The present invention relates to a data medium which can be optically recorded along a track whose elements are materialized in a surface by pre-engraved patterns. Typically, such a data medium can be in the form of a disk whose photosensitive surface is scanned by an optical beam along a spiral trajectory whose pitch is of the order of one micron. The invention of course equally covers the case of a track whose elements are constituted by concentric circles. The photosensitive surface is scanned by a light spot of very small dimensions which is used for recording data along a turn, for example in the form of surface irregularities. In order to assign the recording spot a precise position in the photosensitive surface, each turn is marked out with pre-engraved patterns which can also be in the form of surface irregularities. The pre-engraved patterns generally result from the method of manufacturing the data medium and because of this their implantation complies with a particular format which defines areas reserved for the recording of data and, alternating with these, pre-engraved zones which share the available space. This particular arrangement is advantageous as the post-engraving of a data medium for the purpose of placing useful data on it has no effect on the service data contained in the pre-engraving.

Service data is understood to be that which enables the data to be correctly located along the track and also that which enables, a priori, the organization by means of appropriate addresses of the dividing up of the memory plane into compartments.

The present invention relates more particularly to the pre-engraved structure which enables the reading or writing spot to remain centred on the axis of the track and which supplies the reference time points enabling the sampling of the signals taking account of their position along the track.

In the case of monospot scanning, it is convenient to provide a pre-engraved structure having off-centre patterns in order to have a track following error

signal obtained by the taking of samples and by comparison. Such a structure furthermore comprises patterns enabling the fixing of the sampling time points, in order that the track following error signal has the appropriate sign for maintaining a good centring of the spot in relation to the track. These auxiliary patterns can be oversized with respect to the reading spot in order that they may be easily distinguished from the other patterns available on the data medium, but this solution complicates the carrying out of the pre-engraving. Because of this one is lead not to oversize the auxiliary patterns but to distinguish them by dividing up according to an exclusive code.

A pre-engraved structure including an arrangement of patterns organized as mentioned above has been described in patent applications lodged in France on 12th March 1982 in the name of THOMSON-CSF, with reference numbers 82 04218, 82 04219, 82 04220 and 82 04221. Pre-engraved structures having off set patterns are also described in the documents EP-A-0 077 641, EP-A-0 077642, EP-A-0 077 643 and EP-A-0 077 644 published on the 27th April 1983.

The pre-engraved structures referred to above occupy a certain space on the data medium which thereby reduces the space available for the storing of useful data. In these known structures, the patterns intended for synchronization are placed in front of those which are used for ensuring track following, which uselessly elongates the pre-engraved area.

In order to overcome this disadvantage, the invention proposes a compact pre-engraving structure using patterns which link together the track following and synchronization functions.

The subject of the invention is a data medium which can be optically recorded along a track which is marked out with pre-engraved zones alternating with areas for recording useful data, each of the said pre-engraved zones comprising at least two patterns having leading and trailing edges, the said patterns enabling the detection

of track following errors when being scanned optically one after the other by means of a reader spot by interaction with at least one portion of the pattern off-centre in relation to the longitudinal axis of the said track and a time base setting signal resulting from the interaction of the spot with at least two leading edges and two trailing edges, characterized in that at least one of the said patterns has the said off-centre portion of pattern associated with at least one edge of a pair of leading and trailing edges paired with one pair of leading and trailing edges defining along the track axis two predetermined distances, each of them being included between two consecutive multiples of the data recording pitch.

The subject of the invention is also an optical track following device using such a data medium.

The invention will be better understood by means of the following description and of the appended figures in which:

Figure 1 is an isometric view of a data medium including a pre-engraving and essential units of a monospot device enabling the recording and the optical reading of useful data in reserved areas of a track to be followed.

Figure 2 shows a pre-engraved structure of known type together with the associated readout signals.

Figure 3 is an explanatory diagram.

Figure 4 shows a first example of a pre-engraved structure according to the invention.

Figure 5 shows a second example of a pre-engraved structure according to the invention.

Figure 6 to 9 show other examples of pre-engraved structures according to the invention.

Figure 10 is the electrical block diagram of a device enabling the reading of data media produced according to the invention.

Figure 11 shows another variant of pre-engraving according to the invention.

In Figure 1 there can be seen a data medium, for

example in the form a disk, including a layer support 1 which is permeable to optical radiation and a photosensitive structure 2 whose interaction with an optical recording radiation enables the transcription of the incident data. By way of non-limitative example, the upper surface of the layer support 1 comprises a hollow engraving formed from micropits 10, 11, 12, 13, 14, which form a pre-engraved relief. This relief is covered with a photosensitive structure 2 which closely follows the shape and which comprises the deposit of a sub-layer of thermodegradable organic material and a thin metallic coating. This coating can resist the heating produced by the impact of an optical recording beam but it distorts locally above a certain optical power threshold in order to give rise to a bubble representative of the data which was used to modulate the optical recording beam. The invention is not limited to the case of photosensitive bubble structures but also relates to other known photosensitive structures, particularly those where the impact of an optical beam causes an ablation, the rupture of a diazo compound, a change of physical state or the creation of a latent image. Each micropit or each bubble constitutes a pre-engraved or post-engraved pattern. This pattern is demarcated on the sensitive surface of the data medium by a closed contour and the assembly of patterns forms the two-dimensional dividing up of this surface into compartments. The annular area reserved for the storage of data is generally contained between the periphery 4 of the data medium and an inner circumference 5. It is subdivided into sections of track having a radial width l and pitch p. Each section of track in Figure 1 is contained between two dotted lines 6 and 7 which are the turns of two interleaved spirals whose centre is in principle located on the axis of rotation Z. The centring of the data medium is provided by a centring hole 3 whose bore, in principle centred in relation to the spirals, corresponds to a bearing provided on the rotary pin 15 of the drive motor 16. Another subdivision of the annular area 4, 5 is provided according to a set

of radii 8 and 9 which alternately define the angular sectors D and S. The angular sectors D are allocated for the storage of useful data, while the angular sectors S are reserved for pre-engraved patterns enabling, in particular, the showing up of an optical track following error. It must be understood that the structure of the data medium shown in Figure 1 actually comprises a very large number of track elements and a very large number of sectors. The size of the sectors S has been exaggerated in Figure 1 as the invention relates to the detail and arrangement of these sectors. It is also useful to state that the pit shape of the patterns 10 to 14 and the expression "pre-engraved" do not limit in any way the extent of the invention.

It is in fact possible to consider patterns having no relief but being differentiated from the environment by a differences in optical density or by a change of optical reflectivity. The advantage of the hollow or protruding pre-engraving is at the data medium manufacturing level. In fact, the layer support 1 is a copy in relief of a die manufactured using the technique of exposing a photo resist. A glass blank provided with a layer of photosensitive resin is placed in a recording machine which uses, for the exposure, a laser beam which is modulated in intensity and appropriately focussed. The laser beam produces a light spot which is generally circular and which is made to describe a trajectory, for example a spiral trajectory. By modulating the intensity of the laser beam the future centred patterns are defined such as 10, 11, 12. In order to define the future off-centre patterns 13 and 14, the point of impact of the laser beam is off-centre, for example by means of an acousto-optical deflector in order to create, in the spiral trajectory, a transient radial off-centre of predetermined amplitude. Given the pulse exposure mode, each pre-engraved pattern closely follows the shape of a more or less elongated mark having a leading edge and a training edge which are similar in shape to that of the spot used to obtain them.

Figure 1 also shows other essential units of an optical reading and recording device which uses the pre-engraved data medium. In addition to the drive motor 16, it can be seen that in order to record useful data it is necessary to provide an optical head 17 capable of projecting a light spot 24 capable of illuminating an element of track situated at a variable distance R from the axis of rotation Z. For this purpose it is possible to envisage that the optical head 17 receives a collimated radiation 22 emitted by a fixed laser source which is reflected by a pivoting mirror 19 towards a lens 21. The beam 23 focussed by the lens 21 illuminates the photosensitive structure 2 through the layer support 1 and gives rise to the spot 24 which can move from one track element to the next under the control of the motor 20. A larger displacement of the spot 24 can be performed by displacing the optical head 17 by means of the motor 18.

The optical interaction of the beam 23 with the patterns carried by the data medium causes the light which emerges from the portion of structure 2 illuminated by the spot 24 to contain particular characteristics which indicate the presence of the pattern, its location in relation to the spot and, if necessary, the fact that it has been post-engraved in order to store useful data. The frontal section of the data medium shows the relief of the pattern 10 located over three successive track-elements. The two left-hand patterns reflect the pre-engraving alone and it can be seen that the photosensitive structure 2 closely follows the hollows of the layer support 1. The right-hand pattern has been post-engraved which results for example in a detachment of the photosensitive structure 2 with the formation of a bubble. Provision is not generally made for post-engraving the sectors S. The sectors D can, if necessary, contain no pre-engraving.

The pre-engraved patterns 11, 12, 13 and 14 located in the sectors S have an important function in marking the spatial positions of the track elements and

the inter-track spaces separating them, and also for time referencing the various stages of scanning the data medium by the spot 24. The patterns 13 and 14 shown in Figure 1 are more particularly intended to show up track following errors while the patterns 11 and 12 are used for resetting the time base.

In Figure 1 the photodetector means which pick up the light which has interacted with the data medium are not shown but they are generally disposed in such a way as to collect the radiation returned through the lens 21 by the data medium. In the diagram shown in Figure 10 these means bear the reference 55.

Figure 2 illustrates a pre-engraved structure of known type and the various electrical signals which result from the optical interaction of this structure with a spot 25 assumed to be centred on the longitudinal axis of the track and then off-centre upwards or downwards as shown by the contours 25 and 26.

At (a) in Figure 2, the axis of the track has been graduated with a pitch H by means of vertical dotted lines numbered 0 to 14. This graduated area represents the extent of a sector S framed by two sectors D each of which comprises a continuous pre-engraved pattern 10. In the graduated area, there has been provided an end space followed by a first centred pattern 11 which occupies one and a half graduations and a second identical centred pattern 12 shifted to the right by two and a half graduations. These two patterns 11 and 12 constitute an encoded phase mark which an appropriate filter can recognize without reacting to digital data present on the data medium with the writing pitch H. In the graduated area, there has then been provided two other patterns 13 and 14 which are off-centre in opposite directions in relation to the axis of the track. The pattern 13, off-centre upwards extends between the graduations 7 and 9 while the pattern 14 off-centre downwards extends between the graduations 10 and 12. The patterns shown in (a) in Figure 2 are cross-hatched in order to show the fact that they are analysed by the photodetector means, as appear-

ing less reflective than their smooth environment.

At (b) in Figure 2 the diagram shows how the readout signal supplied by the photodetector means varies. The amplitude of the signal is represented vertically with a low level 29 and a high level 27. The curve 31 shown in solid line represents the readout of the pre-engraved structure by a centred spot 24. It is noted that in the region in which the spot interacts with the patterns 13 and 14 the readout signal shows less deep hollows but they are the same for the two off-centre patterns. The curve 30 shown in dotted line represents the variation of the readout signal with an off-centre spot illustrated in (a) with the contour 25. It can be seen that the interaction with the patterns 10, 11 and 12 results in less deep hollows and that the hollows corresponding to the interactions with the patterns 13 and 14 are displaced in opposite directions. This latter comment shows that by sampling the readout signal at the graduations 8 and 11 and by subtracting the samples, a measurement of the off-centre of the spot in relation to the axis of the track with an indication of the sign of the off-centre is obtained.

The readout signal shown at (b) in Figure 2 contains no sudden transitions and consequently it is re-shaped before being used for extracting useful data from it. This re-shaping consists in creating a rectangular signal whose transitions occur at the intersections of the readout signal with a decision threshold represented by the level 28.

The signal 32 re-shaped during a scanning with a centred spot is shown at (c) in Figure 2. At (d), the re-shaped signal 33 corresponds to a scanning with a spot which is off-centre upwards according to the contour 25 and, at (e), the re-shaped signal 34 corresponds to a scanning with a spot off-centre downwards according to the contour 26.

As the re-shaped signal is used for resetting the time base of the record-readout device, it is necessary that the spot following error has the same effect on the

position of the transitions whatever the sign of the error may be.

In Figure 2 there have been shown at (d) and (e) the off-centres resulting from track following errors. Horizontal arrows show the tendency of the readout system to detect the leading edges and trailing edges of the patterns 11 to 14 earlier or later. When the off-centres of transitions of the same direction are considered, it can be seen that the phase marks 11 and 12 are detected with a deviation between these transitions which is substantially invariable with respect to the spot following error. The same does not apply when considering the detection of the tracking marks 13 and 14.

It is thus established that the pre-engraved structure of Figure 2 gives satisfactory results because the leading edges and trailing edges of the two phase marks 11 and 12 alone are used for resetting the time base while the only useful portion of the tracking marks 13 and 14 is constituted by the off-centre arrangement of their edges. However this solution uses a large amount of space since it uses four spaced marks and end spaces between them and the adjacent data sectors.

In the light of the above, the invention proposes a compacting of the pre-engraved structure which consists in using at least two patterns at least one of which has an off-centre portion associated with at least one edge of a pair of leading and trailing edges paired with a pair of leading and trailing edges defining along the axis of the track two predetermined distances, each of them being included between two consecutive multiples of the data recording pitch.

Figure 3 shows a rough sketch which reveals the concept of the invention well. In a system of axes T,R, which defines the plane of the data medium surface and where the axis of the track is directed along T, the essential components of two pre-engraved patterns have been shown without particularly complying with their real contours. With regard to the revealing of a tracking error ΔR of the spot 24, the positioning of the edges 37

and 41 along R will be of importance. On the other hand in order to define a good resetting of the time base, it is the leading edges 36 and 39 and the trailing edges 38 and 40 which must be judiciously positioned.

The interaction of the spot with the leading edge 36 is illustrated in Figure 3 by making this edge form a tangent with the contour 24, 25 or 26 of the reading spot when it comes into contact with the left-hand pattern. The curve 35 is the geometric locus of the centre of the spot at the instant of the start of interaction and it enables the setting error ΔT which results from the off-centre of the spot ΔR to be revealed. In order for the pre-engraved structure shown in Figure 3 to be recognizable and separable from the useful data recorded with the predetermined pitch H, two distances A and B are defined by means of two leading edges and two trailing edges which satisfy the condition that each of them is included between two adjacent multiples of the pitch H; we therefore have:

$$kH < A < (k+1)H$$

$$mH < B < (m+1)H$$

where k and m are any integers. Typically, a half integer distance is chosen to express the distances A and B as a function of H.

In Figure 3 there has been shown between the edges 39 and 40 the centre C of the pattern, since, because of symmetry, it is the instant at which the centre of the spot and the centre C have the same abscissa which gives the surest indication for a resetting of the time base. This instant is derived by linear interpolation of the instants corresponding to the spot passing over the edges 39 and 40 which delimit the pattern of centre C. Thus it is possible to overcome faults relating to the defocussing of the spot and in the production of the pre-engraving and, in addition, the setting error ΔT is compensated.

Without leaving the extent of the invention, it is also possible to define the distances A and B not between edges of the same type as shown in Figure 3 but

for example between the edges 36 and 40 on the one hand and between the edges 38 and 39 on the other hand. The latter mode of pairing edges is more sensitive to pre-engraving and focussing errors but it lends itself to a particularly compact production of the pre-engraving as will be seen below.

Having given the general characteristics of the pre-engraved structure according to the invention, it is now possible to move on to other embodiments which are included in the scope of the present invention.

In Figure 4 can be seen at (a) a first example of a pre-engraved structure according to the invention. It is located between the graduations 0 to 10 and is formed of two patterns 42 and 43 each of which comprises a central portion which is off-centre and two end portions which are centred. Section (b) of Figure 4 shows the shape of the readout signal, using the same references as in Figure 2. the curve 44 in dotted and dashed line has been added to illustrate the readout signal corresponding to a spot which is off-centre according to contour 26 in Figure 2. The curve 32 which can be seen in (c) of Figure 4 represents the re-shaped signal with indication of the half integer distances A and B in relation to the graduation which can be seen in (a). The distance A is the distance between two leading edges of the patterns 42 and 43, while the distance B is the distance between the trailing edges. The difference between the patterns 42 and 43 is in the direction of the off-centre of the central portion. In section (d) of Figure 4 can be seen the signal 45 defining the sampling window of the readout signal for the first pattern 42 and the signal 47 defining the sampling window of the second pattern 43.

The signals 46 and 48 represent the samples taken with three heights which correspond to the three cases envisaged in section (b) of Figure 4. The signals 45 and 47 are supplied by circuits synchronized with the time base of the recording and reading device, which is reset by means of the transitions of the signal 32. It is also possible to produce the pre-engraved structure in a more

compact way by using the configuration shown in (a) of Figure 5. It is noted that this structure associates with the central pattern 49 two framing patterns which can consist in extensions of the pre-engraved groove 10 where the useful data are post-engraved. The central pattern 49 comprises two portions off-centre in opposite directions and two centred end portions. The framing patterns which extend upstream of the graduation 1 and downstream of the graduation 7 are necessary for defining at the extreme left a trailing edge and at the extreme right a leading edge. These two edges are paired with the edges of the same type of the central pattern 49. The distances A and B are indicated in (c) in Figure 5. The parts (b) to (d) of Figure 5 are analysed like their homologous equivalents in Figure 4. The oblique central section of the pattern 49 is optional but can remain without disadvantage.

As a numerical example, a pre-engraved configuration structured as shown in Figure 5 can be based on a clock period of 200 nanoseconds. Figure 5, like the other figures, is subject to two interpretations as it represents a link between a geometric arrangement and the representation of the electrical signals resulting from this arrangement. This link of course results from the track scanning speed v. A length such as the pitch H of the graduation shown in (a) has a time homologue which is a duration equal to the clock period. In the present case, with a scanning speed of 8.25 m/sec provided with a reading ray of 0.0705 m and a rotational speed of approximately 1120 r.p.m., it can be seen that a clock period of 200 nanoseconds corresponds to a bit length of 1.65 micron which takes the overall length of the sector S of Figure 5 to 1.65 x 9 microns, or 14.85 microns. This sector S can be adjacent to blocks D each comprising 91 clock periods, giving a block length of 150.15 microns.

Typically, the pitch p of tracks is equal to 1.7 micron, with a track width l equal to 0.6 microns. This track size is appropriate when the scanning spot diameter at mid-height is taken as equal to 1 micron. The off-

centre of the portions of the pattern 49 shown in Figure 5 as included between the graduations 3 and 4 and passing through the graduation 5 is ± 0.3 microns. This off-centre represents the distance between the off-centre axis passing though the centre of the width of an off-centre section and the longitudinal axis of the track. Typically, the width of the pattern 49 is constant and equal to the track width l.

Among other possible configurations, Figure 6 illustrates a pre-engraved structure which is derived from the configuration of Figure 4 by substituting for the pattern 43 a pattern 50 which has no off-centre section whatsoever. Because of this, it is necessary to provide on the data medium that a data sector D is framed by two sectors S of the type shown in Figure 6 while alternately changing the direction of off-centre of the off-centre portion of the pattern 42. In fact the evaluation of a tracking error of the spot requires the taking into account of two samples which will be taken in turns in two successive pre-engraved structures. In the case of Figure 6 it is not necessary for the pre-engraved groove 10 to take part, by means of its extensions, in the definition of phase marks, but it is of course possible to omit the mark 50 and to have this phase mark function performed by the extensions of the groove 10 towards the mark 42.

It is also possible, as shown in Figure 7, to choose a pre-engraved structure configuration having three patterns. The latter is derived from the configuration of Figure 6 where the pattern 42 is replaced by two patterns 51 and 52 each of which has an off-centre portion and a centred portion.

The system of Figure 7 supplies two track following mark samples like the configurations of Figures 4 and 5 and it is possible to apply the comment made with respect to Figure 6 to it relating to the possibility of substituting for the pattern 50 extensions of a pre-engraved groove 10.

The configuration having three patterns is a

variant of the configuration of Figure 7 in which the centred pattern 50 is framed by patterns 53 and 54 which resemble the patterns 51 and 52 but which are arranged in another way in order to obtain distances A and B which are equal and relatively small. In this case also it is possible to replace the pattern 50 with extensions of grooves 10.

The configuration shown in Figure 9 provides four track following samples by repeating the pattern 49 shown in Figure 5. Because of the repetition of the pattern 49 it is not necessary to make use of groove extensions 10 in order to define the distances A and B.

Figure 10 shows, by way of non-limitative example, the electrical circuit of a data transcription device adapted to the use of the pre-engraved structure according to the invention.

This circuit comprises photodetector means 55 which supply the readout signal shown in (b) in Figures 4 and 5. This readout signal is applied to the input of the re-shaping circuit 56 and to the inputs of two sampling circuits 61 and 64 which retain the sampled value until the next sampling command. The outputs of the circuits 61 and 64 are connected to the inputs of a comparator circuit 60 which supplies a track following error signal which is used to control the motor 20 which directs the mirror 19. The sampling circuits 61 and 64 are controlled by a sampling windows generator circuit 68 which produces signals such as shown in (d) in Figures 4 and 5 with the references 45 and 47. The time reference necessary for the marking of the sampling windows is supplied to the generator 68 by a time base circuit 71.

The circuit 71 is fed with a clock 70 which supplies the rate H of scanning the useful data which, apart from resetting, corresponds to the graduation used in (a) in Figures 4 and 5.

The circuit 71 also receives a resetting signal coming from an interpolation circuit 59. It is the detection of the phase marks which determines the functioning of the interpolation circuit 59. For this pur-

pose, the re-shaped signal supplied by the circuit 56 is applied to two transition selector circuits 57 and 62.

The selector circuit 57 has a function of isolating the transition which, in Figures 3 to 9, marks the start of the second phase mark and the selector circuit 62 is responsible for isolating the transition which marks the end of this mark.

In order to make this selection, each selector circuit 57 or 62 comprises a sampling window generator which uses as a time reference any transition of the reshaped signal having the appropriate sign. The sampling window is produced for sampling the transition distant by A or B from the starting transition. As it is necessary for the selected transition to be actually one of those which delimit the second phase mark, it is necessary either to provide a sufficient dead space upstream of the phase marks, or to locate the leading edge of the first phase mark in agreement with the graduation which manages the data distribution, or to accept at the input of the selector circuits 57 or 62 only transitions in agreement with the scanning of the phase marks.

The interpolator circuit 59 interprets the instants of detection defined by the transitions coming from the circuits 57 and 62 according to a division of the clock cycle 70 supplied by a frequency multiplier circuit 66 connected to the latter. The time references allocated to these instants serve as digital data for accessing an interpolation table which determines the time base setting error taking as a reference the coincidence of the centre of the spot with the centre C of the second phase mark. This error is used by the time base circuit for a resetting which takes place during each scan of a set of phase marks. The taking into account of the resetting error is commanded for example by the transition selected by the circuit 62. The time base 71 enables the synchronization of the routing of useful data into a buffer memory 65 whose control is provided by a timing generator 69.

The data enter into the buffer memory 65 after

reshaping by the circuit 56. They are available at the output 72.

The time base 71 also provides the control of a sampling window generator 63 which selects with a circuit 58 one or more samples of the signal that measures reading beam focussing error. This signal is supplied by the photodetector means 55. The taking of samples of the defocussing indicator signal can take place in a data medium area which is free of pre-engraving or in pre-engraved areas such as a centred area or two areas which are off-centre in opposite directions. The circuit 58 controls the motor 67 which focuses the optical beam.

In the above description compact pre-engraved structures have been described which use sinuous patterns or step-shaped patterns. However, provided there is good control of the dimensional characteristics of the pre-engraving, an even greater compactness can be aimed for.

In Figure 2 it has been seen that the transitions of the re-shaped readout signal undergo shifts related to the spot following error with respect to the axis of the track. By comparing the curves (d) and (e), it can be seen that the distance which separates the transitions of the same direction corresponding to the scanning of the leading edges of the patterns 13 and 14, changes when the spot moves away from the axis of the track. On the other hand, considering a pair of transitions of opposite directions which correspond to the scanning of a leading edge of one of the patterns 13 or 14 and to the scanning of a trailing edge of the other of these patterns, it is noted that the inter-distance thus defined does not vary in relation to the track following error. It is therefore possible to further reduce the overall size of the pre-engraved structure.

At (a) in Figure 11 there is shown a pre-engraved structure made of two off-centre patterns 73 and 74 whose leading and trailing edges are paired in a particular way in order to enable a resetting of the time base.

The leading edge of the pattern 73 starts at the graduation 2 and is paired with the trailing edge of the

pattern 74 in order to determine a half-integer distance B as shown at (c) in Figure 11. The trailing edge of the pattern 73 is paired with the leading edge of the pattern 74 in order to determine another half-integer distance A.

Compared with the structure of Figure 2 it can be seen that the structure of Figure 11 enables the entire elimination of the centred phase marks 11 and 12 and that it locates the marks 73 and 74 which serve for detecting the spot following errors in relation to the axis of the track 75 in such a way as to be able to use the transitions of opposite sign which they produce for resetting the time base. It will be noted that in Figures 4 to 9 it is transitions of the same sign generated by the edges of centred patterns which define the distances A and B.

The sections (b),(c),(d) and (e) in Figure 11 need no particular comment, the same references denoting the same elements as in the previous figures.

As explained before, the time base setting deviation Δc is to be determined by estimating the instant at which the centre C of the mark 74 and the centre of the reading spot are in the same position.

For this purpose there have been shown, at (f) in Figure 11, pulses 76 and 77 which respectively correspond to the positive and negative transitions of the re-shaped signal shown at (c).

In order to sample the negative transition produced when the spot meets the pattern 74, it is necessary to generate a sampling window exclusively centred on this transition which appears at the distance A from the end of scanning the pattern 73.

By way of non-limitative embodiment, the first transition selector circuit 57 (Figure 10) comprises a counter incremented by the pulses coming from the frequency multiplier circuit 66.

The resetting of this counter to zero occurs when the elapsed time is slightly greater than the duration corresponding to the time taken to travel the distance A.

The counter begins its count when it receives a pulse 76 and a logic circuit associated with the counter forms a sampling window between a value slightly less than the duration which corresponds to A and the zero reset. This functioning is illustrated at (g) in Figure 11 where the rectangular shape 78 symbolizes the incrementation up to A - ϵ and the rectangular shape 79 symbolizes the incrementation up to A + ϵ. The distance ϵ is the half-width of the sampling window and it can be seen at (g) that several windows F_1, F_A, F_2 are thus generated by the pulses 76. The window F_A is that which enables the sampling of the negative pulse 80 as shown at (h) in Figure 11. This pulse is supplied to the interpolation circuit 59 which determines a time reference H_A as shown at (k) in Figure 11.

Having marked the reaching of the pattern 74 it is also necessary to mark the end of scanning this pattern. This is carried out in the second selector circuit 62 which comprises a counter which reacts to the negative pulses 77 in order to define another sampling window. At (i) in Figure 11 can be seen the rectangular shapes 81 and 82 which represent B - ϵ and B + ϵ and at (j) can be seen the selected pulse 83 which determines, in the interpolator circuit 59, a second time reference H_B shown at (k) in Figure 11. By linear interpolation or with the help of a table of values with two inputs, the interpolator circuit 59 determines the time reference H_c shown at (k) in Figure 11 and finally the time error Δc which enables the resetting of the time base.

In the above description it has been seen how it is possible to overcome the synchronization inaccuracy due to the off-centre of the spot with respect to the longitudinal axis of the track. It is a matter of pairing the leading and trailing edges of two patterns in such a way as to define two characteristic distances which do not vary in relation to the off-centre of the spot. When the pairing is based on a first marking by the two leading edges and on a second marking by the two trailing edges, these edges must be centred and in this case the

patterns are partially off-centre to also enable the detection of the track following error. When the pairing is based on a marking by a leading edge and a trailing edge, these edges are off-centre in opposite directions in such a way that the detection of the track following error and the time base resetting can be provided with totally off-centre patterns. The use of sinuous patterns has the advantage of reducing the synchronization inaccuracy due to imperfections in the pre-engraving of the patterns. The use of exclusively off-centre patterns enables a higher compactness to be achieved, but on the other hand requires a greater control of the dimensioning of the pre-engraving. In any case, the solutions described within the scope of the present invention are distinctly more favourable than those which recommend that the track following marks are preceded by one or more preliminary patterns for directly controlling the sampling of these marks.

The invention applies to any system with a recordable layer. It is necessary to note that the pre-engraving can include, in the areas reserved for the transcription of useful data, sections which assist in the determination of phase marks and whose extensions in some way form a reverse pattern since its trailing edge precedes its leading edge. The post-engraving resulting from the useful data transcription can be such that it produces an increased reflectivity of the data medium. The result of this is that the re-shaped signal contains no transitions due to useful data and that it is possible to re-shape these data with a decision threshold having a value higher than that used for the re-shaping of the pre-engraving readout signal. This case occurs in particular when the data sectors are provided with a continuous pre-engraved groove and when the recordable layer is a layer of bubbles whose detachment provides an increase in reflectivity.

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CLAIMS

1. Data medium which can be optically recorded along a track (6, 7) which is marked out with pre-engraved zones (S) alternating with areas (D) for recording useful data, each of the said pre-engraved zones comprising at least two patterns (13, 14) having leading and trailing edges, the said patterns enabling the detection of track following errors when being scanned optically one after the other by means of a reader spot (24) by interaction with at least one portion of the pattern off-centre in relation to the longitudinal axis of the said track and a time base setting signal resulting from the interaction of the spot with at least two leading edges and two trailing edges, characterized in that at least one of the said patterns has the said off-centre portion of pattern (37, 41) associated with at least one edge of a pair of leading and trailing edges (36, 38) paired with one pair of leading and trailing edges (39, 40) defining along the track axis two predetermined distances (A, B), each of them being included between two consecutive multiples of the data recording pitch (H).

2. Data medium according to Claim 1, characterized in that one of the said distances (A, B) represents the spacing of the said leading edges (36, 39), the said edges (36, 38, 39, 40) being centred on the said axis.

3. Data medium according to Claim 1, characterized in that one of the said distances (A, B) represents the spacing of one leading edge (36, 39) and one trailing edge (38, 40); the said patterns (73, 74) being entirely and symmetrically off-centre in relation to the said axis.

4. Data medium according to Claim 2, characterized in that the said patterns (42, 43, 49, 51, 52, 53, 54) each have an off-centre portion.

5. Data medium according to either of Claims 2 or 4, characterized in that one of the said patterns (50, 10) is entirely centred in relation to the said axis.

6. Data medium according to Claim 5, characterized in that the said centred pattern is an extension of a pattern (10) belonging to the framing sectors (D) of the sector (S) wherein the said pre-engraved area is located.

7. Data medium according to Claim 2, characterized in that two successive patterns (42, 43, 51, 52, 53, 54) comprise portions which are symmetrically off-centre in relation to the said axis.

8. Data medium according to Claim 2, characterized in that a same pattern (49) comprises two portions symmetrically off-centre in relation to the said axis.

9. Data medium according to Claim 8, characterized in that it comprises two patterns (49), each having two portions symmetrically off-centre in relation to the said axis.

10. Data medium according either of Claims 5 or 6, characterized in that the said centred pattern (50) is associated with two other patterns having a centred edge and an off-centre portion.

11. Data medium according to any of Claims 1 and 2 and 4 to 10, characterized in that at least one of the patterns has a sinuous shape.

12. Optical track following device intended for using a data medium according to any of Claims 1, 2 and 4 to 10, comprising means for sampling the edges of patterns and their off-centre portions, characterized in that the transitions of the re-shaped readout signal, which are determinant in relation to the said predetermined distances (A, B), are transitions having the same directions.

13. Optical track following device intended for using a data medium according to Claim 3, comprising means for sampling the edges of patterns and their off-centre portions, characterized in that the transitions of the re-shaped readout signal, which are determinant in relation to the said predetermined distances (A, B), are transitions having opposite directions.

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14. Optical device according to either of Claims 12 or 13, characterized in that the sampling means comprise counting means supplying a framing for the transitions which characterize the edges of a pattern, and interpolation means enabling the determination of the time of coincidence of the centre of the reading spot and the centre (C) of the pattern.