PATENT SPECIFICATION

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(19)

(54) MAGNETIC RECORDING OR READING

(71) We, N.V. PHILIPS' GLOEILAMPENFABRIEKEN, a limited liability Company, organised and established under the laws of the Kingdom of the Netherlands, of Emmasingel 29, Eindhoven, the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an information carrier with a magnetic storage layer. The invention also relates to an apparatus for reading or writing such an information carrier.

For controlling the position of a write-read head it is possible to record optically readable servo tracks on information carriers, for example in the magnetic layer of a magnetic disc. Such a servo-track can be small relative to the width of a magnetic information track and can be arranged between two adjacent information tracks. In order to avoid cross-talk when reading the magnetic information tracks it is anyway necessary to maintain a certain free distance between the information tracks. The magnetic layer between the information tracks thus recorded may be modified so that the optically readable servo-tracks can be arranged between the information tracks. The major advantage of position control by means of optical servo tracks over position control by means of magnetic servo tracks is that the servo-information occupies little or no storage area and that no data blocks need be interrupted.

It is an object of the invention to carry out the position control of a write-read head for magnetic information carriers with simple means. According to a first aspect of the invention an information carrier is provided with a magnetic storage layer adapted to record magnetic information tracks side by side in the plane of the layer, comprising optical tracks, for the use in a servo tracking control system, written one each between adjacent magnetic information tracks each optical track comprising an interrupted line having a periodic structure of line sections alternating with line interruptions, the period length of the periodic structure being constant along a given track, and the phase of the periodic structure differing between adjacent optical tracks.

According to a second aspect of the invention an apparatus is provided for magnetically reading and/or writing on such an information carrier comprising a magnetic read/write head connected to an optical scanner for sensing the optical track, and a diaphragm having two apertures in the radiation path of the optical scanner, a first aperture having a dimension along the path of relative movement between the read/write head and the optical track adapted to transmit radiation from at the most the length of one line section, and a second aperture having a dimension across the tracks adapted to transmit radiation from at least three adjacent optical tracks.

The invention also provides apparatus for magnetically reading and/or writing on an information carrier comprising a magnetic read/write head connected to an optical scanner for sensing the optical track, and an apertured diaphragm in the radiation path of the optical scanner, wherein the aperture has the shape of a rhombus, one diagonal of the rhombus being parallel to the tracks and having a dimension adapted to transmit radiation from at the most the length of one line section, the other diagonal of the rhombus having a dimension across the tracks adapted to transmit radiation from at least three adjacent optical tracks.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings where:

Figure 1a shows optical servo tracks with examples of apertured diaphragms,

Figure 1b shows servo tracks and a further example of an apertured diaphragm,

Figure 2 schematically represents the construction of the optical scanner, and

Figure 3 is a block diagram which illustrates how the position control voltage is obtained.

The servo tracks consists of periodically interrupted lines, a line section La and an interruption Lu preferably having the same length. The period length τ or in the case of concentric tracks the arc length of a period, is constant and equal for all servo tracks. However, between adjacent servo tracks there is a uniform phase shift of exactly $\tau/3$ (see Figure 1a). In this way the line sections 1a of all servo tracks viewed transversely to the track direction overlap by exactly $\tau/6$. Of course, this also applies to the interruptions Lu.

The servo information may be written in the information carrier by a laser beam which burns away the magnetic layer until a reflective layer under the magnetic layer becomes visible. It is also possible to put the servo information onto the information carrier by photo-lithographic techniques known per se.

The optical scanner (Figure 2) is rigidly connected to the magnetic write-read head, for example as shown in "IBM Techn. Discl, Bulletin" Vol. 16 Febr. 1976 page 3020. It comprises an arrangement of a light source 1 which may be a micro light source, imaging lenses 2 and 4, a diaphragm 5 and a photodiode 6. The lens 2 forms an out-of-focus image of the light source 1 onto the surface of the information carrier 3, so that on this surface a spot with a diameter of several information track widths is uniformly illuminated. The lens 4 images this area onto the diaphragm 5. The light which passes through the specially shaped diaphragm apertures 5′ reaches the photodiode 6. It is prerequisite that the optical reflection factor of the servo track and thus of the line sections should differ from the reflection factor of the surrounding area. Thus, the luminous flux changes depending on whether a line section La or an interruption Lu is imaged in the diaphragm aperture (Figs. 1a and 1b).

Fig. 1a in addition to the servo tracks shows the simplest forms of the diaphragm, which may also be a mask with suitable apertures. The two apertures 5′a and 5′b have different functions. The aperture 5′a in the Z-direction substantially correlates with the length of the line sections. The width in the X-direction substantially corresponds to the distance between two servo tracks. During operation, the information carrier is moved in the Z-direction and the luminous flux through this aperture changes accordingly with the period of the servo track and, in response, the photo diode 6 (Fig. 2) supplies a current I_1 with the angular frequency ω. Owing to the oblique edge K the phase of I_1 does not only depend on the servo track which is covered, but also on the position of the track relative to the aperture 5′a in the X-direction. I_1 thus essentially has the form

$$I_1 = A.\cos\ [\omega\ t+P(x)].$$

The opening 5′b extends over approximately 1/6 period in the Z-direction and covers several servo tracks S in the X-direction. Owing to this arrangement an additional photo-current I_2 is obtained with the angular frequency $3\ \omega$ and, as may be inferred from Fig. 1a, whose phase is independent of X. The additional photo-current I_2 is thus essentially described by the formula $I_2 = B.\cos 3\ \omega$.

The electronic processing of the signals I_1 and I_2 into a correction voltage for the X-position of the write-read head is now effected as follows (see Fig. 3). A voltage controlled reference oscillator RO, approximately tuned to 3ω is connected to a phase comparator PV_1. The signal I_2 is amplified by V_2 and via the phase comparator PV_1 and a low-pass filter TP2 which complete a phase lock loop controlling the frequency of RO, locks the reference oscillator RO to frequency 3ω. This serves to ensure that the reference oscillator RO and the frequencies derived from it remain in synchronism with the photo diode output, even when the signal flow from the detector 6 is briefly interrupted, for example owing to soiling of the information carrier. The oscillator frequency 3ω is reduced to the angular frequency ω with a shift-register counter SZ and is divided into three 120° phase-shifted square-wave reference voltages U1, U2 and U3. In a further phase comparator PV2 the signal I_1, which has first been amplified in VV and V1 and whose amplitude has been limited by automatic gain control, is compared with a selected one of the three reference voltages. At the output of the low-pass filter TP1 the desired control or correction voltage U_s is obtained. The phase-shifter PS is adjusted so that, when the write/read head is in a central position relative to the information track, the selected reference voltage and I_1 have a phase difference of 90°, so that the correction voltage $U_s = 0$. By switching to a different reference voltage by means of switch US the write/read head is then unambiguously transferred to and centred on the adjacent right or left track in accordance with the new reference phase (plus or minus 120°).

For counting the number tracks traversed, direction-dependent counting pulses can be taken from the reference voltage switch US (track change). Such counting pulses can also be obtained by additional hardware phase comparators between each of U1, U2 and U3 and I_1. This last-mentioned step has the advantage that these counting pulses are also available when the write-head is for example continuously moved over the tracks when the control circuit is interrupted. These devices for track counting are not shown in Fig. 3.

After the position control has been switched on, the phase relationship of the reference voltages U1 to U3 is trivalent, since the initial set of the shift-register counter SZ and the lock-in point of the reference oscillator RO are arbitrary. An unambiguous relationship is obtained in that in the information tracks of a magnetic disc an optically readable mark is inserted for example at one point on the periphery. This mark is read with the same detector. The signal component due to this mark is separated from the rest of the signal in a pulse separator stage JA, and processed to a synchronous pulse.

With this synchronous pulse the initial set of the shift-register counter SZ is checked and, as the case may be, corrected, so that an unambiguous phase-relationship of the reference voltages U1 to U3 is obtained.

In addition to the synchronous pulses, track identification is possible in a similar way. Finally, it is possible to derive an information clock frequency from the reference oscillator RO. The optical method for the position control of a write-read head can of course also be realized when the phase shift between the periods of adjacent servo tracks is selected to differ from τ 3. In that case it is merely necessary to adapt the geometry of the mask aperture and the electronic circuit accordingly.

In a simplified embodiment the period of the servo tracks is cyclicly changed from track to track. For example every third track repeats the same period, the phase relationship being irrelevant. With a changed mask aperture 5'c (see Fig. 1b) for example three servo tracks are then covered at the same time, so that from the photo diode 6, at the same time, three frequencies are obtained. These three frequencies are divided into three channels by electronic means. By amplitude comparison of the two outer frequencies in the mask aperture an unambiguous control signal can be obtained. When more frequencies are used the bandwidth necessary for counting the tracks must be increased and moreover the individual frequencies must be accurately separated from each other.

WHAT WE CLAIM IS:—

1. An information carrier with a magnetic storage layer adapted to record magnetic information tracks side by side in the plane of the layer, comprising optical tracks, for use in a servo tracking control system, written one each between adjacent magnetic information tracks, each optical track comprising an interrupted line having a periodic structure of line sections alternating with line interruptions, the period length of the periodic structure being constant along a given track, and the phase of the periodic structure differing between adjacent tracks.

2. An information carrier as claimed in Claim 1, wherein the line sections and interruptions have the same length.

3. An information carrier as claimed in Claim 1 or 2, wherein the optical tracks are concentric tracks, the arc length of a period is constant and equal for all optical tracks, and there is a uniform phase shift between adjacent optical tracks of 120°.

4. Apparatus for magnetically reading and/or writing on an information carrier as claimed in any one of Claims 1, 2 or 3 comprising a magnetic read/write head connected to an optical scanner for sensing the optical track, and a diaphragm having two apertures in the radiation path of the optical scanner, a first aperture having a dimension along the path of relative movement between the read/write head and the optical track adapted to transmit radiation from at the most the length of one line section, and a second aperture having a dimension across the tracks adapted to transmit radiation from at least three adjacent optical tracks.

5. Apparatus as claimed in Claim 4, wherein the first aperture has the shape of a parallelogram, one pair of opposite sides of which are parallel to the track direction.

6. Apparatus as claimed in Claim 4 or 5, wherein the second aperture has the form of a rectangle, one pair of opposite sides of which are parallel to the track direction and have a length at least equal to the extent of the overlap in the track direction of two adjacent optical tracks.

7. Apparatus for magnetically reading and/or writing on an information carrier as claimed in any one of Claims 1, 2 or 3 comprising a magnetic read/write head connected to an optical scanner for sensing the optical track, and an apertured diaphragm in the radiation path of the optical scanner, wherein the aperture has the shape of a rhombus, one diagonal of the rhombus being parallel to the tracks and having a dimension adapted to transmit radiation from at the most the length on one line section, the other diagonal of the rhombus having a dimension across the tracks adapted to transmit radiation from at least three adjacent optical tracks.

8. Apparatus as claimed in either Claim 4 or Claim 5 wherein the optical scanner comprises a photodetector which in operation supplies a signal voltage corresponding to the line sections transmitted by said apertured diaphragm, and wherein said apparatus comprises a signal processing circuit for producing a position control signal for said servo tracking control system, said circuit comprising, a voltage controlled reference oscillator locked to a harmonic of the fundamental frequency of said signal voltage by a phase lock loop comprising a first phase comparator connected to receive the signal voltage and the reference oscillator output and to supply a control voltage to said oscillator, and a second phase comparator connected to receive the signal voltage and a phase adjusted signal of said second fundamental frequency derived from said reference oscillator, the second phase comparator thereby supplying said position control signal.

9. Apparatus as claimed in Claim 4, 5, 6 or 7, wherein the optical scanner consists of a micro light-source and a photo-diode, in front of which the apertured diaphragm is arranged.

10. An information carrier substantially as described with reference to Figures 1a or 1b of the accompanying drawings.

11. Apparatus for magnetically reading and/or writing an information carrier substantially as described with reference to Figures 2 and 3 of the accompanying drawings.

R. J. BOXALL,
Chartered Patent Agent,
Mullard House,
Torrington Place,
London WC1E 7HD,
Agent for the Applicants.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

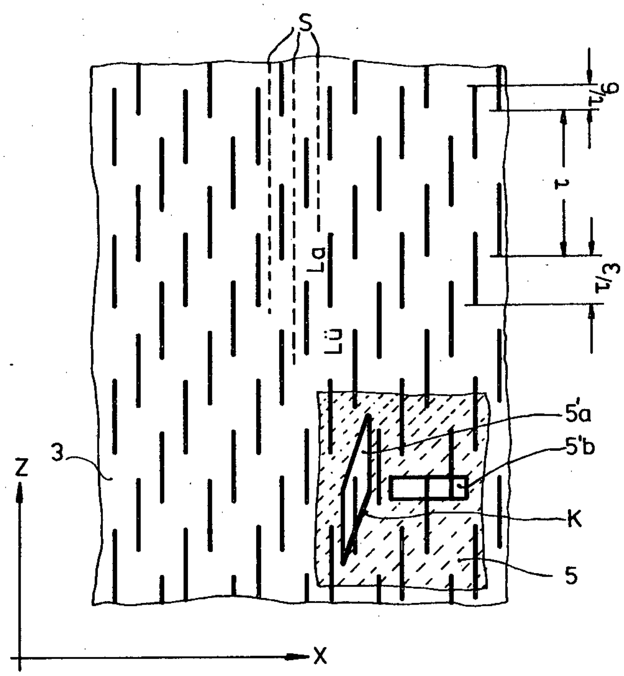

Fig.1a

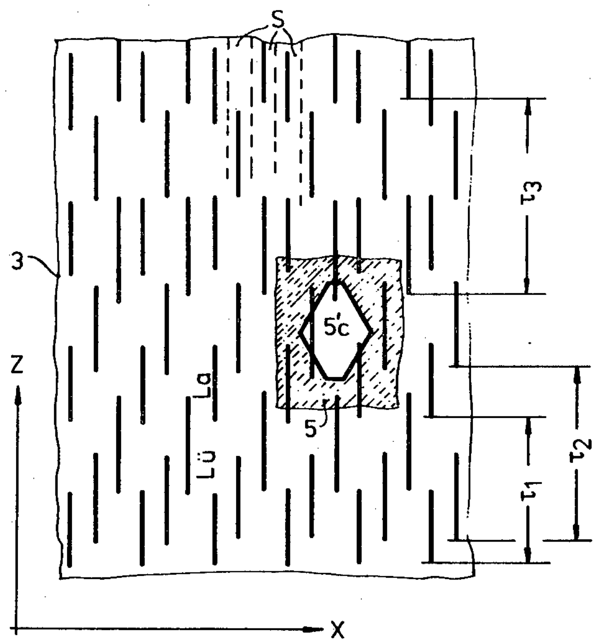

Fig.1b

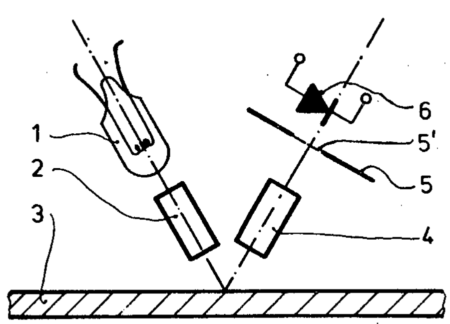

Fig.2

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

Fig.3