

The present invention relates to optical memories for storing data in reserved areas of the surface of an information carrier.

The writing and reading of the data involves illumination of the information carrier with a light spot produced by the precise focusing of an incident beam. Pre-engraved patterns are arranged in the reference surface of the information carrier to form adjacent track elements. These are located outside the areas reserved for the recording of data.

Each track element is thus divided up into alternate sites which are successively scanned by the light spot.

When the light spot is used for reading the pre-engraved patterns and the content of the data blocks, the illumination of the carrier needs to be such that the optical characteristics of the information carrier are unaffected, while still being of sufficient intensity to generate precise detected signals. Contrariwise, during a data post-engraving phase, the energy received by the information carrier is boosted in order to enable the data to be recorded. In this type of operation on two levels of intensity, the high level is strictly confined to the data areas, as the pre-engraved patterns have to be preserved from any alteration. To accomplish this, the recording/reading device is provided with a circuit controlling the power of the incident beam which takes account of the alternation of the specific areas occupied by the pre-engraved patterns and the more extensive areas reserved for the storage of data.

Using an optical memory necessarily involves phases of writing and reading, but in most cases these phases occupy only a small proportion of the total operating time. Thus, in the case of an optical disk memory, the rotation of the disk is maintained, as are the functions of focusing, synchronization, and tracking, even if no writing or reading instruction is being executed. Such a condition of standby ensures a rapid response to the instructions received. The energy density of the illuminated part of the disk is considerable during scanning of the pre-engraved patterns, as the spot has to read these patterns with high precision. The same is true during the reading and writing of data, but it is easy to see that, in the standby condition, or in order to perform a function

other than writing or reading, it is possible to modify the density of the illumination received by the carrier.

Optical memories, and in particular those whose operation is reversible, are subject to the universal phenomenon of ageing, and it is well known that ageing is accelerated by stresses of all kinds. It is also well known that, to erase a disturbance of a given extent, the means of selective erasure have to act in a field which extends at least slightly beyond the recorded zone, without reproducing the conditions which occur in the writing phase. This type of disk is described in particular in Patent Application EP-A 106673 which relates to an erasable disk operating in three modes, viz. the read mode, the write mode and the erase mode.

Taking account of the above considerations, and setting aside the writing of the data, it is fair to say that there is a disadvantage in maintaining constant illumination of an information carrier during the remainder of the operating time.

With a view to remedying this disadvantage, the present invention provides a common mode of illumination of the information carrier for reading the transcribed data or the pre-engraved patterns interposed between the areas reserved for the storage of data, and provides for modification of this illumination mode during a scanning phase for these areas which is neither a writing phase nor a reading phase.

The subject-matter of the invention is an optical memory system with sampled tracking for a pre-engraved information carrier, the carrier comprising pre-engraved areas or interposed areas including a plurality of pre-engraved patterns defining the position of the track elements and of the address information, and reserved areas alternating with the interposed areas for recording user data, the system comprising:

- means for producing at least one optical beam of variable level for scanning the track elements;
- means for modulating the level of the optical beam;
- means for controlling the modulation means so as to adjust the level of the optical beam such that:

- in a read mode, the interposed areas and the reserved areas are scanned by a beam having a first level sufficient to allow reading,

- in a write mode, in which data are written into the reserved areas, the reserved areas are scanned by a beam having a level above that of the first level, and the interposed areas are scanned by a beam having the first level;

- and means for sampling such that focusing and tracking are performed only on the portions of the photodetected signal which correspond to the contents of the interposed areas, characterized in that the level of the optical beam is further adjusted such that in a standby mode, in which data are neither read nor written in the reserved areas, but the pre-engraved patterns are tracked, the reserved areas are scanned by a beam having a lower level than the first level, and the interposed areas are scanned by a beam having the first level.

The invention will be better understood from the description which follows, and from the accompanying drawings, in which:

- Figure 1 is an isometric view of an optical memory of a known type,
- Figure 2 is an isometric view of an electrooptical device for modifying the mode of illumination of an information carrier,
- Figures 3 to 5 are explanatory diagrams,
- Figure 6 represents the electrical control means of an optical memory according to the invention, and
- Figure 7 is an electrical diagram of an alternative form of the electrical control means shown in Figure 6.

In Figure 1, a portion of the surface of an information carrier has been drawn, in which there is a section of a track element containing areas 3 reserved for transcription of data in blocks of length a . Two areas 3 are separated from one another by an interposed area containing, for example, the pre-engraved patterns 1 and 2. The two patterns 1 are centred on the x axis of the track element, whereas the patterns 2 are offset by equal but opposite amounts.

The y and x axes define the surface of the information carrier, and the

z axis the normal direction of incidence of a light beam which is focused by the objective 5. The track element is scanned by the spot 4 when the information carrier moves in the positive direction of the x axis. Tracking is provided by a reflecting mirror 6 whose pivoting about an axis parallel with the x axis is controlled by a motor 7. Illumination of the information carrier is produced by a laser source 12, emitting, for example, a collimated beam plane-polarized in the direction 20. This beam passes through a polarization separator cube formed by two isosceles right-angled prisms 9 and 10 with their large faces 11 back to back, this face having been optically treated so as to transmit radiation whose polarization 20 is in the incident plane and to reflect radiation whose polarization 23 is perpendicular to the incident plane. A quarter-wave plate 8 converts the plane polarization 20 into circular polarization 21. After being reflected back from the information carrier via the objective 5 and mirror 6, the light comes back to the quarter-wave plate 8 with circular polarization 22 which is of opposite sign, since this light is travelling in the opposite direction. On leaving the quarter-wave plate 8, the polarization of the beam is such that it is reflected at 45° on the treated face 11. The collector lens 16 gathers this beam with polarization 23 and passes it to a photoelectric assembly 17 which delivers an electrical signal taking account of the optical interaction of the spot 4 with the pre-engraved or post-engraved patterns along the track element being scanned. The electrical processing circuit 18 receives the electrical signal coming from the photodetector assembly 17. It contains a clock and synchronization means capable of defining time segments coinciding with the scanning of the areas a, b and c. Synchronization is based on the scanning of the patterns 1, which are recognized by a suitable identification circuit.

The patterns 2 are used for evaluating, by sampling, the deviations of the spot 4 with respect to the track element, actuating an automatic control of the motor 7 to compensate these deviations. The patterns 2 or other zones of the information carrier may be used for determining the focusing error of the beam, which is taken into account by a control loop governing the distancing of the objective 5. The output 19 of the circuit 18 supplies an electrical signal corresponding to the reading of the data written in the areas 3. All these features are abundantly de-

scribed in the state of the art.

Included in Figure 1 alongside the track element is a diagram representing the incident luminous intensity I at different stages of the scanning of the information carrier. The stage DC corresponds to the reading of a data area 3. The stage CB corresponds to the scanning of an interposed area containing the pre-engraved patterns 1 and 2. During this stage and the stage which precedes it, the diagram shows that the luminous intensity is kept to a low level I_1 which is sufficient for the carrier to be read, but below the threshold level for modifying the optical characteristics of the information carrier. The stage BA is assumed to be a stage in which data 14 are written. It can be seen from the diagram in Figure 1 that the luminous intensity changes to a higher level I_2 in order to leave on the information carrier a trace of the bits "1" contained in the data. This level I_2 exceeds to a greater or lesser degree the engraving threshold mentioned above. This change to the write level is accomplished by the control circuit 13 which modulates the laser source 12.

A link is provided between the circuit 18 and the circuit 13 for transmitting to the input 15 a signal preventing the change to Level I_2 during scanning of the interposed areas b and c. This ensures that the pre-engraving is not affected during writing.

In the three stages illustrated in Figure 1, the law of distribution of the illumination does not vary in the reference surface of the information carrier and the incident energy is maintained at the same level I_1 for the stages DC and CB.

The use of an optical memory includes time segments during which information is recorded or reproduced, but these segments may be separated by standby periods during which the only imperative function is that of reading the pre-engraved patterns.

In this case, it is unnecessary to scan the data areas 3 using the same type of illumination as for scanning the pre-engraved patterns. Hence it is possible to consider modifying the quantity of light or the dis-

tribution of the illumination so as to shield the data areas from the effect of incident radiation whose harmlessness at high level is not proven. In the case of reversible optical memories, this is a wise precaution as it allows more durable preservation of the stored information.

Depicted in Figure 2, and given by way of nonlimiting example, is an electrooptical device for modifying the mode of illumination of the information carrier.

This device is for interposition between the laser source 12 of Figure 1 and the separator cube 9-10.

It comprises two electrooptical cells consisting of blocks 25 and 35 of electrically birefringent material such as lithium niobate. The block 25 is provided with electrodes 26 and 27 to set up an induction field in the block in response to a control voltage supplied by the circuit 38. This electric field is in a direction parallel with one of the bisectors of the angle xoz . The block 35 is equipped with electrodes 37 and 36 to produce the same modulator effect as the assembly 25, 26, 27 in response to a control voltage which may be the same as that applied to the electrodes 26 and 27.

The two electrooptical cells possess an electrical birefringence such that the transit of the optical radiation through the refringent block 25 or 35 in the z direction induces a change of polarization equal to that produced by passage through a half-wave plate whose neutral lines 45 and 46 are oriented at 45° to the polarization of the incident radiation.

Depicted in Figure 2 is a polarization separator cube comprising two isosceles right-angled prisms 28 and 29 with their large faces 34 back to back, this face having been treated so as to transmit radiation polarized in the incident plane and to reflect radiation whose polarization is perpendicular. The prism faces parallel with the direction z of transmission of the radiation are provided with quarter-wave plates 30 and 31 whose exposed faces 32 and 33 are for the moment considered as rendered reflecting.

The complete separator cube which has just been described is interposed

between the two electrooptical cells, and, taking account of what has been stated above, the radiation with polarization 20 passes in a straight line through the whole of the structure in Figure 2 when no voltage is applied to the electrodes 26, 27 and 36, 37.

However, the light path is modified when the voltage supplied by the circuit 38 causes a switch of polarization at the exit from the first cell 25, 26, 27. When this occurs, the radiation incident on the facet 34 has a polarization 40 at right angles to the polarization 20. It is reflected towards the plate 30 with a polarization 41, and after passing forward and back in this quarter-wave plate it comes back with the polarization 42 which lets it pass through the facet 34. The beam then strikes the plate 31 with polarization 42, and after returning in the opposite direction it comes back to the facet 34 with polarization 43 which causes it to be reflected towards the second cell 35, 36, 37. The function of the second cell is to switch the polarization 44 to restore the polarization 20.

Thus the optical system in Figure 2 allows a choice to be made between a direct path and a meandering path.

If the plane faces 32 and 33 of the quarter-wave plates are used as plane reflectors and if the facet 34 is plane, the two paths are equivalent as regards the form and orientation of the wavefronts which emerge from the structure.

However, the reflectivities of the faces may differentiate the paths in terms of intensity, and this represents one possible use of the setup for varying the mode of illumination of the information carrier; but this can be achieved more easily by controlling the light source, provided it lends itself to rapid modulation of intensity.

Besides this first possible use for the optical setup illustrated in Figure 2, it possesses the advantage that the distribution of the illumination can be influenced by modification of the form or orientation of the wavefront with an extremely short response time. Hence new possible uses can be contemplated.

As illustrated in Figure 3, the reflection conditions at the plate 31 can be modified by placing back to back with this plate a plano-convex lens 47 with a face 48 curved in at least one direction. This face 48 is given a reflecting surface. A collimated beam which passes through the structure without encountering the faces 33 and 48 has been shown in unbroken lines; this is the situation when no control voltage is present at the terminals of the cells 25 and 35. The modification of the progress of the light rays when a control voltage is present has been shown in dotted lines. If the surface 48 is spherical, the emerging beam has modified convergence, putting the beam projected by the objective 5 out of focus with respect to the information carrier.

This change is illustrated in Figure 5, which shows a front view of a fragment of an information carrier and its illumination.

Two adjacent track elements are shown, with, to the left of the line 51, in the interposed area 49, the pre-engraved patterns 1 which serve to establish them, and, to the right, in the reserved area 50, data storage zones 56. In accordance with the invention, the spot 4 is shown in the area 49 as having a well focused circular form and an intensity affording a good interpretation of the pre-engraved patterns. In the area 50, assuming neither writing nor reading of data is being effected, the mode of illumination has been modified.

The reference 52 denotes illumination by a spot whose intensity has been substantially reduced, with no change to its extent.

The reference 53 denotes illumination by a spot of increased extent; this effect is obtained with a switching device in accordance with Figure 2, but equipped with a spherical reflecting surface 48 in accordance with the adaptation seen in Figure 3.

The reference 55 illustrates another variant with an extended spot, which also uses the switch in Figure 2, but this time with a reflecting surface 48 with simple curvature such as a cylindrical mirror. In this variant, an astigmatism is introduced: this is useful in particular for creating conditions for erasure of the inscribed data.

The invention is not limited to the examples described. Provision must be made for a fairly rapid change of the mode of illumination on crossing the boundary line 51, and whenever a write or read instruction follows a period of standby.

Figure 4 depicts a variant which consists of replacing the lens 47 in Figure 3 by a prism. This variant does not affect the convergence of the beam, but causes the beam to deviate slightly so that the spot scans the between-track band as illustrated by reference 54 in Figure 5.

Figure 6 is an electrical diagram of a circuit for changing the mode of illumination of an information carrier in accordance with the present invention.

To avoid unnecessary complication of this diagram, switches W, R, P have been used to denote the data write and read instructions and the instruction ordering periodic reading of the pre-engraved patterns.

Closure of the switch W corresponds to an external write demand. Closure of the switch R corresponds to an external read demand. Closure of the switch P takes place periodically under the control of the circuit 18 which transmits a signal precisely locating the scanning of the pre-engraved patterns.

The radiation 58 which illuminates the information carrier is produced by a laser module which comprises a laser diode 57 and a photodiode 60 which takes a portion 59 of the radiation emitted. The laser diode 57 is assembled in series with a field effect transistor 61 between the earth M and the terminal 62 of a negative voltage source. The photodiode 60 connects the terminal 63 of a positive voltage source to the reversing input 69 of an operational amplifier 64 whose output is connected to the control electrode of the transistor 61.

A potentiometer 67 supplies a fraction of the negative feed voltage to a fixed resistor 66 which is connected to the input 69 with a variable resistor 65 providing a return to earth M. The non-reversing input 68 of the amplifier 64 receives a voltage on several levels which defines three

values of the radiated optical power 58, for example: 0.125 mW, 1.25 mW and 10 mW. This voltage is supplied by an operational amplifier 70 whose input 79 is looped to the output via an impedance 71. This voltage depends on the currents injected at the input 79 by three resistors 72, 73 and 74.

The resistor 74 is directly connected to the voltage source V and fixes the lowest level of transmission of the laser diode 57. Advantageously this level is not zero, as it is desirable for there to be no interruption in the optical counter-reaction provided by the photodiode 60, otherwise reestablishment of normal operation of the laser diode would involve a transient operation which could be troublesome.

Closure of the switch W applies the voltage V to the resistor 72 which is adjusted so that the emission 58 causes the data to be written with the desired level of intensity. Without the elements R, P and 73, the circuit is a known control circuit which produces the scheme of illumination reproduced in the diagram in Figure 1. According to an alternative way of carrying out the invention, the periodic closure of the switch P applies the voltage V to the resistor 73, the effect of which is to adjust the emission of light 58 to a read level which is between the standby level set by the resistor 74 and the write level set by the resistor 72. This assures a read power level which is sufficient for reading the pre-engraved patterns.

The switch R is connected in parallel with the switch P in order that this read power level is likewise assured when the data are actually being read, and this provides at the reading level the logical addition necessary for scanning the pre-engraved patterns and the data areas which have been selectively interrogated.

According to another variant, which is also illustrated by Figure 6, it is possible to use a control circuit 38 of the beam adapter illustrated in Figures 2 to 4. When this circuit is used, the switches R and P and the resistor 73 become optional, as it is not vitally necessary to provide for control of intensity.

Control of the electrooptical cells 25 and 35 is provided by an operation-

al amplifier 75 capable of supplying a high output voltage with a short rise time. The input 80 of the amplifier is looped to the output via an impedance 76. A resistor 77 mounted in series with a resistor 78 connects the input 80 to a voltage source 39 which supplies a voltage V' with respect to the earth M. The common point of the resistors 77 and 78 is connectable to earth by three switches W' , R and P which are connected in parallel. If at least one of these switches is closed, the electro-optical cells 25 and 35 are dead, and this affords a very accurately located and centred illumination of the track element being scanned.

If none of the switches W' , R or P is closed, the electrooptical cells switch the polarization so that the illumination of the carrier assumes one of the forms 52, 53, 54 or 55 illustrated in Figure 5.

The switches R and P connected to M are of the same type as the switches R and P connected to V. However, the switch W' differs from the switch W, as it can be kept closed throughout an entire data writing cycle. Also it should be noted that the switch W has to be open during each scan of an interposed area provided with pre-engraved patterns, except during a possible first writing of these patterns, and that it closes only for transcription of the "I" bits of the sequence of data.

The use of a beam control whereby the convergence characteristics can be changed and the intensity modulated finds a useful application in the field of information carriers permitting erasure of the data by virtue of a process of reversible transcription. In this field, there exist magnetic film carriers in which the direction of magnetization of a field enables a bit to be labelled 0 or 1. Writing makes use of an optical head fitted with an inductive coil which selects the direction of magnetization within a field defined by a transient temperature-rise resulting from the impact of an addressing optical beam. Reading of a field relies on the Faraday effect and consists of a fine analysis of the rotation of polarization of the light which interacts with the information carrier. Erasure of the information is comparable with the writing process, but differs from it in the sign of the magnetic field to be created, since it involves restoration of the magnetization to its initial direction and, if appropriate, extension of the optically addressed zone.

Erasure may, for example, be performed by closing the switch W while keeping switch W' open, thus putting the spot out of focus during scanning of the data areas to be erased. Defocusing may, for example, be that illustrated by the outlines 53 or 55 in Figure 5.

This mode of operation is also relevant to reversible films based on a thermo-optical interaction producing a change of phase between the amorphous state and the crystalline state. The kinetics of the change of phase require the temperature-rise to be prolonged when it is desired to erase data, and this may, for example, involve elongating the spot in the direction of scanning of the track element. In this case it may be helpful to allow for this elongation by providing, for example, a margin at the start and end of the data areas.

The invention is not limited to the creation of illumination conditions favourable to standby operation. It also covers the creation of illumination conditions allowing previously inscribed data to be erased. Modification of the illumination conditions may be effected by using the electro-optical means described above, but it could equally well be based on the use of a cell with acousto-optical modulation, or on the alternate use of beams produced by two electrically modulable light sources with an optical superimposition device between these sources transmitting these beams on a common optical axis.



CLAIMS

1. Optical memory system of the sampled tracking type for a pre-engraved information carrier, the carrier comprising pre-engraved areas or interposed areas bearing a plurality of pre-engraved patterns defining the position of the track elements and of the address information, and reserved areas alternating with the interposed areas for recording user data, the system comprising:

- means for producing at least one optical beam of variable level for scanning the track elements;
- means for modulating the level of the optical beam;
- means for controlling the modulation means so as to adjust the level of the optical beam such that:

- in a read mode, the interposed areas and the reserved areas are scanned by a beam having a first level sufficient to allow reading,

- in a write mode, in which data are written in the reserved areas, the reserved areas are scanned by a beam having a level above the first level, and the interposed areas are scanned by a beam having the first level;

- and means for sampling such that focusing and tracking are performed only on the portions of the photodetected signal which correspond to the contents (1, 2) of the interposed areas, characterized in that the level of the optical beam is further adjusted such that in a standby mode, in which data are neither read from nor written in the reserved areas, but the pre-engraved patterns are tracked, the reserved areas are scanned by a beam having a lower level than the first level, and the interposed areas are scanned by a beam having the first level.

2. System according to Claim 1, characterized in that it comprises in addition means for selecting at any time only one of the modes among a) the read mode or b) one of the other modes.

3. System according to Claim 1, characterized in that it comprises in addition means for causing modes other than the said read mode to differ from the read mode by using a different distribution of the optical energy impinging on the surface of the carrier.

4. System according to Claim 3, characterized in that the means provid-



ing a different energy distribution comprise an objective for projecting the illuminating beam and means (R, P, 77, 78, 25, 35) for modifying the wavefronts of the optical waves received by the projection objective.

5. System according to Claim 4, characterized in that the said objective comprises a means for projecting a light spot (53, 55) having a contour dilated in at least one direction of the said surface with respect to the circular contour (4) of the light spot projected in the read mode.

6. System according to Claim 5, characterized in that the projection means produce a dilated contour (53) of circular shape.

7. System according to Claim 5, characterized in that the means for dilating the contour comprise a means for modifying the astigmatism of the spot such that the long axis is oriented in the direction of scanning of the said track elements.

8. System according to Claim 3, characterized in that the means for modifying the read mode comprise means for shifting the spot (54) projected by the said objective in relation to the track element (56) which is being scanned.

9. System according to Claim 1, characterized in that the means for producing an optical beam comprise a light source (12) and a projection objective (5), between which an electrically controlled electrooptical device is interposed, comprising a polarization separator (28, 29, 34) between two electrooptical cells (25, 35).

10. System according to Claim 9, characterized in that the said polarization separator (28, 29, 34) is placed between two quarter-wave plates (30, 31) whose external faces (32, 33) are provided with reflector means (47, 48) which receive the polarized radiation coming from the said source only when its linear polarization has been rotated through 90° by one of the said cells (25, 35).

11. System according to Claim 10, characterized in that at least one of the said reflector means (47, 48) modifies the divergence of the incident beam in at least one direction.



12. System according to Claim 1, characterized in that the said information carrier is of the type permitting repeated reinscription.

13. System according to Claim 1, characterized in that the said information carrier allows only one final inscription of data.

14. System according to Claim 1, characterized in that the said information carrier is a disk bearing a thermoinscriptible structure on at least one of its faces.