as random errors.

Fig. 1 schematically represents an example of the conventional interleaving technique. In accordance with 10 the conventional interleaving method, 272 "synchronization signals for a frame and bit" (simply, referred to "synchronization signals") are first arranged, each of which is composed of 8 bits, for instance, and indicated by symbol "F" as illustrated in Fig. 1. Subsequently, a 15 272-bit packet "a", a 272-bit packet "b", a 272-bit packet "c", ---, a 272-bit packet "n" are arranged in parallel to each other, as illustrated in Fig. 1. The first 272-bit packet "a" contains 190-bit data consisting of a<sub>1</sub>, a<sub>2</sub>, ---, and a<sub>190</sub>, and an 82-bit error correction code consisting 20 of a<sub>191</sub>, a<sub>192</sub>, ---, and a<sub>272</sub>. Similarly, the second 272-bit packet "b" contains 190-bit data consisting of b<sub>1</sub> to b<sub>190</sub>, and an 82-bit error correction code consisting of b<sub>191</sub> to b<sub>272</sub>, and the third 272-bit packet "c" contains 25 190-bit data consisting of c<sub>1</sub> to c<sub>190</sub>, and an 82-bit error correction code consisting of c<sub>191</sub> to c<sub>272</sub>. Also, the final 272-bit packet "n" contains 190-bit data consisting of n<sub>1</sub> to n<sub>190</sub>, and an 82-bit error correction code consisting of n<sub>191</sub> to n<sub>272</sub>.

The 8-bit synchronization signals and the plurality of 30 packets, which have been arranged in the above-described

manner, are read in the direction indicated by arrows shown in Fig. 3 as follows. The reading operation is carried out sequentially from the synchronization signal F, the first bit a1 of the first packet "a", the first bit 5 b1 of the second packet "b", the first bit c1 of the third packet "c", and up to the first bit n1 of the last packet "n". Next, the reading operation is performed sequentially from the synchronization signal F, the second bit a2 of the first packet "a", the second bit b2 of the 10 second packet "b", the second bit c2 of the third packet "c", and up to the second bit n2 of the final packet "n". In this reading manner, the packets up to the 272-nd bit n272 of the last packet "n" are read out, and then they are rearranged as a bit stream as shown in Fig. 2.

15 Conventionally, such a rearranged bit stream is recorded on the information recording medium.

The bit stream, beginning from the synchronization signal "F" through a1 to n272, as shown in Fig. 2 is called a "sector". In the conventional recording medium with the above described recording format, the larger the 20 number of interleaving processes becomes (namely, the greater the quantity of packets becomes), the more error correction can be performed with respect to the burst error. However, the increasing number of interleaving processes requires a longer sector. Since various lengths 25 of data are normally recorded in a single sector, a long sector may include a useless storage capacity in case of short (small) data. Consider now the case where short data having three packets is stored into a long (large) 30 sector. As shown in Fig. 3, even if  $(8+273) \times 3$  bits data

from F, a1, b1, c1, F, a2, b2, c2, ---, up to F, a272, b272 and c272 is recorded in this large sector, a substantial sector portion will remain as a "non-recorded portion". Furthermore, if the fourth packet d1, d2, ---, 5 d272 is to be additionally recorded into this large sector, although the bit "d1" should be originally interleaved between the above bit c1 and the synchronization signal F, this bit "d1" cannot be interrupted between c1 and F since the bit c1 and the 10 synchronization signal F are consecutive. Similarly, the second bit "d2" of the fourth packet cannot be interrupted between the bit c2 and the synchronization signal F.

Although the overall portion of one sector may be rewritten in case of the rewritable type information recording medium, additional recording becomes practically difficult in case of the write once type information recording medium. Furthermore, additional writing of information into a non-recorded portion will reduce the error correction capability as compared with a case 20 wherein all frames of this recording medium are originally interleaved to be stored. This is because a single sector will be divided into more than two groups in such a case, and hence, the total number of interleaving processes is decreased.

25 As previously described, the conventional data recording medium posses a trade-off problem in that if a sector is set long, the useless unrecorded portion is increased, and therefore the recording efficiency is lowered, whereas if a sector is set short, the error 30 correction capability is reduced.

In the first aspect of the present invention, there is provided a write once type information recording medium having a format that includes a plurality of sectors, each of said sectors including  $x$  p-bit frames, each of said p-bit frames comprising an  $f$ -bit synchronisation signal region; and a  $d$ -bit data region;

5 said recording medium further comprising a data recording format wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$  p-bit frames; and

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

In the second aspect of the present invention, there is provided a method for formatting a write once type recording medium, by forming a plurality of sectors on the write once type recording medium, each of the sectors including  $x$  p-bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region, the method comprising the steps of:

20 writing each of said  $x$  synchronisation signals into a position separated by a  $d$ -bit region following the preceding synchronisation signal beginning from the first synchronisation signal at the starting position of the sector; and

25 writing each of said  $x$  data signals into said  $d$ -bit regions;

wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$  p-bit frames; and

30 where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

In the third aspect of the present invention, there is provided a method for writing data into a write once type



recording medium having a format that includes sectors, each of the sectors including  $x$  p-bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region, said method comprising:

5 a memory storage step for storing into a memory, at least one  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data; and

10 a data writing step for writing the respective bits of said packet read out from said memory into said data regions of said  $x$  frames; and

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

In the fourth aspect of the present invention, there is provided a method for reading data from a write once type recording medium having a format that includes sectors, each of the sectors including  $x$  p-bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region,

15 said recording medium further comprising a data recording format wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$  p-bit frames; and

20 said data reading method comprising:

a step for storing into a memory,  $x$  pieces of data read out from said data regions of said  $x$  frames;

25 a step for reading information in units of a single bit from said  $x$  pieces of data stored in said memory; and

a step for serially connecting the read information to construct an  $x$ -bit packet; and



where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

In the fifth aspect of the present invention, there is provided a formatting apparatus for formatting a write once type recording medium, by forming a plurality of sectors on the write once type recording medium, each of the sectors including  $x$   $p$ -bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region, the apparatus comprising:

10 a ROM (Read Only Memory) for previously storing a program to execute an initiating process of said formatting apparatus when a power supply of said formatting apparatus is turned ON;

15 input means for inputting an instruction of a format; synchronisation signal writing means for writing  $x$  pieces of said synchronisation signal into a position separated by a  $d$ -bit data region following the preceding synchronisation signal beginning from a first synchronisation signal at a starting position of a sector based upon said input of the format instruction; and

20 output means for outputting a completion of said format after said formatting operation has been accomplished; and

writing each of said  $x$  data signals into said  $d$ -bit regions;

25 wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$   $p$ -bit frames; and

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

30 In the sixth aspect of the present invention, there is provided a data writing apparatus for writing data into a write once type recording medium having a format that includes sectors, each of the sectors including  $x$   $p$ -bit



frames, each of the frames containing an f-bit synchronization signal region and a d-bit data region, said data writing method comprising:

5 a ROM (Read-Only-Memory) for previously storing a program to execute an initiating process of said data writing apparatus when a power supply of said data writing apparatus is turned ON;

10 a memory for storing at least one x-bit packet in which a v-bit error correction code has been added to u-bit data;

data writing means for writing the respective bits of said packet read out from said memory into said data regions of said x frames; and

15 output means for outputting a completion of said data writing operations after said data has been written; and

where x, p, f, d, u and v are positive integers.

In the seventh aspect of the present invention, there is provided a data reading apparatus for reading data from a write once type recording medium having a format that 20 includes sectors, each of the sectors including x p-b frames, each of the frames containing an f-bit synchronization signal region and a d-bit region, said recording medium further comprising a data recording format wherein the respective bits of an x-bit packet in which a v-bit error correction code has been added to u-bit data are 25 distributed to said data regions of said x p-bit frames; and said data reading apparatus comprising:

a ROM (Read-Only-Memory) for previously storing a program to execute an initiating process of said data



reading apparatus when a power supply of said data reading apparatus is turned ON;

a memory for storing x pieces of data read out from said data regions of said x frames; and

5 reading means for reading information from said x pieces of data stored in said memory in unit of a single bit; and

where x, p, f and d, u and v are positive integers.

The above and other effects, features and advantages 10 of the present invention will become more apparent from the following description of embodiments thereof taken in conjunction with the accompanying drawings.

Fig. 1 is a diagram for explaining a conventional interleaving process;

15 Fig. 2 schematically indicates an example of the conventional sector structure;

Fig. 3 schematically illustrates another example of the conventional sector structure;

20 Fig. 4 schematically shows an example of the arrangement of frames and a sector in the recording format of a write once type information recording medium according to the present invention;

Fig. 5 schematically represents another example of the arrangement of frames and a sector in the recording format 25 of the write once type information recording medium shown in Fig. 4;

Fig. 6 is a hardware block diagram schematically showing a first embodiment of a formatting apparatus and a



data reading/writing apparatus, according to the present invention;

5 Fig. 7 is a flow chart for explaining a formatting operation executed in the first formatting apparatus and the first data reading/writing apparatus according to the present invention;

Fig. 8 is a diagram schematically illustrating a memory map of a memory incorporated in the controller employed in the apparatus of Fig. 7;

10 Fig. 9 is a schematic block diagram showing the processing circuit of the memory shown in Fig. 8;

Figs. 10A and 10B are explanatory diagrams of a scratched optical memory card; and

15 Fig. 11 is a hardware block diagram schematically showing a second embodiment of a formatting apparatus and a data reading/writing apparatus according to the present invention.

20 Referring now to the drawings, various preferred embodiments of the present invention will be described in detail.

#### Embodiment 1

25 In Fig. 4, there is shown one concrete example of a recording format employed in the present invention. As shown in this drawing, a single sector is formed by serially arranging 272 pieces of 48-bit frames (usually, x pieces of frames with 48 bits). A 48-bit (usually, p bits) frame contains an 8-bit (usually, f bits) synchronization signal "F" placed at the leading portion,

and maximum 40 bits (usually, p-f bits) of data and an error correction code following the synchronization signal "F". In other words, one sector is constructed of 48X272 bits (usually, px bits).

5 Both the data and the error correction codes are recorded in such a memory region whose capacity is an integer multiple of the bit size of a single packet, where the integer is 1 - 40. A single packet includes 190-bit (usually, u-bit) data and an 82-bit (usually, v-bit) error  
10 correction code.

When the data is short, consisting of three packets as illustrated in Fig. 5, for example, the synchronization signal "F", and the three bits "a1", "b1", "c1" are recorded in frame 1. Similarly, the synchronization signal "F", and the three bits "a2", "b2", "c2" are recorded in frame 2, and finally the synchronization signal "F", and the three bits "a272", "b272", "c272" are recorded in frame 272. As will be apparent from Fig. 5, an additionally writable non-recorded portion is left in each of these 272 frames. When a packet 4 is additionally written, the bit "d1" of the fourth package is additionally written following to the bit c1 within the frame 1, which already has the synchronization signal "F". Similarly, the other bits "d2", "d3", ---, "d272" of the fourth packed are successively written after the preceding bits "c2", "c3", --, "c272".

25 Fig. 6 is a block diagram schematically showing a first embodiment of the hardware arrangement of an apparatus for formatting the above-described write once  
30 type recording medium of Fig. 4, according to the present

invention. In the formatting apparatus of Fig. 6, reference numeral 602 designates a CPU (central processing unit) for controlling the overall arrangement of this formatting apparatus. Reference numeral 604 denotes a ROM (read-only memory) for previously storing a program for executing an initializing process when the power supply (not shown) of the formatting apparatus is turned ON.

5 Reference numeral 606 denotes a RAM (random access memory) for temporarily storing data required during the operation 10 of the program. Reference numeral 608 denotes an input

means for inputting instructions of the formatting operation, such as a keyboard, a mouse, and a communication device. Reference numeral 614 denotes a driver for a write once type information recording medium,

15 which formats the write once type information recording medium, and for writing data to and reading data from this recording medium. Reference numeral 610 is an output means for outputting information to a user, such as a CRT (cathode-ray tube), an LCD (liquid crystal display), and a

20 communication device. Reference numeral 612 denotes a controller for controlling the driver 614 for a write once type information recording medium in response to the 25 instructions issued from the CPU 602.

Referring now to a flow chart of Fig. 7, a description 30 will be made of a formatting operation of the formatting apparatus shown in Fig. 6. At the first step S702 of this flow chart, the instruction for the formatting operation by the formatting apparatus is inputted. Then, at step S704, CPU 602 judges via the controller 612 whether or not a write once type information recording medium is inserted

into the driver 614. If a write once type information recording medium is not inserted into the driver 614, this state is supplied to the output means 610 at step S706 and then the process terminates. On the other hand, when a 5 write once type information recording medium is inserted into the driver 614, the CPU 602 instructs the controller 612 to move the head of the driver 614 to a predetermined track (S708). Subsequently, the first f-bit synchronization signal "F" is written to the starting 10 position of a first sector on this track of the recording medium (S710). Furthermore, the second f-bit synchronization signal "F" is written into the position, which is adjacent to the first f-bit synchronization signal F and is separated by a p-bit data region (S712). 15 The writing operation of the synchronization signal F is repeated until the synchronization signals F are written into the entire (x pieces of) frames in this sector which is being formatted (S714).

When x pieces of synchronization signals F have been 20 written into this sector, another x pieces of synchronization signals F will be similarly written into the next sector (from S710 to S714). The CPU 602 handles 25 as a single sector the region from the starting position of the first synchronization signal to the end position of the p-bit data following the x-th synchronization signal. It should be noted that the sector number or the like may be written into the starting position of the respective sectors. When the CPU 602 conforms that x pieces of synchronization signals F have been written into all of 30 the sectors within this track (S750), the CPU 602 makes

further judgment as to whether or not all of the desired tracks have been formatted (S760). When all of the desired tracks have not yet been formatted, the head of the diver 614 is transported to the succeeding track to 5 commence the formatting operation of this track (from S708 to S750) under the control of the CPU 602. In contrast, when all of these desired tracks have been formatted, this process operation is completed (S760).

An embodiment of data reading/writing apparatus and a 10 method for reading data from and writing data to the above-explained write once type information recording medium, in accordance with the present invention, will now be described with reference to Figs. 8 and 9. A hardware block diagram of this data reading/writing apparatus is 15 identical to the above-explained hardware block diagram of the formatting apparatus shown in Fig. 6. It should be noticed, however, that in order to increase the data read and write speed, a data memory having a memory capacity corresponding to a single track, and a memory processing circuit may be employed in the controller 612 of the data 20 reading/writing apparatus, which will be described in more detail.

Fig. 8 shows the memory map of a memory, which stores data contained in a single track. One code word in the 25 row (horizontal) direction is composed of 272 bits, and 40 code words are arranged in the column (vertical) direction, one code word consisting of 190-bit data and an 82-bit error correction code. Fig. 9 is a schematic block diagram of a memory processing circuit having the memory map shown in Fig. 8. This memory processing circuit 30

performs recording and reproducing operations using an optical memory card as the write once type information recording medium.

First, the data recording operation will be described.

5 An encoder 901 produces error correction codes so that the data sent from CPU 602 are provided with the error correction codes, and then stored into a memory 902 in the form shown in Fig. 8. For instance, the row "a" (a1 to a272) shown in Fig. 8 is stored into the memory 902 as 10 follows: First, a switch 906 is connected to the "a" side, and the data sent from CPU 602 are sequentially stored into the row "a" of the memory 902 as bits a1, a2, a3, ---, a190. Thereafter, the switch 906 is connected to the "b" side, and the 82-bit error correction code 15 produced by the encoder 901 is supplied to the bits a191 - a272 of the memory 902.

The above-explained operation is successively and repeatedly performed with respect to the remaining rows "b" to "n" of the memory 902, so that both of the error correction codes and the data of all of the rows "a" to 20 "n" are stored into the memory 902. Then, the data which have been stored into the memory 902 in the form of Fig. 8, are retrieved from this memory in the vertical direction as shown in Fig. 8, and are encoded by an 25 encoder 903 into a data form recordable on an optical memory card. These data of the necessary rows together with the synchronization signals are stored into the optical memory card.

Next, a data reproducing operation from the optical 30 memory card will now be explained. The data in the

optical memory card have been stored by the above-described recording operation. The data read out from the optical memory card is decoded into a digital signal by a decoder 904. The digital signal is stored into the memory 902 in the vertical direction in such a manner that they are arranged in accordance with the memory map of Fig. 8. Subsequently, the data is retrieved from the memory 902 in the horizontal direction and is supplied to the decoder 905, and which processes the data in accordance with the error correction method. Thus, the error-corrected data is sent to the CPU 602 as reproduction data.

The above-described data recording/reproducing methods can achieve the effective error correction not only when scratches 10a are made in the optical memory card 908 in a uniform distribution as illustrated in Fig. 10A, (in this case, error corrections are carried out even in the conventional recording format), but also when scratches 10a are concentratedly made at one place as shown in Fig. 10B,. In particular, the error correction capability will be considerably increased in the case of a short sector, as compared with the conventional error correction method.

#### Embodiment 2

Fig. 11, is a schematic block diagram showing a second embodiment of a hardware arrangement for a formatting apparatus and a data input/output device according to of the present invention. As is shown in this drawing, the second embodiment includes a host interface 1120 in accordance with SCSI or SASI which can be used as an input means and an output means instead of the input means 608

and the output means 610 of the formatting apparatus and the data input/output apparatus of the first embodiment. In addition, all or a part of the function of the controller 612 may be replaced by a CPU 1102, a ROM 1104, 5 and a RAM 1106. Furthermore, the controller 612 may be interposed between a write once type recording medium driver 1114 and the CPU 1102. Alternatively, a communication interface with LAN (local area network), WAN 10 (wide area network), or public network may be substituted for the host interface 1120, so that the interface is used 15 as the input means and the output means.

As previously explained in detail, in accordance with the present invention, the bit storage efficiency to the frame can be increased. Also, the sector of a large size 15 can be selected. As a consequence, the data recording efficiency and the error correction capability can be improved. Moreover, data can be additionally written on a sector without dividing it.

The present invention has been described in detail 20 with respect to preferred embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and 25 it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.

The claims defining the invention are as follows:

1. A write once type information recording medium having a format that includes a plurality of sectors, each of said sectors including  $x$  p-bit frames, each of said p-bit frames comprising an  $f$ -bit synchronisation signal region; and a  $d$ -bit data region;

5 said recording medium further comprising a data recording format wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$  p-bit frames; and

10 where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

15 2. A method for formatting a write once type recording medium, by forming a plurality of sectors on the write once type recording medium, each of the sectors including  $x$  p-bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region, the method comprising the steps of:

20 writing each of said  $x$  synchronisation signals into a position separated by a  $d$ -bit region following the preceding synchronisation signal beginning from the first synchronisation signal at the starting position of the sector; and

25 writing each of said  $x$  data signals into said  $d$ -bit regions;

30 wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$  p-bit frames; and

35 where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

3. A method for writing data into a write once type recording medium having a format that includes sectors, each of the sectors including  $x$  p-bit frames, each of the frames



containing an f-bit synchronisation signal region and a d-bit data region, said method comprising:

5 a memory storage step for storing into a memory, at least one x-bit packet in which a v-bit error correction code has been added to u-bit data; and

a data writing step for writing the respective bits of said packet read out from said memory into said data regions of said x frames; and

where x, p, f, d, u and v are positive integers.

10 4. The data writing method as claimed in claim 3, wherein:

said memory storage step includes a step for storing said at least one packet into a plurality of memories; and

15 said data writing step includes a step for writing an n-th bit of each packet into an n-th frame; and

where x, p, f, d, u and v are positive integers.

20 5. A method for reading data from a write once type recording medium having a format that includes sectors, each of the sectors including x p-bit frames, each of the frames containing an f-bit synchronisation signal region and a d-bit data region,

25 said recording medium further comprising a data recording format wherein the respective bits of an x-bit packet in which a v-bit error correction code has been added to u-bit data are distributed to said data regions of said x p-bit frames; and

said data reading method comprising:

a step for storing into a memory, x pieces of data read out from said data regions of said x frames;



a step for reading information in units of a single bit from said  $x$  pieces of data stored in said memory; and

a step for serially connecting the read information to construct an  $x$ -bit packet; and

5 where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

6. A formatting apparatus for formatting a write once type recording medium, by forming a plurality of sectors on the write once type recording medium, each of the 10 sectors including  $x$   $p$ -bit frames, each of the frames containing an  $f$ -bit synchronisation signal region and a  $d$ -bit data region, the apparatus comprising:

a ROM (Read Only Memory) for previously storing a program to execute an initiating process of said formatting 15 apparatus when a power supply of said formatting apparatus is turned ON;

input means for inputting an instruction of a format; synchronisation signal writing means for writing  $x$  pieces of said synchronisation signal into a position 20 separated by a  $d$ -bit data region following the preceding synchronisation signal beginning from a first synchronisation signal at a starting position of a sector based upon said input of the format instruction; and

25 output means for outputting a completion of said format after said formatting operation has been accomplished; and

writing each of said  $x$  data signals into said  $d$ -bit regions;

30 wherein the respective bits of an  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data are distributed to said data regions of said  $x$   $p$ -bit frames; and

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.



7. A data writing apparatus for writing data into a write once type recording medium having a format that includes sectors, each of the sectors including  $x$  p-bit frames, each of the frames containing an  $f$ -bit synchronization signal region and a  $d$ -bit data region, said data writing method comprising:

a ROM (Read-Only-Memory) for previously storing a program to execute an initiating process of said data writing apparatus when a power supply of said data writing apparatus is turned ON;

a memory for storing at least one  $x$ -bit packet in which a  $v$ -bit error correction code has been added to  $u$ -bit data;

data writing means for writing the respective bits of said packet read out from said memory into said data regions of said  $x$  frames; and

output means for outputting a completion of said data writing operations after said data has been written; and

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

8. The data writing apparatus as claimed in claim 7 wherein:

said memory has a memory capacity capable of storing a plurality of packets; and

said data writing means includes a means for writing an  $n$ -th bit of each of said plural packets stored in said memory into an  $n$ -th frame;

where  $x$ ,  $p$ ,  $f$ ,  $d$ ,  $u$  and  $v$  are positive integers.

9. A data reading apparatus for reading data from a write once type recording medium having a format that



includes sectors, each of the sectors including x p-bit frames, each of the frames containing an f-bit synchronization signal region and a d-bit region, said recording medium further comprising a data recording format 5 wherein the respective bits of an x-bit packet in which a v-bit error correction code has been added to u-bit data are distributed to said data regions of said x p-bit frames; and said data reading apparatus comprising:

10 a ROM (Read-Only-Memory) for previously storing a program to execute an initiating process of said data reading apparatus when a power supply of said data reading apparatus is turned ON;

15 a memory for storing x pieces of data read out from said data regions of said x frames; and

20 reading means for reading information from said x pieces of data stored in said memory in unit of a single bit; and

where x, p, f and d, u and v are positive integers.

10. The write once type information recording medium 20 as claimed in claim 1 wherein:

said frame number "x" per said sector is selected to be 272;

said bit number "p" of the frame is selected to be 48;

25 said bit number "f" of the synchronizing signal region is selected to be 8; and

said bit number "d" of the data region is selected to be 40.

11. The write one type information recording medium as claimed in claim 1 wherein:

said frame number "x" per said sector is selected to be 272;

    said bit number "p" of the frame is selected to be 48;

    said bit number "f" of the synchronizing signal region 5 is selected to be 8;

    said bit number "d" of the data region is selected to be 40;

    said bit number "u" of the data is selected to be 190; and

10      said bit number "v" of the error correction code is selected to be 82.

12.     The formatting method as claimed in claim 2 wherein:

15      said frame number "x" per said sector is selected to be 272;

    said bit number "p" of the frame is selected to be 48;

    said bit number "f" of the synchronizing signal region is selected to be 8; and

20      said bit number "d" of the data region is selected to be 40.

13.     The writing method as claimed in claim 3 wherein:

25      said frame number "x" per sector is selected to be 272;

    said bit number "p" of the frame is selected to be 48;

    said bit number "f" of the synchronizing signal region is selected to be 8;

said bit number "d" of the data region is selected to be 40;

      said bit number "u" of the data is selected to be 190;

      said bit number "v" of said error correction code is 5 selected to be 82.

14. The reading method as claimed in claim 5  
wherein:

      said frame number "x" per said sector is selected to 10 be 272;

      said bit number "p" of the frame is selected to be 48;

      said bit number "f" of the synchronizing signal region is selected to be 8; and

      said bit number "d" of the data region is selected to 15 be 40.

15. The formatting apparatus as claimed in claim 6  
wherein:

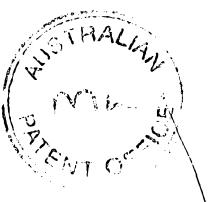
      said frame number "x" per said sector is selected to 20 be 272; and

      said bit number "p" of the frame is selected to be 48;

      said bit number "f" of the synchronization signal region is selected to be 8; and

      said bit number "d" of the data region is selected to 25 be 40.

16. The writing apparatus as claimed in claim 7  
wherein:



said frame number "x" per sector is selected to be 272;

said bit number "p" of the frame is selected to be 48;

5 said bit number "f" of the synchronization signal region is selected to be 8;

said bit number "d" of the data region is selected to be 40.

said bit number "u" of the data is selected to be 190; and

10 said bit number "v" of the said error correction code is selected to be 82.

17. The reading apparatus as claimed in claim 9 wherein:

15 said frame number "x" per said sector is selected to be 272;

said bit number "p" of the frame is selected to be 48;

said bit number "f" of the synchronization signal region is selected to be 8; and

20 said bit number "d" of the data region is selected to be 40.

18. A write once type information recording medium substantially as herein described with reference to Fig. 4.

25

19. A write once type information recording medium substantially as herein described with reference to Fig. 5.

20. A formatting apparatus substantially as herein described with reference to Figs. 6, 7, 8 and 9.

21. A formatting apparatus substantially as herein  
5 described with reference to Fig. 11.

DATED this Twentieth Day of March 1997

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Nippon Conlux Co., Ltd.

### Patent Attorneys for the Applicant

SPRUSON & FERGUSON

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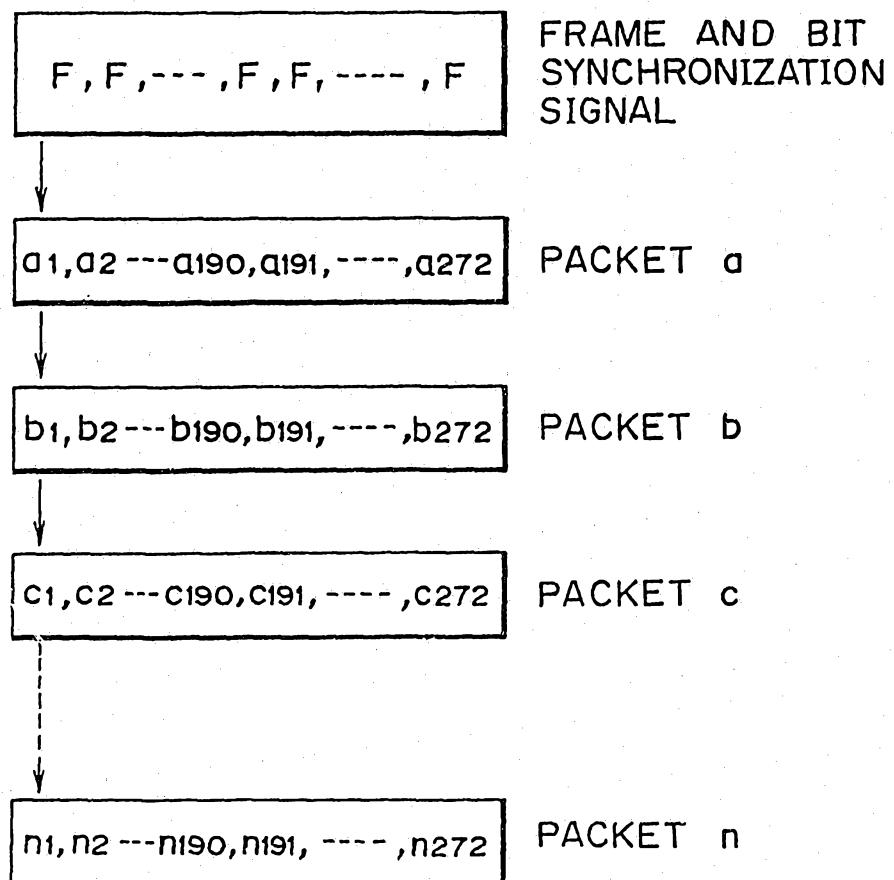
WRITE ONCE TYPE INFORMATION RECORDING MEDIUM, METHOD AND APPARATUS FOR  
FORMATTING THE SAME, AND METHOD AND APPARATUS FOR WRITING DATA TO OR  
READING DATA FROM THE SAME

Abstract

A write once type information recording medium having a recording format that includes sectors (500). Each 5 sector includes  $x$  pieces of  $p$ -bit frames (510). Each frame contains an  $f$ -bit synchronization signal region (512) and a  $d$ -bit data region (514). Each bit of at least one  $x$ -bit packet (a, b, c, ..., n) in which a  $v$ -bit error correction code has been added to  $u$ -bit data, is 10 distributed to each one of the data regions (514) of the  $x$  pieces of frames (510). This makes it possible for the write once type information recording medium to have an increased data storage efficiency and an effective error correction capability for a burst error.

15

Figure 5.



**FIG. 1 (PRIOR ART)**

23 03 94 59024

F,a<sub>1</sub>,b<sub>1</sub>,c<sub>1</sub>,----n<sub>1</sub>,F,a<sub>2</sub>,b<sub>2</sub>,c<sub>2</sub>,----,n<sub>2</sub> ----,F,a<sub>272</sub>,b<sub>272</sub>,c<sub>272</sub>,----,n<sub>272</sub>

SECTOR

**FIG.2 (PRIOR ART)**

F,a<sub>1</sub>,b<sub>1</sub>,c<sub>1</sub>, F,a<sub>2</sub>,b<sub>2</sub>,c<sub>2</sub> ----- F,a<sub>272</sub>,b<sub>272</sub>,c<sub>272</sub>

UNRECORDED  
PORTION

SECTOR

**FIG.3 (PRIOR ART)**

23 03 94 59024

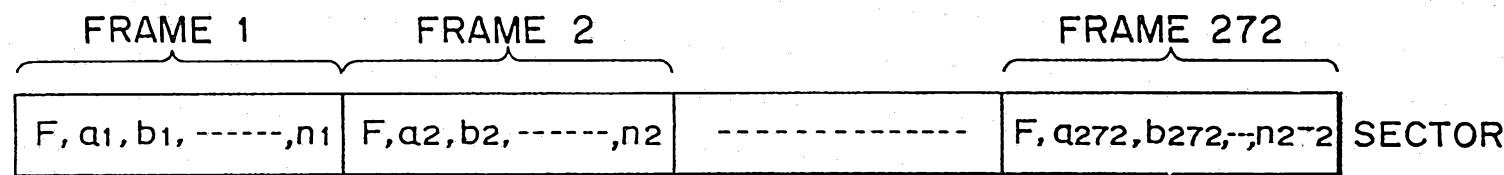
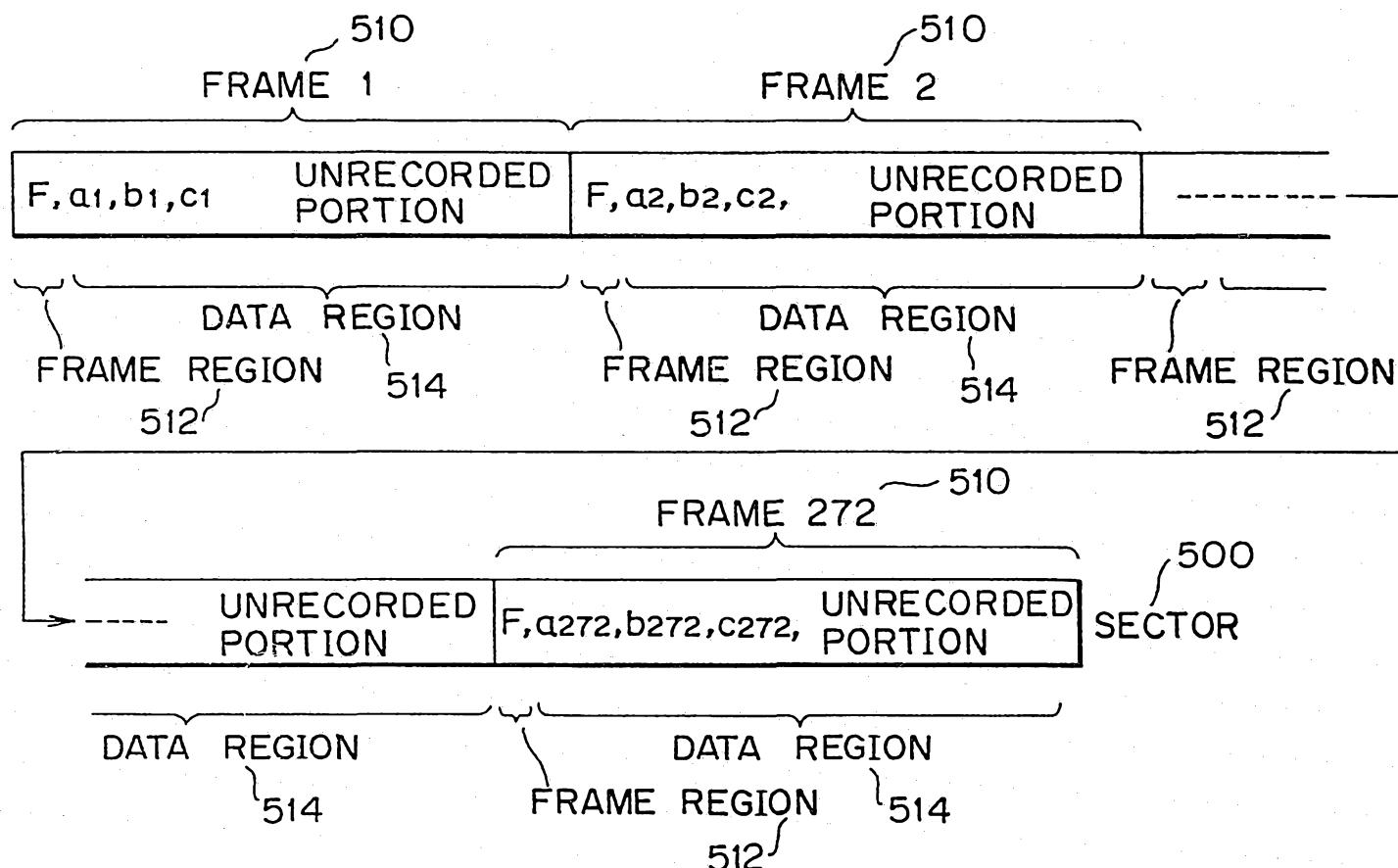


FIG.4

59024 | 94

23 03 94 59024



**FIG. 5**

23 03 94 59026

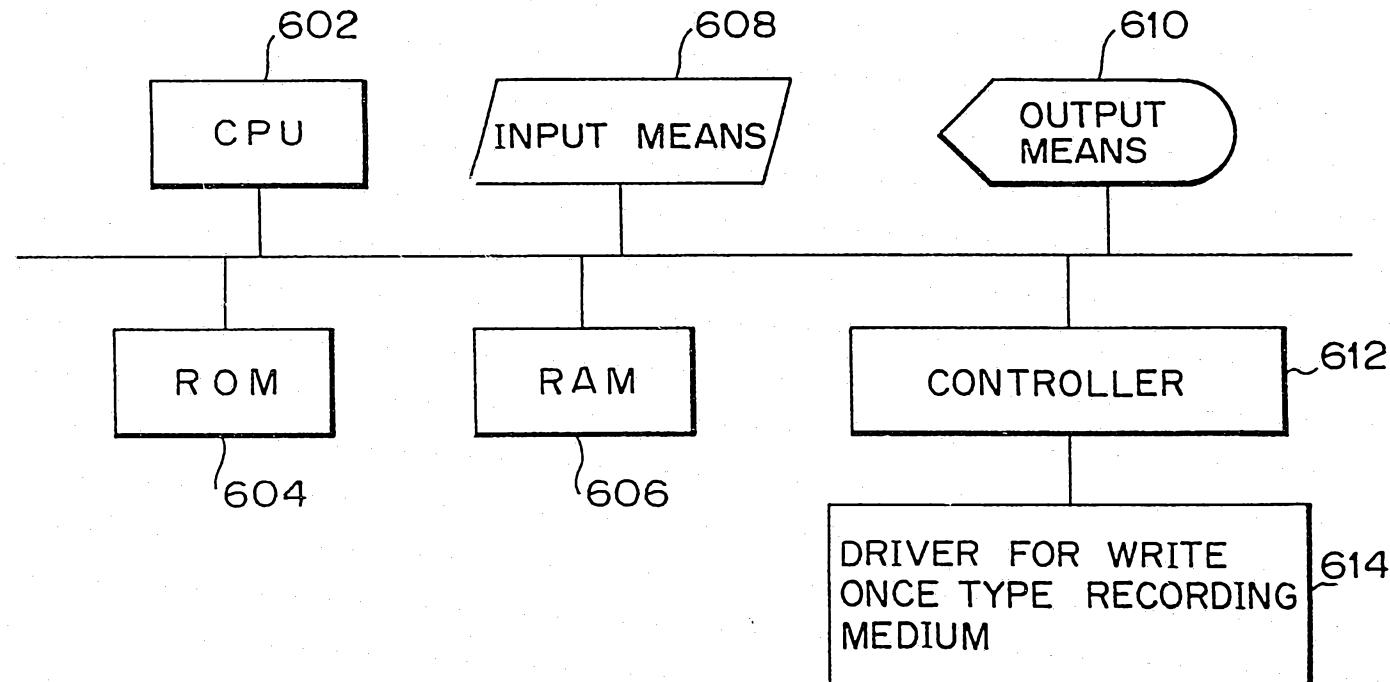


FIG.6

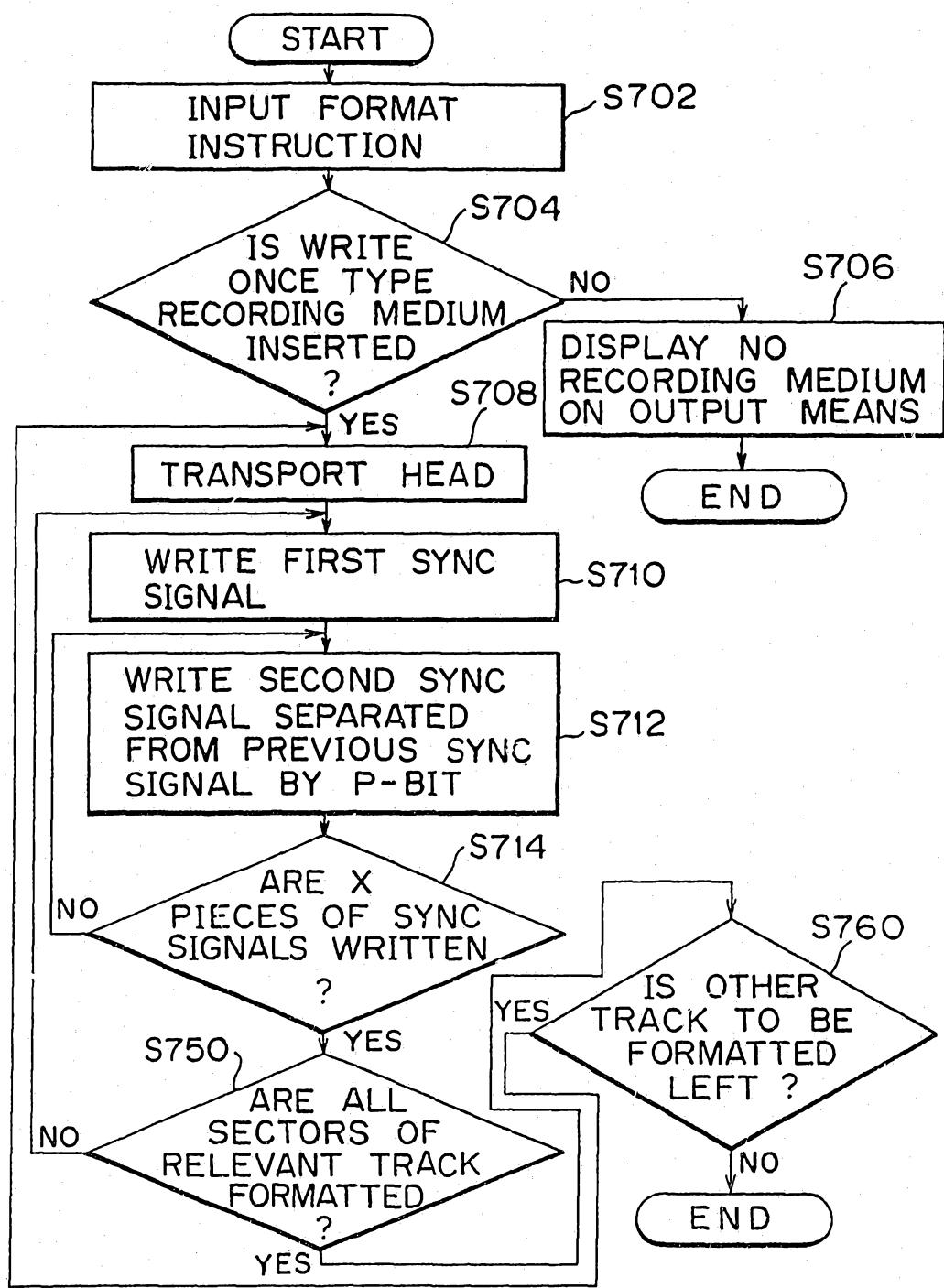


FIG. 7

23 03 94 59024

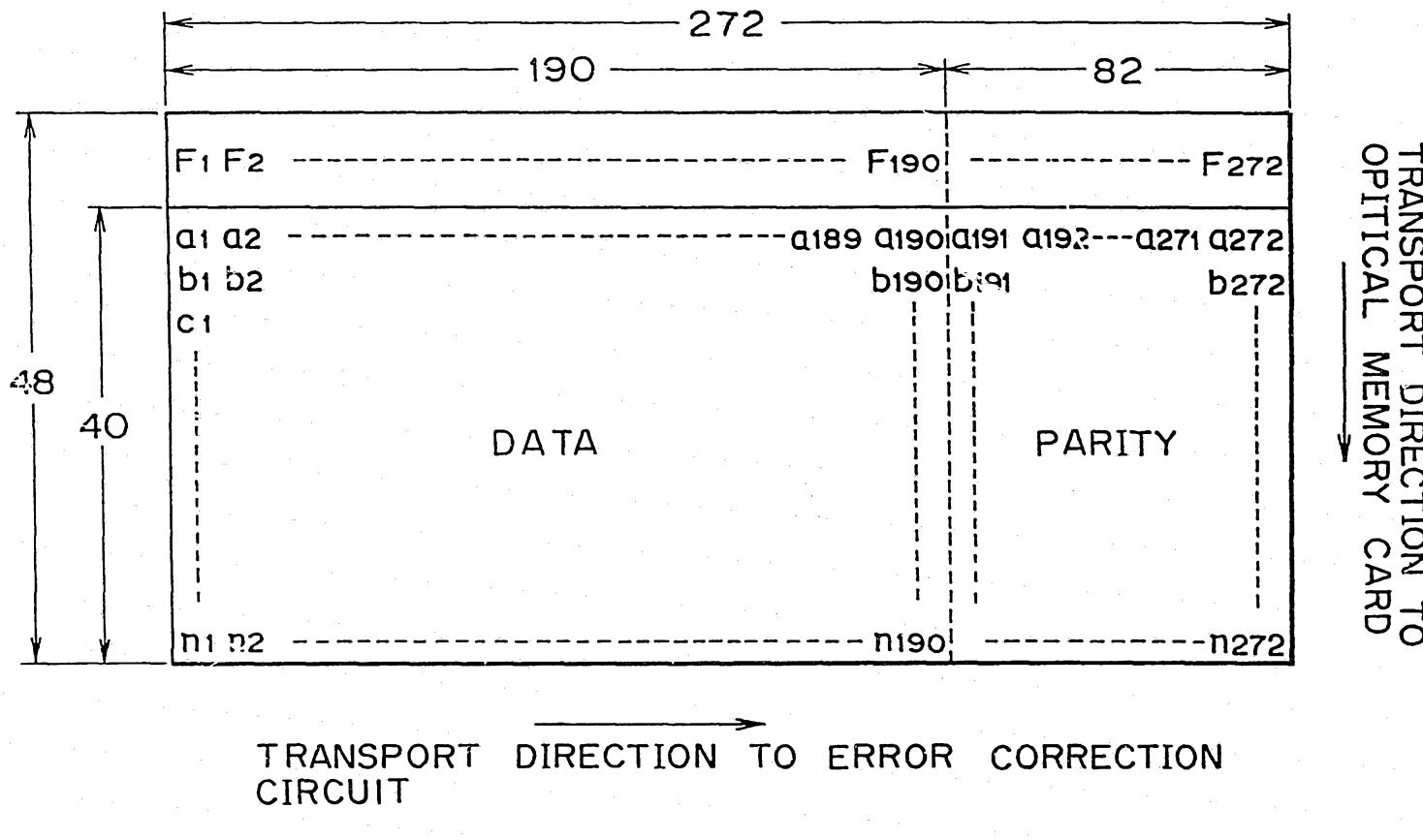


FIG.8

23 03 94 59024

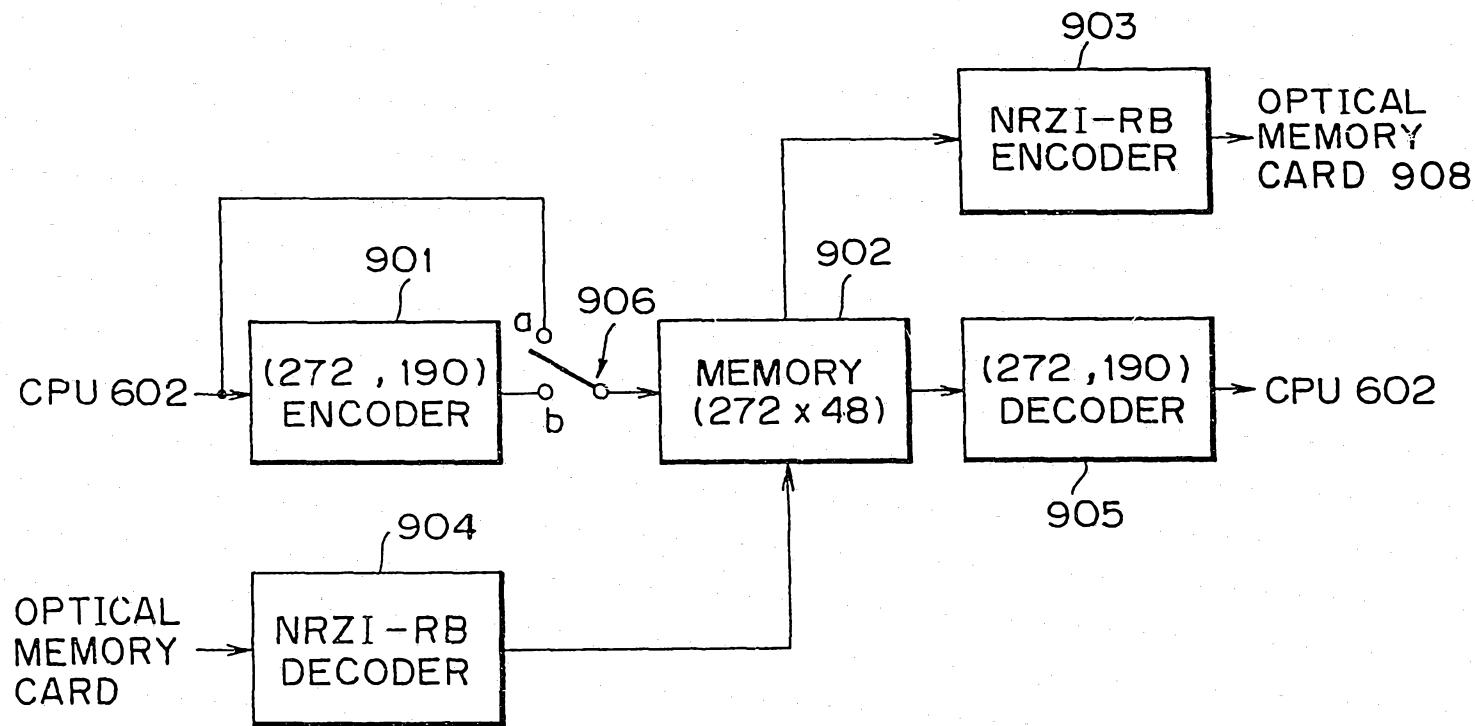
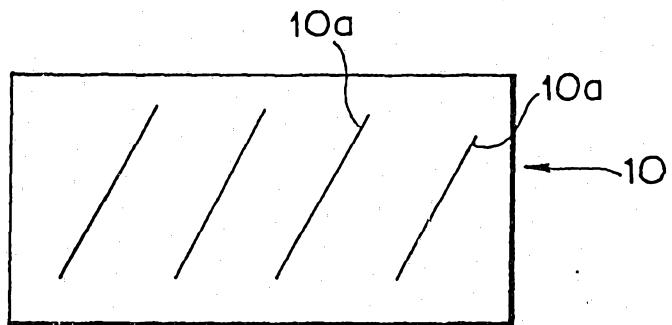
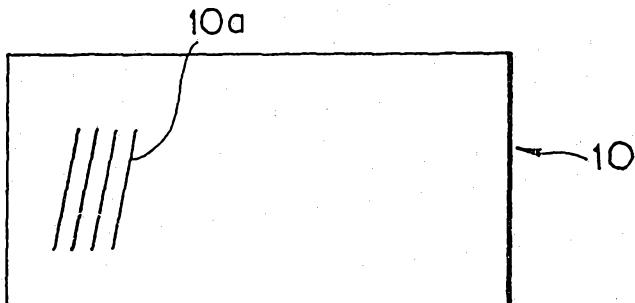


FIG.9



UNIFORMLY DISTRIBUTED SCRATCHES

**FIG.10A**



CONCENTRATED SCRATCHES

**FIG.10B**

23 03 94 5902k

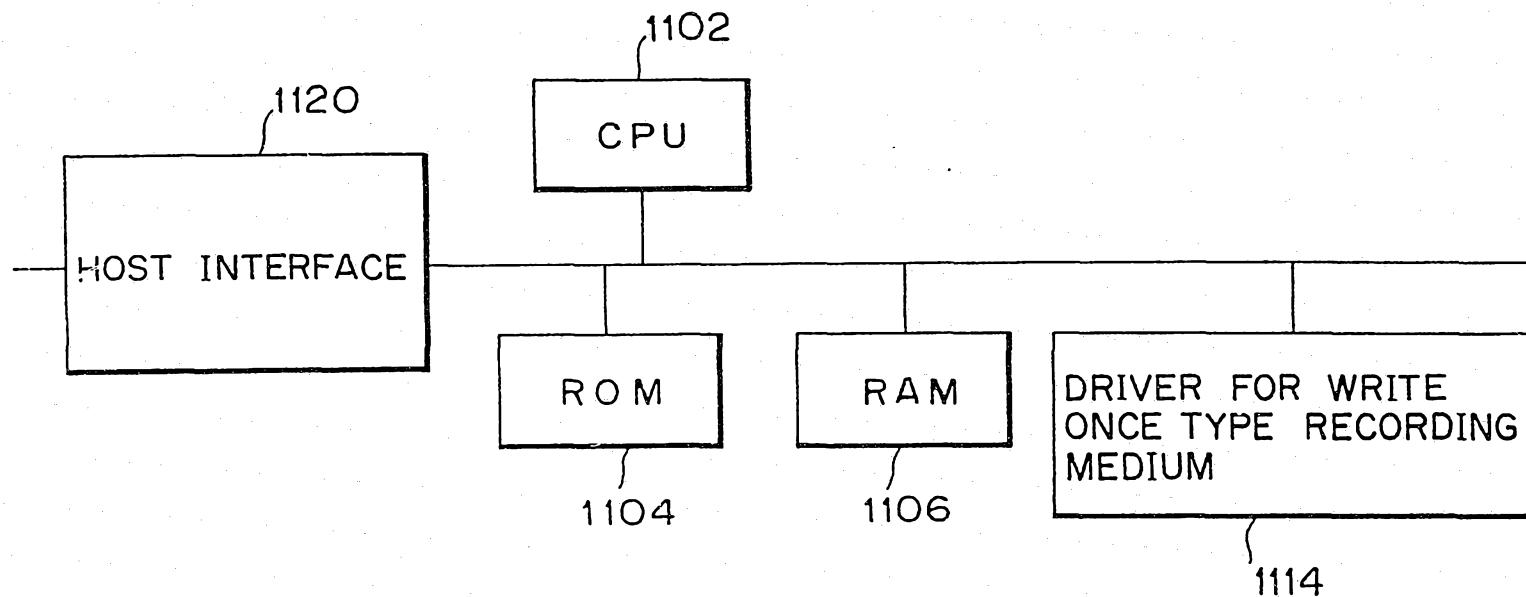


FIG.11