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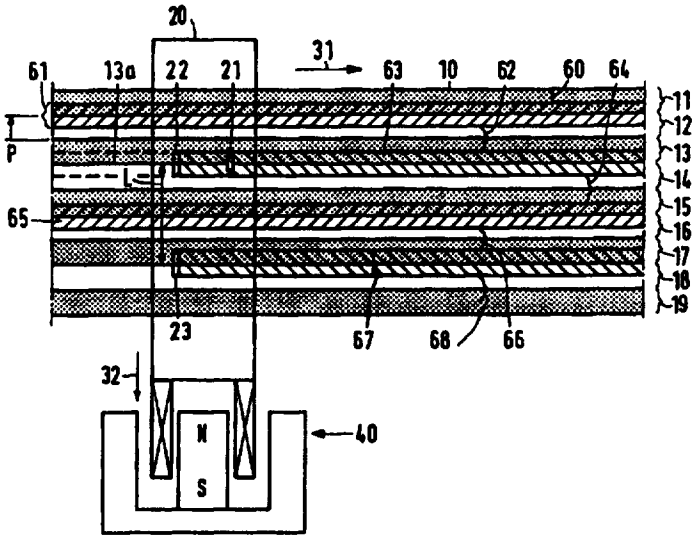

(57) Abstract

The system comprises a magnetic tape (10), a magnetic-head unit (20) and an actuator (40). The magnetic tape (10) has servo tracks (11-19) containing servo signals. The servo signals have been written with a magnetic head, not shown, having a comparatively large gap length. As a result, the servo signals are recorded deep into the magnetic tape (10). The magnetic-head unit (20) comprises a read head (21) and a write head (22) to inscribe the track (63), the read head following a bounding line (13a) between adjacent servo tracks (13 and 14) in response to the servo signals read from said servo tracks (13 and 14) by the read head (21). The system in accordance with the invention is characterized in that it comprises control means which determine the sequence in which the information tracks (61-68) are written, the read head (21) either following a track (61 or 63) between two respective non-overwritten parts (60 and 62 or 62 and 64) of the magnetic tape (10), or following a track (62 or 64) between two respective overwritten parts (61 and 63 or 63 and 65) of the magnetic tape (10).

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System, apparatus and method for recording and reproducing information.

The invention relates to a system for recording and/or reproducing information, comprising a magnetizable medium provided with a pattern of servo tracks containing servo signals in the form of a deep recorded magnetization pattern, and an apparatus comprising a magnetic-head unit comprising a read head, means for relatively moving the medium with respect to the magnetic-head unit in a direction along the servo tracks, an actuator for relatively moving the magnetic-head unit with respect to the medium in a direction transverse to the servo tracks, a servo circuit arranged between the read head and the actuator and adapted to make the read head follow a bounding line between two adjacent servo tracks in response to the servo signals read from said servo tracks by the read head, which apparatus is adapted to write information signals in information tracks over the servo signals in the servo tracks.

The invention also relates to an apparatus for use in such a system.

The invention further relates to a method of writing information signals in information tracks on a magnetizable medium provided with a pattern of servo tracks containing servo signals in the form of a deep recorded magnetization pattern, a read head following a bounding line between two adjacent servo tracks in response to the servo signals read from said servo tracks by the read head.

A magnetic recording system is known from US 4,318,141, which uses buried servo or track-position-indication signals for the purpose of tracking. To record servo signals a magnetic head having a relatively large gap length is used, so as to enable the servo signals to be recorded to a large depth in the recording medium. For the storage of information signals a magnetic head having a relatively small gap length is used. Thus, the information signals are stored in a less deep part of the recording medium. The servo signals are stored in servo tracks, two adjacent servo tracks each storing a servo signal of a different frequency. A read head can be made to follow the bounding line between two adjacent servo tracks by positioning the read head by means of an actuator in such a manner that frequencies of the same amplitude are read. A disadvantage of the known system is that the

read head does not always exactly follow the bounding line between two servo tracks in the case that a recording medium has been provided only partly with information signals.

It is an object of the invention to provide a system, an apparatus and a method for recording and/or reproducing information, wherein the read head follows the bounding line between two servo tracks with comparatively high accuracy.

The system in accordance with the invention is characterized in that the apparatus comprises control means for writing the information tracks in a sequence in which the read head either follows a track between two non-overwritten parts of the medium or follows a track between two overwritten parts of the medium.

The invention is based on the recognition of the fact that the read head not only reads signals from the track followed by the read head but also reads signals from parts of the medium which directly adjoin the track. This is particularly so in the case that the last-mentioned signals are low-frequency signals, as is customary for servo signals. In the case that an information signal has already been written to one side of the track to be followed and no information signal has been written yet to the other side of the track to be followed, the read head will not accurately follow the boundary area between two servo tracks. This is caused by the fact that when an information signal is written the underlying servo signal is attenuated in that it is overwritten with the information signal in the upper part of the magnetizable medium. Since the read head also reads parts of the medium which directly adjoin the track, which is referred to as the side reading effect, the amplitude of the servo signal of the partly overwritten servo track will be smaller than the amplitude of the non-overwritten servo track if the center of the read head is at the bounding line between the two servo tracks. The servo system will position the center of the read head off the bounding line between the two servo tracks so as to equalize the amplitudes of the two servo signals in the adjacent servo tracks. The measure in accordance with the invention ensures that in the parts adjacent the track to be followed the servo signal either is not overwritten, i.e. not attenuated, in both parts or is overwritten, i.e. attenuated, in both parts. As a result, the signal from both parts read with the side reading effect are read with equal amplitudes and the center of the read head is accurately positioned on the bounding line between the servo tracks.

An embodiment of the system in accordance with the invention is characterized in that the magnetic head unit comprises a write head coupled to the read head to inscribe the track followed by the read head. By having the read head and the write head

follow the same track the dimension of the magnetizable medium in a direction transverse to the tracks can be utilized completely for the storage of information. This measure further enables such a magnetic-head unit to be used for writing on media having mutually different distances between the bounding lines formed between the servo tracks.

An embodiment of the system in accordance with the invention is characterized in that the magnetic-head unit comprises a plurality of write heads , the center distance between adjacent write heads is equal to four times the center distance between adjacent information tracks, and the control means are adapted to write four adjacent and consecutively numbered information tracks by means of one write head in the sequence first track, third track, second track and fourth track. In order to simplify the manufacture of the magnetic-head unit it is preferable to arrange the write heads at some distance from one another. However, large a mutual distance also has disadvantages. As a matter of fact, it has been found that a magnetizable medium having a plastics base, such as for example a magnetic tape, contracts and expands in a direction transverse to the tracks as a result of humidity and temperature influences. As a consequence, the center distance between the information tracks on such a medium will also vary. If the magnetic-head unit comprises a plurality of magnetic heads the distance between these write heads will vary to a substantially smaller extent. This may lead to a mismatch between the center distance of the information tracks and the center distance of the write heads. It has been found that the above measures keep such a mismatch within acceptable limits even when eight write heads are used.

An embodiment of the system in accordance with the invention is characterized in that the magnetic-head unit comprises eight write heads. It has been found that this measure forms a satisfactory compromise between the complexity of the apparatus and the speed with which information can be written on the magnetizable medium.

The apparatus in accordance with the invention comprises a magnetic-head unit comprising a read head, means for relatively moving the medium with respect to the magnetic-head unit in a direction along the servo tracks, an actuator for moving the magnetic-head unit in a direction transverse to the servo tracks, a servo circuit arranged between the read head and the actuator and adapted to make the read head follow a bounding line between two adjacent servo tracks in response to the servo signals read from said servo tracks by the read head, and control means for writing information tracks over the servo tracks in a sequence in which the read head either follows a track between two non-overwritten parts of the medium or follows a track between two overwritten parts of the medium.

The method in accordance with the invention is characterized in that the information tracks are written in a sequence in which the read head either follows a track between two non-overwritten parts of the medium or follows a track between two overwritten parts of the medium.

The invention will now be described in more detail, by way of example, with reference to the drawings, in which

Figure 1 shows diagrammatically the system in accordance with the invention,

Figure 2 illustrates the recording of information signals on a magnetizable medium in an embodiment of the system in accordance with the invention,

Figure 3 shows the sequence in which information signals are written on a magnetizable medium in another embodiment of the system in accordance with the invention, and

Figure 4 shows a magnetic-head unit for a further embodiment of the system in accordance with the invention.

Figure 1 shows diagrammatically the system in accordance with the invention. The system comprises an apparatus 100 and a magnetizable medium, in the present case a magnetic tape 10. The magnetic tape 10 has been provided with a pattern of servo tracks 11-19 containing servo signals in the form of a deep recorded magnetization pattern (see Figure 2). The apparatus 100 (see Figure 2). The apparatus 100 comprises a magnetic-head unit 20 and means, in the present case a motor 30, for relatively moving the magnetic tape 10 with respect to the magnetic-head unit 20 in a direction 31 along the servo tracks (see Figure 2). The apparatus 100 further comprises an actuator 40 for moving the magnetic-head unit 20 transversely to the servo tracks and a servo circuit 50 arranged between the magnetic-head unit 20 and the actuator 40. The apparatus 100 comprises control means, in the present case a microcomputer 70, for controlling the actuator 40 and the magnetic-head unit 20.

Figure 2 shows diagrammatically a magnetizable medium in the form of the magnetic tape 10, the magnetic-head unit 20 and the actuator 40. The magnetic tape 10 has been provided with a pattern of servo tracks 11-19 containing servo signals. The servo signals have been recorded with a magnetic head, not shown, having a comparatively large gap length. As a result, the servo signals are stored deep into the magnetic tape 10. The

servo tracks having odd reference numerals contain a servo signal of a first frequency, and the servo tracks having even reference numerals contain a servo signal of a second frequency. The magnetic-head unit 20 comprises a read head 21 and a write head 22 coupled to the read head 21 in order to inscribe the track 63 followed by the read head. The apparatus 100 as shown in Figure 1 is constructed to write information signals in information tracks 61-68. To position the information tracks 61-68 the apparatus 100 comprises a servo circuit 50 (see figure 1). The servo circuit 50 is arranged between the read head 21 and the actuator 40 and is adapted to make the read head 21 follow a bounding line 13a between two adjacent servo tracks, in the present case 13 and 14, in response to the servo signals read from the servo tracks 13 and 14 by the read head 21. In accordance with the method described comprehensively in US 4,318,141 the servo circuit 50 then controls the actuator 40 in such a manner that the read head 21 reproduces the first and the second frequency with the same amplitude. This is normally so if the center of the read head 21 follows a bounding line 13a between two adjacent servo tracks 13 and 14. The system in accordance with the invention is characterized in that the apparatus 100 comprises control means 70 (see Figure 1) which determine the sequence in which the information tracks 61-68, the read head 21 following a track 61 or 63 between two respective non-overwritten parts 60 and 62 or 62 and 64 of the magnetic tape 10, or a track 62 or 64 between two respective overwritten parts 61 and 63 or 63 and 65 of the magnetic tape 10.

The magnetic-head unit 20 in Figure 2 comprise a plurality of write heads, in the present case a write head 22 and a write head 23. The center distance L between the adjacent write heads 22 and 23 is equal to four times the center distance P two adjacent information tracks. In the embodiment of the system in accordance with the invention as shown in Figure 2 the control means 70 (see Figure 1) are adapted to write four adjacent and consecutively numbered information tracks 61, 62, 63 and 64 by means of the write head 22. In addition, the control means 70 is adapted to write another four adjacent and consecutively numbered information tracks 65, 66, 67 and 68 by means of the write head 23. The control means 70 are further adapted to record said information tracks in the sequence 61 simultaneously with 65, 63 simultaneously with 67, 62 simultaneously with 66, and 64 simultaneously with 68.

Figure 3 shows a magnetizable medium, in the present case a magnetic tape 80, and a magnetic-head unit 120 comprising a read head 121 and a write head 122 in a further embodiment of the system in accordance with the invention. The magnetic tape 80 has information tracks TR1 to TR11. The information tracks TR1 to TR11 have been written

over servo tracks, not shown, in a manner as described with reference to Figure 1 and Figure 2. In this further embodiment of the system in accordance with the invention the information tracks TR1 to TR11 have also been written in a sequence in which the read head 121 either follows a track between two non-overwritten parts of the magnetic tape 80 or a track between two overwritten parts of the magnetic tape 80. This is achieved in that under control of control means, not shown, the read head 121 follows a path indicated by arrows 123 when recording information signals by means of the write head 122. This path is such that the information tracks TR1 to TR11 are written in the sequence: TR1, TR3, TR5, TR7, TR9, TR11, TR10, TR8, TR6, TR4 and TR2.

Figure 4 shows a magnetic-head unit 220 in another embodiment of the system in accordance with the invention. The magnetic-head unit 220 comprises eight write heads 222. This enables eight information tracks to be recorded simultaneously. The magnetic-head unit 220 further comprises eight read heads 221. The read heads 221 are arranged in such a manner that they each follow the same track together with one of the write heads 222.

It is to be noted that the invention is not limited to the embodiments shown. Various other embodiments are possible within the scope of the invention. For example, instead of a magnetic tape a magnetic disc may be used. Moreover, the microcomputer 70 may be replaced by an analog circuit.

It is to be noted that the invention is particularly suitable to cope with the side reading effect in thin-film magnetic heads having a magnetoresistive transducing element. This is caused by the fact that such a magnetoresistive transducing element is very susceptible to the side reading effect described above, particularly if the servo signals have been stored on the medium as long-wave magnetization patterns.

CLAIMS:

1. A system for recording and/or reproducing information, comprising
- a magnetizable medium (10) provided with a pattern of servo tracks (11-19) containing servo signals in the form of a deep recorded magnetization pattern, and
- an apparatus (100) comprising
- a magnetic-head unit (20) comprising a read head (21),
- means (30) for relatively moving the medium with respect to the magnetic-head unit in a direction (31) along the servo tracks,
- an actuator (40) for relatively moving the magnetic-head unit with respect to the medium in a direction (32) transverse to the servo tracks,
- a servo circuit (50) arranged between the read head and the actuator and adapted to make the read head follow a bounding line (13a) between two adjacent servo tracks (13, 14) in response to the servo signals read from said servo tracks by the read head,
- which apparatus is adapted to write information signals in information tracks (61, 65) over the servo signals in the servo tracks,

characterized in that the apparatus comprises control means (70) for writing the information tracks (61-68) in a sequence in which the read head either follows a track between two non-overwritten parts (62, 64) of the medium or follows a track between two overwritten parts (61, 63) of the medium.

2. A system as claimed in Claim 1, characterized in that
- the magnetic head unit (20) comprises a write head (22) coupled to the read head (21) to inscribe the track (63) followed by the read head.

3. A system as claimed in any one of the preceding Claims, characterized in that
- the magnetic-head unit (20) comprises a plurality of write heads (22, 23),
- the center distance (L) between adjacent write heads is equal to four times the center distance (P) between adjacent information tracks (61, 62), and

- the control means (70) are adapted to write four adjacent and consecutively numbered information tracks (61, 62, 63, 64) by means of one write head (22) in the sequence first track (61), third track (63), second track (62) and fourth track (64).

4. A system as claimed in Claim 3, characterized in that the magnetic-head unit (120) comprises eight write heads (122).

5. An apparatus (100) comprising

- a magnetic-head unit (20) comprising a read head (21),
- means (30) for relatively moving the medium with respect to the magnetic-head unit in a direction (31) along the servo tracks,
- an actuator (40) for relatively moving the magnetic-head unit with respect to the medium in a direction (32) transverse to the servo tracks,
- a servo circuit (50) arranged between the read head and the actuator and adapted to make the read head follow a bounding line (13a) between two adjacent servo tracks (13, 14) in response to the servo signals read from said servo tracks by the read head,
- which apparatus is adapted to write information signals in information tracks (61, 65) over the servo signals in the servo tracks,

characterized in that the apparatus comprises control means (70) for writing the information tracks (61-68, TR1-TR11) in a sequence in which the read head (21) either follows a track between two non-overwritten parts (62, 64) of the medium or follows a track between two overwritten parts (61, 63) of the medium.

6. A method of writing information signals in information tracks on a magnetizable medium (10) provided with a pattern of servo tracks (11-19) containing servo signals in the form of a deep recorded magnetization pattern, a read head (21) following a bounding line (13) between two adjacent servo tracks (11, 12) in response to the servo signals read from said servo tracks by the read head,

characterized in that the information tracks (61, 62) are written in a sequence in which the read head either follows a track between two non-overwritten parts (62, 64) of the medium or follows a track between two overwritten parts (61, 63) of the medium.

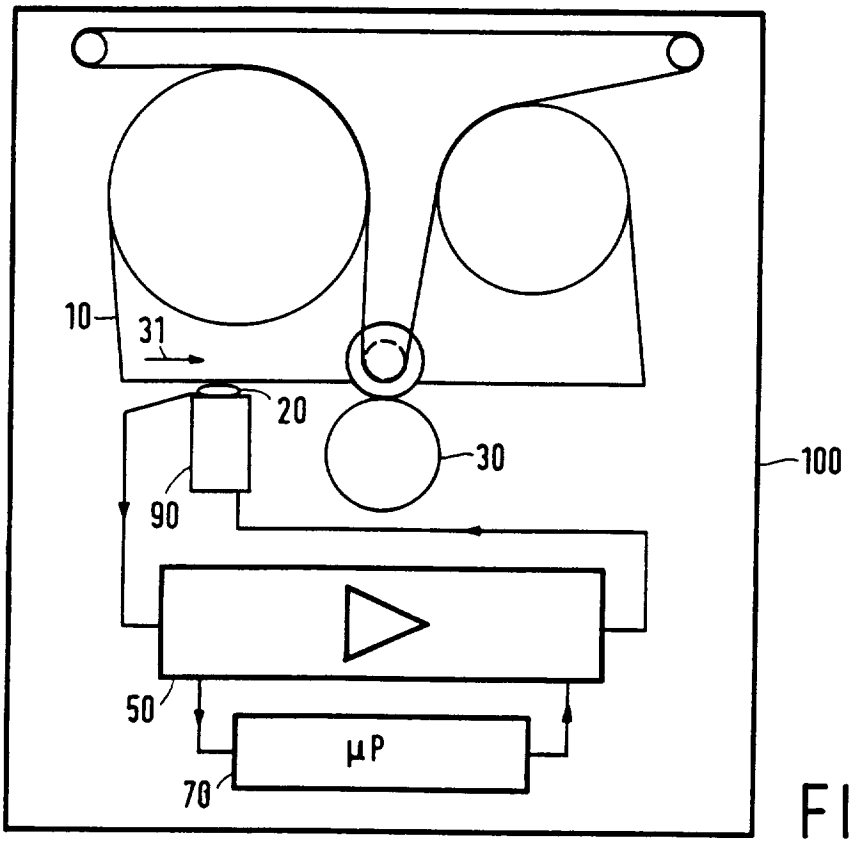
10
31
20
30
100
90
50
μP
70

FIG.1

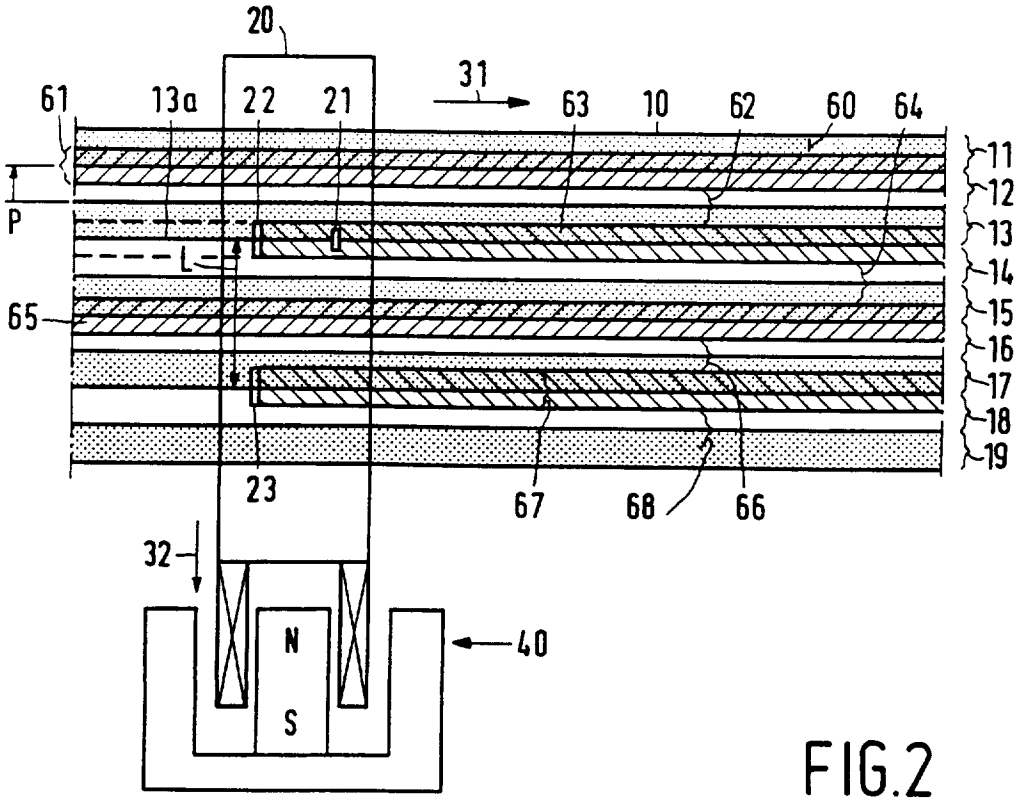
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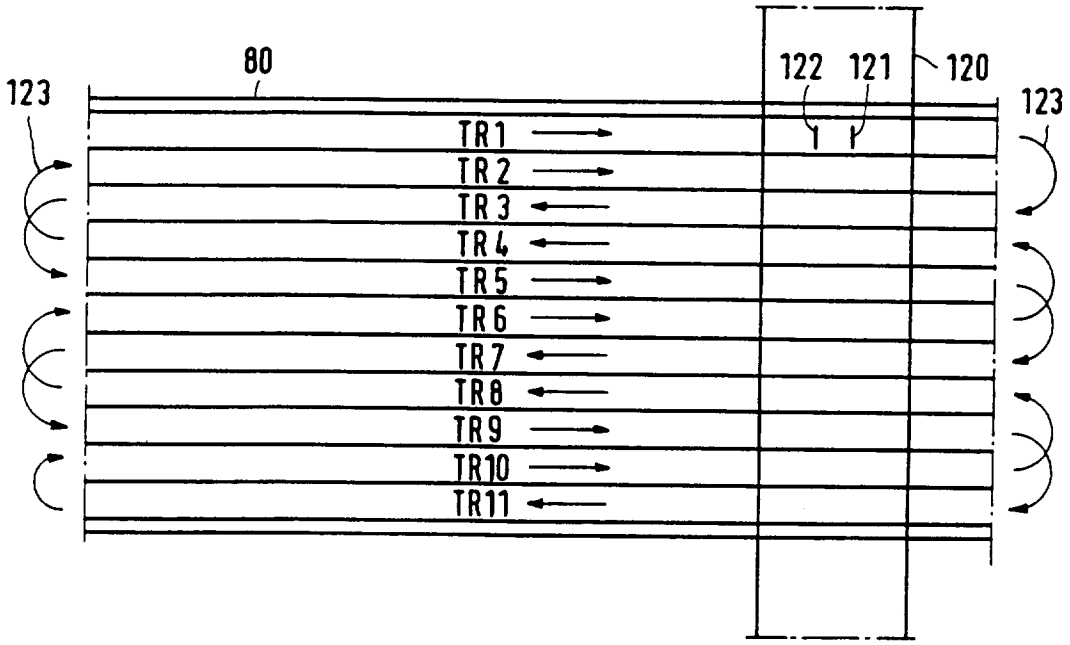
FIG.2


80
122
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TR2
TR3
TR4
TR5
TR6
TR7
TR8
TR9
TR10
TR11

FIG.3

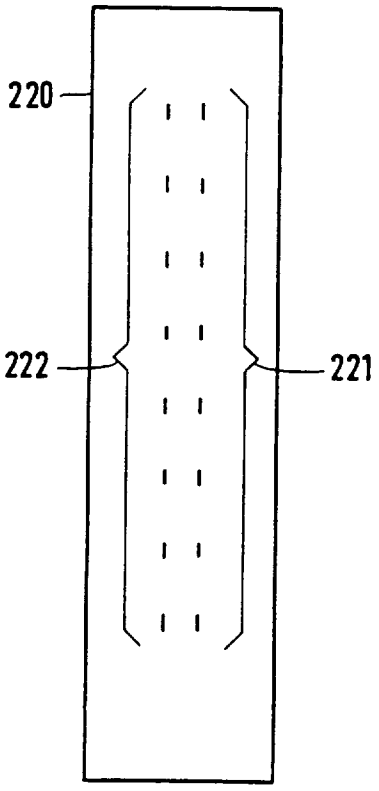
220
222
221

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 96/01154

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 5/584
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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

EDOC, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5291348 A (COPOLILLO), 1 March 1994 (01.03.94), column 4, line 6 - column 7, line 11 --	1-6
A	US 4318141 A (HAYNES), 2 March 1982 (02.03.82), Cited in the application -- --------	1-6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

03/02/97

International application No.
PCT/IB 96/01154

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 5291348	01/03/94	NONE	
US-A- 4318141	02/03/82	CA-A- 1149508	05/07/83
		EP-A,B- 0030644	24/06/81
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