Description

This invention relates to an optical pickup head apparatus which can be used for recording and reproducing or erasing optical information on and from an optical or opto-magnetic medium.

The optical memory technique using a pit-like pattern as a high-density and high-capacity storage medium has been practiced by finding many applications such as digital audio disk, video disk, document file disk and data file. The optical pickup head (hereinafter abbreviated as OPUH) apparatus is based on three functional components, i.e., (i) an imaging optics for forming a diffraction-limited micro-spot, (ii) a component for effecting focusing of the optics and tracking error signal detection as well as pit-signal detection, and (iii) an actuator. In the past, advanced aspherical lens design and highly precise press work technologies have contributed to remarkable size-reduction and weight-reduction of the functional component in item (i) above and consequently compactness and high performance of the actuator in item (iii) have promisingly been insured. As regards the component for error signal detection in item (ii), however, even a signal detection component for use in an OPUH apparatus dedicated to reproduction and capable of being constituted with the simplest optical system must comprise a beam splitting means, a focusing control means based on an astigmatic aberration method or a knife edge method and a tracking control means in independent form or combined form. Optical parts such as beam splitter, lens and prism to be used conventionally in the signal detection component are difficult to manufacture in mass production, to assemble and to adjust and have disadvantages from the standpoint of size reduction, cost reduction, mass production and reliability.

Recently, a countermeasure to solve the above problems has been reported in "High Performance Optical Head using Optimized Holographic Optical Element" by Y. Kimura et al, Proc. of the International Symposium on Optical Memory, Tokyo, Sept. 16-18, 1987 (p. 131). In this proposal, an optical element having a complex function is introduced to solve the aforementioned problems and as shown in Fig. 1b in the accompanying drawings of the present application, a hologram element 16 is disposed near a focusing lens 3. Conventionally, when a hologram element prepared using light of a wavelength λ_1 (400 to 500 nm) suitable for hologram recording is irradiated, for reconstruction, with a near infrared or red laser beam of a wavelength λ_2 (~ 800 nm or 633 nm) suitable for a light source of OPUH apparatus, the lens action of the hologram suffers from a noticeable aberration which is difficult to correct. Under the circumstances, the hologram element is generated by means of a computer under design consideration based on a so-called Fourier transform holographic system which is an optics model as shown in Fig. 1a wherein an interference fringe pattern due to interference of two points P_1 and P_2 with a reference beam R is formed or an ϵ - η plane or hologram surface (practically, an interference fringe pattern due to wave fronts 230 and 231 is formed on one half of the hologram surface and an interference fringe pattern due to wave fronts 230 and 232 is formed on the other half). Thus, the hologram element 16 used in Fig. 1b is prepared by electron beam graphics and in particular, has two domains 161 and 162 to attain effects equivalent to those of "wedge-prism method" or "double-knife edge method". In an optical head optics shown in Fig. 1b, a laser beam such as infrared beam or visual beam emitted from a laser source 1 passes through the hologram element 16 and lens 3 and irradiates the surface of an optical disk 4. A reflected beam from the optical disk passes through the lens 3 and element 16, whereby the diffracted beams are detected by a beam detector 15 so as to be used for focusing control, tracking control and the like. Light spots incident upon the photodetector 15 are diagrammatically shown in Fig. 1c. The hologram element prepared in the above manner can advantageously act as an aberration-free hologram lens for a wavelength limited to the design wavelength λ_2 of the laser source 1 used and even in the event that an aberration due to a slight variation in wavelength of the laser source appears as the beam shift on the photoelectric conversion surface of the beam detector or photodetector 15, four photoelectric conversion domains 151, 152, 153 and 154 which can conveniently be operated in push-pull fashion suppress the variation to a practically satisfactory extent.

However, the prior art optics using the hologram element 16 is disadvantageous in that in order to focus a small spot upon the linear domain-boundary (B in Fig. 1c) of the photodetector 15, the position of the spot has to be adjusted correctly within a range of ± several microns relative to the photodetector 15 as in the case of the usual optical system. In an astigmatic aberration type system in which astigmatic aberration wave fronts are detected by a four-domain or -element (quadrant) detector 15 as shown in Fig. 1c, the same difficulties are encountered in performing accurate final adjustment of the photodetector 15. In this connection, one may refer to, for example, "A Multi-functional Reflection Type Grating Lens for the CD Optical Head" by K. Tatsumi et al, Proc. of the International Symposium on Optical Memory, Tokyo, Sept. 16-18, 1987 (p. 127) and USP 4,731,722 to Wai-Hon Lee entitled "Optical head using hologram lens for both beam splitting and focus error detection functions" issued May, 1988.

Further, in making an attempt to integrally form the light source (semiconductor laser) and the photodetector in the conventional OPUH apparatus using the holographic element, the position of the photodetector relative to the light source must also be adjusted with high accuracy.

In the conventional optics using a diffraction grating (knife edge method), an unwanted diffraction beam is produced from the diffraction element 16 irradiated with the light source 1, though not illustrated in the conceptive diagram of Fig. 1b, and focused by the lens 3 upon the surface of the optical disk 4 to form an unwanted diffraction spot image. The unwanted spot is a small spot like the 0-order diffraction beam spot and in a write-once type or erasable type optical disk, its intensity is too high to be neglected and degrades the S/N ratio upon signal recording or reading.

An aim of this invention is to provide a compact, light and highly reliable OPUH apparatus which is suitable for mass production.

With the above aim in mind, the present invention provides an optical pickup head apparatus comprising:

a light source for emitting a beam;

imaging optics for focusing the beam into a small spot;

a diffraction element, disposed in an optical path on which the beam passing through said optics is reflected from a given optical storage medium or diffracted thereby, for producing two wave fronts of the same diffraction order and having different focal points in one half of the off-axis region relative to the optical axis of said optics; and

photodetector means for receiving beams of the two wave fronts from the diffraction element;

characterised

in that said two wave fronts are respectively focused upon two planes which are respectively located forwardly and backwardly of a plane perpendicular to said optical axis and containing a focusing point of the 0-order diffracted beam produced from said diffraction element; and

in that said photodetector means includes first and second photodetectors, respectively having a plurality of linear element boundaries extending in one or the other direction which are coincident with or substantially parallel to a radial line with a center located at a focal point of a 0-order diffraction beam produced from said diffraction element, far receiving said two wave fronts on their coplanar detection surface which is disposed substantially at a center between the focal point of one of said two wave fronts and the focal point of the other of said two wave fronts.

Specific embodiments of the present invention are now described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1a shows a model of an optics for preparation of a conventional hologram;

Fig. 1b is a schematic diagram illustrating an optical head optics using the conventional hologram;

Fig. 1c is a diagram illustrating light spots on a photodetector used in the optics of Fig. 1b;

Fig. 2a is a schematic diagram illustrating an OPUH apparatus according to an embodiment of the invention;

Fig. 2b is a diagram conceptually illustrating the relation between diffraction element and photodetector in the Fig. 2a embodiment;

Fig. 3 is a diagram for explaining the principle of another embodiment of the invention;

Fig. 4a is a schematic diagram illustrating an OPUH apparatus according to still another embodiment of the invention;

Fig. 4b conceptually schematically illustrates a photodetector arrangement to be used in the Fig. 4a embodiment in place of that shown in Fig. 4a;

Figs. 5a to 5c are diagrams useful in explaining the operation of the photodetector in respect of three focusing states of beams;

Fig. 6a conceptually schematically illustrates another embodiment of photodetector arrangement according to the invention;

Fig. 6b conceptually illustrates integral formation of the photodetector and light source for use in the Fig. 6a embodiment;

Fig. 7 is a schematic diagram illustrating an example of a recording optics for preparation of a hologram used as a diffraction element according to the invention;

Fig. 8a conceptually illustrates a superposed zone-plates pattern corresponding to a pattern obtained by the Fig. 7 optics;

Fig. 8b conceptually illustrates another diffraction element pattern according to the invention;

Fig. 9a is a plan view of a phase-type diffraction element;

Fig. 9b is a sectional view of Fig. 9a;

Fig. 10 is a diagrammatic representation for explaining 0-order and ± first-order diffraction beams;

Fig. 11 is a schematic diagram illustrating an OPUH apparatus according to a further embodiment of the invention;

Fig. 12a is a similar view illustrating an OPUH apparatus according to a further embodiment of the invention; and

Fig. 12b illustrates a beam on the photodetector in the Fig. 12a embodiment.

Fig. 2a schematically illustrates an OPUH apparatus according to an embodiment of the invention. Referring to Fig. 2a, the OPUH apparatus comprises a semiconductor laser 1 for emitting a coherent beam having a wavelength λ_2 of, for example, about 800 nm falling within the infrared region or a region of shorter wavelengths than infrared rays, a collimating lens 2 having a focal length f_c of about 20 mm, and an objective lens 3 for focusing. The spherical beam emitted from the light source 1 is converted by the collimating lens 2 into a parallel beam which is focused upon an optical storage medium (optical disc) 4 by means of the lens 3. Interposed between the lenses 2 and 3 is a diffraction optical element 6 that can produce two focal points in the off-axis region. On the forward path, the 0-order diffracted transmission light transmitting through the diffraction element 6 is focused upon the disk 4. This disk 4 is comprised of a substrate 42 and a protection layer 41. On the backward or return path, the beam reflected from the disk 4 passes through the lens 3 so as to be converted into a substantially parallel beam which in turn impinges upon the diffraction element 6, so that in addition to the 0-order transmission light, off-axis double wave fronts 61 and 62 of different curvatures are generated.

These diffracted wave fronts are respectively focused by the collimating lens 2 upon two planes in the one half of the off-axis region which are respectively located forwardly and backwardly of a plane 111 that contains a focusing point for the 0-order diffracted light, i.e., an emitting point of the light source 1 and is vertical to the optical axis Z of the lens 2. The apparatus also comprises a photodetector 5 for receiving light which includes three-element photodetectors 51 and 52 as shown in Fig. 2b. The focal plane for the wave front 61 is δ_1 (absolute value) distant from the plane 111 and that for the wave front 62 is δ_2 (also absolute value) distant from the plane 111, and $\delta_1 = \delta_2 = \delta$ is determined in design. But when compared with, for example, the distance between the two astigmatic focal lines in the astigmatic method, $\delta_1 + \delta_2$ can be a few times larger and

$$\delta_1 \neq \delta_2$$

can be permitted with a relatively large tolerance. Conjugate images are formed in the other half of the off-axis region but they are not illustrated in Fig. 2a.

Fig. 2b particularly illustrates the relation between the emitting point 10 and each of the first and second photodetectors 51 and 52 located on the plane 111. The wave front 61 results in an incident beam 610 upon the photoelectric conversion surface of the photodetector 51 and the wave front 62 results in an incident beam 620 upon the photoelectric conversion surface of the photodetector 52. These beams respectively bridge linear element-boundaries B and are aligned on the X axis which is a straight line passing through the emitting point, as shown in Fig. 2b. The OPUH in accordance with the invention differs from the prior art OPUH using a diffraction element in such points as the configuration of domain of the sub-detector, the pattern (Fresnel-zone-plate) of the diffraction element and the positional relation between photodetector and diffraction element, so as to be well adapted to attain special advantages. For convenience of explanation, centers O_1 and O_2 of two Fresnel-zone-plate like patterns of the diffraction element 6 are illustrated in Fig. 2b but the element 6 is used at a portion surrounded by dotted circle. The line $\overline{O_1O_2}$ is parallel to the X axis. The photodetector featured by the invention will be detailed later with reference to Figs. 5a to 5c.

Fig. 3 is a diagrammatic representation illustrative of the concept of another embodiment of the invention. While the transmission type diffraction element is used in the first embodiment, a reflection type diffraction element 66 is used in this embodiment to bend the optical axis by an angle α nearly equalling 90°. In this case, the Fresnel-zone-plate pattern is not circular but is elliptical in which the ratio between major and minor axes approximates 1.4:1. However, the circular Fresnel-zone-plate pattern, though suffers from an astigmatic aberration, may also be used practically satisfactorily in this embodiment. The imaging optics in this embodiment can be devoid of the collimating lens and can be formed of an objective lens system 30 alone to realize compactness of the apparatus and reduce the number of parts.

Fig. 4a schematically illustrates a further embodiment of the invention which differs from the previous two embodiments in that a polarized beam spliter 109 and a quarter wavelength plate 9 are provided with the view of obtaining control beams on a return path separated from a forward path starting from a light source 1, and that a third photodetector 7 of two domains is exclusively used for tracking detection. In this case, the optical system is arranged in such a manner that the direction of the track groove in optical disk

projected on the surface of the photodetector 7 is orthogonal to the linear element-boundary B_1 of the photodetector 5. Thus, by detecting signals while rendering the direction of a linear domain-boundary B_2 of the two-element photodetector 7 coincident with the direction of the projected track groove, noise (offset) due to crossing of the beam across an optical disk groove can be suppressed for the sake of detection by the focusing error detector, thus ensuring that accurate focusing control can be performed and the actuator can be operated with minimal power consumption. The wavelength plate 9 is preferentially designed as $\lambda/4$ plate to facilitate performance balance between wavelength plate 9 and polarized beam splitter 10 and optimize the quantity of return light, thereby maximizing the S/N ratio for signal detection. A mirror 8 is adapted to bend the optical path. In this embodiment, a hologram 666 may preferably be blazed to maximize the diffraction efficiency.

As shown in Fig. 4b, the photodetectors 51 and 52 and a photodetector 50 dedicated to detection of RF signals may be integrated on the focal plane of a focusing lens 20.

The construction of the photodetector used in the foregoing embodiments will now be described in greater detail. Figs. 5a to 5c diagrammatically show the relation between the beams 610 and 620 detected on the elements of the photodetectors 51 and 52 shown in Fig. 2b. Particularly, when an in-focus spot is formed on the disc, the beams 610 and 620 having identical diameter and optical power density can be obtained as shown in Fig. 5b and these beams are subjected to photoelectric conversion. As a result, an output signal detected from one of three elements 510 of the detector 51 equals an output signal detected from one of three elements 520 of the detector 52 and the differential output signal becomes zero. Accordingly, where an output signal from each domain j is represented by S_j, a focusing error signal F_E is given by

$$F_E = S_{510} - S_{520}$$

$$= 0$$

But, preferably, the focusing error signal F_E is obtained from,

$$F_E = (S_{510} + S_{521} + S_{522}) - (S_{520} + S_{511} + S_{512})$$

because this differential detection can improve the error signal detection sensitivity (ratio between focusing error and output signal) and linearity, followed by improved light utilization efficiency leading to extremely improved S/N ratio.

When an out-focus or defocusing spot is formed on the disk, the incident light upon the diffraction element 6 is not a plane wave but is, for example, a diverging spherical wave and therefore the focal point for the wave front 61 affected by convex lens action of the Fresnel-zone-plate pattern of the diffraction element approaches the photodetector while the focal point for the wave front 62 affected by concave lens action of the Fresnel-zone-plate pattern leaves the photodetector, as illustrated in Fig. 5c.

Consequently,

$$F_E = S_{510} - S_{520} > 0$$

stands or obviously

$$F_E = (S_{510} + S_{521} + S_{522}) - (S_{520} + S_{511} + R_{512}) > 0$$

stands.

When an out-focus or defocusing spot is formed on the optical disk in opposite phase relation to the above, the beams are inversed symmetrically to those of Fig. 5c as illustrated in Fig. 5a and

$$F_E = S_{510} - S_{520} < 0$$

or

$$F_E = (S_{510} + S_{521} + S_{522}) - (S_{520} + S_{511} + S_{512}) < 0$$

stands. The linear element-boundaries B of each detectors are parallel to the X axis passing through the focal point 10 for the 0-order diffraction beam and individual beams appearing in each state described above moves along the linear element-boundary B in the X-axis direction when the wavelength of the light source varies. This movement is exemplified at dotted-line circles in Fig. 5b. It will be appreciated that the movement of the beams is due to the parallelism of the line connecting centers O_1 and O_2 of the zone-plate like patterns of diffraction element 6 to the X axis as shown in Fig. 2b.

Where the focal distance f_2 of the collimating lens is 20 mm and the aperture size thereof is 5 mm, an example of design parameters is such that $W_0 = W_1 = W_2 = 0.05$ mm is for each element, the distances ℓ_1 and ℓ_2 from the point 10 to the element centers are 1 mm and 0.65 mm, respectively, the beam diameter D corresponding to the in-focus spot is 0.10 mm, and $\delta_1 = \delta_2 = 0.4$ mm.

In actual OPUH apparatus, it suffices that a focusing variation amount of about ±100 μm on the photodetector surface corresponding to a defocusing amount of about ±5 μm on the optical disk surface is designed for the main operating range and therefore the diameter of beams in Figs. 5a to 5c can afford to change from a maximum value of about 125 μm to a minimum value of about 75 μm.

Returning to Fig. 2a, the signal pits along tracks are sectioned so as to be illustrated as irregularity in the information recording surface. If the track proceeds in a direction parallel to the sheet of drawing, two beams are respectively converging and diverging wave fronts and far-field patterns of the track groove are in counter-phase on the photodetector surface. Accordingly, a tracking error signal T_E can be obtained by calculating,

$$T_E = (S_{511} + S_{521}) - (S_{512} + S_{522}).$$

It will then be appreciated that in accordance with the invention, the mechanical clearance for photodetector can be mitigated considerably in obtaining the focusing error signal F_E and tracking error signal T_E as compared to the case of Fig. 1c.

Generally, when a semiconductor laser is used as the light source, there arises a problem that the wavelength of the beam emitted from the laser shifts in accordance with temperature changes or current changes. In accordance with the invention, the direction of the linear element-boundary B coincides, as shown in Figs. 5a to 5c, with the direction of the spatial carrier frequency of a partial hologram corresponding to reconstruction of the respective wave fronts having different focal points and therefore no trouble occurs even when the beam shifting as shown at dotted-line circle in Fig. 5b takes place in which the beam 611 shifts by $\Delta\ell_1$ and the beam 621 by $\Delta\ell_2$. As the wavelength varies from λ_2 to $\lambda_2 + \Delta\lambda$, the two beams change in magnification by the same amount which is

$$\frac{\lambda_2 + \Delta\lambda}{\lambda_2}$$

and the differential output signal can still remain undisturbed even when the beam diameter changes.

Fig. 6a illustrates another arrangement of photodetectors which can be used for the OPUH apparatus according to each embodiment of the invention. This arrangement differs from the arrangement of Figs. 5a to 5c in that centers of first and second photodetectors 51 and 52 are both ℓ distant from the emitting point 1000, and that linear element-boundaries B of the first and second photodetectors are parallel to lines which extend radially from the point 1000 and make a predetermined angle θ between the lines. In this case, two off-axis Fresnel-zone-plate patterns are symmetrical with respect to a vertical bisector for a line segment connecting centers O_1 and O_2 of the two patterns, as shown in Fig. 8b, and advantageously an absolute value of diffraction angle variation corresponding to the light source wavelength variation is the same for the two beams. Accordingly, when a light source liable to greatly vary in wavelength is used, ℓ is designed to be minimal. Further, the two wave fronts can easily be made to be severely identical to each other in beam intensity.

By slightly rotating the diffraction element or the photodetectors about a rotation center 1000 substantially coincident with the emitting point 10 as indicated at arrow 98 or 99 in Fig. 6a, the relation between the diffraction element or photodetector and the position of beams 611 and 612 angularly separated from each other by θ can be adjusted with ease as in the case of Figs. 2a and 2b. In an example wherein the photodetector 5 and the semiconductor laser 1 are integrally formed, they are located in positional relationship as diagrammatically shown in Fig. 6b. Where $\theta \simeq 45°$, $\ell \simeq 1$ mm and beam diameter $D \simeq 0.1$

mm, it suffices that the emitting point 10 of light source is settled at a design location with a mechanical accuracy of about 0.1 mm, and the integral formation of the light source and photodetector can be realized more easily as compared to the case of $\theta \simeq 0$. This is particularly advantageous for manufacture of the above integral parts by using automated machines. Further, by taking into consideration of the positional errors of the laser diode 1 assembled with the photodetector 5, it is practically possible or recommended to design the boundary intersecting angle θ' between nearly zero and that of the directions of the element boundaries such as illustrated in the Figure, i.e., $0 \leq \theta' \leq \theta$.

Fig. 7 is a diagrammatic representation illustrative of the concept of an example of an optics for recording a Fourier transform hologram used as the diffraction element in each embodiment of the invention.

A coherent plane wave 91 incident upon graded index rod-lenses 901, 902 and 900 is focused on predetermined spatial positions 101, 102 and 100 and then the differently focused beams pass through a Fourier transform lens 99 so as to superpose each other on a recording medium 60, thereby forming a Fourier transform hologram. The Fourier transform hologram, characteristics of which are reported and analyzed in detail in, for example, a literature "Speckle reduction in holography ---" by M. Kato et al, Appl. Opt., 14 (1975) 1093, has been applied practically to a recording/reproduction optics for general images (see "Optical Chinese character edition/processing system" by Sato et al, Research Data, The Institute of Electronics and Communication Engineers of Japan, EC 78-53 (1978) 47). The literature is herein incorporated by a reference as part of this disclosure. Particularly, in a Fourier transform hologram used in the present invention, it suffices that Fourier transform is valid for reconstructed wave fronts near the optical axis to an extent that the function of the hologram as a beam control means is not disturbed practically. Accordingly, the lens used for reconstruction of wave fronts from the hologram element may be replaced with the collimating lens or alternatively, by simply irradiating a converging spherical wave on the hologram element, a desired reconstructed image can also be obtained on a focal plane of the hologram element.

In the recording optics shown in Fig. 7, Z-axis distance Δ_1 between focal point 101 and X axis and Z-axis distance Δ_2 between focal point 102 and X axis can be designed as follows:

$$M^2\Delta_1 = \delta_1', \qquad M^2\Delta_2 = \delta_2',$$

$$\delta_1 = \delta_2', \qquad M = \frac{\lambda_2}{\lambda_1} \cdot \frac{f_2}{f_1}$$

where M is magnification, f_1 is the focal distance of the recording Fourier transform lens 99, and f_2 corresponds to the focal distance of reconstruction Fourier transform lens which is represented by focal distance of the collimating lens 2 in Fig. 2a and by radius of curvature f_2 of a converging wave incident upon the hologram in Fig. 3. Distances L_1 and L_2 between optical axes of the rod-lenses are respectively related to ℓ_1 and ℓ_2 in Fig. 5b by $ML_1 = \ell_1$ and $ML_2 = \ell_2$. Where the focal distance f_1 of the recording Fourier transform lens approximates 50 to 100 mm, L_1 and L_2 approximate 1 to 2 mm for the purpose of dimensional matching with the optical head optics and photodetector system described in connection with Figs. 2a to 4b. With an ordinary lens optics, a desired hologram is difficult to obtain but a rod-lens of about 1 mm diameter is easy to realize, thus facilitating preparation of a desired hologram.

In this way, the hologram used as the diffraction element having the Fresnel-zone-plate pattern can be prepared using the laser interferometric optics. But, as well known in the art, the Fresnel-zone-plate can also be drawn in the form of a concentric zone pattern by using a method other than the interferometric method. Taking a single Fresnel zone 660 diagrammatically illustrated in Fig. 9, for instance, radius r_j of zones constituting the single Fresnel zone having focal distances $\pm f_z$ is given by

$$r_j = \sqrt{2j\lambda f_z + j^2\lambda^2} \qquad (1)$$

where λ is wavelength of the light source. A phase-type zone plate in the form of a phase plate 669 having a step ϵ in a section on the line AA' of Fig. 9a as illustrated in Fig. 9b can be obtained and used as a diffraction element like a phase-type hologram having high diffraction efficiency.

Fig. 8a illustrates two zone patterns, as designated by 660 and 661, each corresponding to the hologram prepared through the interferometric optics, with the two patterns separated from each other by a predetermined distance ($L_1 + L_2$) to overlap each other. However, an area within dotted-line circle, as

designated at 6, is actually used such patterns, like a mask pattern used in the fabrication process of semiconductor devices, can be drawn directly using the computer output. The pattern of Fig. 8a is used as a mask for photoetching to form a phase-type diffraction element 6 as shown in Fig. 9a which can be used as the diffraction element 6 in the optical system of Fig. 2a. The phase-type diffraction element 6 having its surface coated with a film of metal such as aluminum or gold or a multi-layer dielectric thin film may be used as the reflection-type diffraction element in Fig. 3. It is however noted that for simplicity of explanation, Fig. 9a illustrates only a partial pattern (single zone plate). Fig. 8b conceptionally shows a diffraction element pattern used in combination with the photodetector arrangement shown in Fig. 6. In addition to the above, various types of Fresnel-zone-plate can be designed and prepared depending on the type of optics and can be combined with electron beam graphics, as necessary, to obtain a highly precise Fresnel-zone pattern.

Referring to Fig. 10, a diffraction element 6 prepared on the basis of the double zone pattern shown in Fig. 8a is combined with a collimating lens 2. When the diffraction element 6 is irradiated with a parallel coherent beam, 0-order and ± first-order diffraction waves are produced. The ±1 first-order diffraction beams (diverging and converging beams) from the respective zone patterns are diffracted waves corresponding to virtual images on optical axes respectively distant from the optical axis of the lens 2. The diffraction waves are focused by the lens 2 to form light fluxes 61, 62, 64 and 65. Light flux corresponding to the 0-order diffraction beam is designated by 63. To meet the first embodiment of the invention (Figs. 2a and 2b), the light fluxes 61 and 62 are detected by the first and second photodetectors, respectively. The distances L_1 and L_2 in Fig. 10 correspond to ℓ_1 and ℓ_2 in Fig. 5b and are determined by the focal distance f_c of lens 2 and the focal distances $\pm f_z$ of zone plate. CX1 and CX2 indicate center axes of zone plates. The Fresnel-zone-plate prepared by graphics is more vulnerable to wavelength variation to cause a slight chromatic aberration than the Fresnel-zone-plate in the form of the Fourier transform hologram, but it has advantages of (i) long focal distances (ii) ability to be used with a differential detection system and (iii) signal detection in the far field and ability to realize the function of an auxiliary lens for forming two focal points which are forwardly and backwardly of the focal plane of the focusing lens, and it can be used for realizing an OPUH apparatus which is practically satisfactory. The relation between f_c and f_z (more strictly, f_z represents focal distances $\pm f_{z1}$ and $\pm f_{z2}$ of the two zone plates) can be indicated in accordance with the simple geometrical optics as follows:

$$\frac{1}{-f_{z1}} + \frac{1}{f_c - \delta} = \frac{1}{f_c} \qquad \cdots\cdots (2)$$

and

$$\frac{1}{f_{z2}} + \frac{1}{f_c + \delta} = \frac{1}{f_c} \qquad \cdots\cdots (3)$$

where δ is the distance between the photodetector surface and each of under and over-focus images and related to f_c by $2\delta < f_c$. Values of f_{z1} and f_{z2} depend on a pattern designed pursuant to equation (1) and a wavelength used. Especially where the objective lens 3 in Fig. 2a has a focal distance f_0, $f_0 << f_{z1} \simeq f_{z2} = f_z$ stands and equations (2) and (3) can be approximated by,

$$\frac{1}{f_c} + \frac{1}{f_z} = \frac{1}{f_c - \delta}$$

and

$$\frac{1}{f_c} - \frac{1}{f_z} = \frac{1}{f_c + \delta}$$

, respectively. Obviously, if so desired, a Fourier transform type zone-plate pattern may be synthesized and drawn by means of a computer.

In a preferred embodiment of the present invention, the distance 2δ between the two different focal points is defined by,

$$\frac{f_c}{50} \lesssim 2\delta \lesssim \frac{f_c}{5}$$

Fig. 11 illustrates conceptionally schematically a OPUH apparatus according to still another embodiment of the invention. Like the embodiment of Fig. 2a, a diffraction element 6 is disposed in a coherent beam emitted from a light source 1 and on the backward optical path, two-focal-point images are detected by three-element photodetectors 51 and 52, respectively. This embodiment is identical to the Fig. 2a embodiment with the exception that (i) an imaging optics is devoid of the collimating lens 2 and comprised of only an objective lens 300, (ii) slit-like grating areas 671 and 672 are formed on the surface of the diffraction element 6 wherein diffraction gratings at predetermined pitches are formed in the respective areas obliquely by making angles $+\phi$ and $-\phi$ to X axis, respectively, and (iii) photodetectors 71 and 72 are the three element photodetectors 51 and 52 are integrated on the same chip. The direction of tracks in an optical disk 4 coincides with the Y-axis direction near the beam focusing point and the direction of the two grating areas 671 and 672 also coincides with the Y-axis direction substantially. The pattern of the diffraction element 6 is the same as the pattern 6 in the circular aperture shown in Fig. 8b and the line segment $\overline{O_1O_2}$ in Fig. 8b is substantially parallel to the X axis in Fig. 11. With this contruction, since the tracking signal can be picked up from a slit aperture at a position where the far-field pattern of the track groove changes maximally on the diffraction element surface, a stable tracking error signal can be produced from a differential output circuit 77 of the photodetectors 71 and 72. Accordingly, there is no need of separating the tracking error signal from the three-element photodetectors 51 and 52 and when the absolute value of angles $\pm\theta/2$ subtended by the linear element-boundary of respective photodetectors 51 and 52 and the X axis is designed to be $\theta \leq 45°$, noise due to crossing of the beam across the groove and contained in the focusing error signal can be suppressed remarkably.

Fig. 12a schematically illustrates a OPUH apparatus according to a further embodiment of the invention. In this embodiment, part of a single zone plate as shown in Fig. 9a substitutes for the diffraction element 666 shown in Fig. 4a to form a diffraction element 661 having, in its aperture, slit-like grating areas 671 and 672. In this embodiment, the linear element-boundary B of each of the three-element photodetectors 51 and 52 is parallel to X axis which connects optical axis Z and zone plate center O_1 and mutually conjugate two-focal-point images due to the convex and concave lens functions of the single zone plate are differentially detected to provide a focusing error signal. A central photodetector 77 located near the optical axis is used for RF detection. Other diffraction beam components stemming from the slit-like grating areas are detected by photodetectors 73, 74, 730 and 740 and a tracking error signal S_T is given by,

$$S_T = (S_{74} + S_{740}) - (S_{73} + S_{730}).$$

In this embodiment, the direction of the track groove projected on the surface of photodetector can be set so as to accurately coincide with the Y-axis direction and even in the event that there occur as shown in Fig. 12b offsets of far-field pattern distribution of the track groove (hatched areas p and q) which are superimposed on a beam 611 bridging two linear element-boundaries B of the three-element photodetector, the differential output will not be affected by the offsets. Further, the focusing detection pattern in the form of the single zone plate according to this embodiment can be simpler than the pattern used for taking out four first-order diffraction beams from two zone plates and the light utilization efficiency can advantageously

be high.

While the embodiments of Figs. 11 to 12b are described by referring to the slit-like grating areas 671 and 672, a grating pattern being able to maintain the radius of curvature of a wave front incident upon the diffraction element 6 and to change only the travelling direction of the wave front may be formed to cover the entire area of the diffraction element 6, as well known in the art of holography.

As described above, in the OPUH apparatus according to the invention, a plurality of wave fronts produced from the diffraction element are used for light beam control and far-field patterns of a spot focused on the optical disc are differentially detected by means of the photodetectors, thereby attaining the following meritorious effects.

(i) While in the prior art apparatus the diffraction element plays the part of a beam splitter and the higher order diffraction component including ± first-order diffraction components appearing on the forward path is focused on the optical disk, the defocusing pattern occurs in the present invention to reduce power density by orders of two as compared to the prior art example to thereby prevent unnecessary recording and defective servo operation.

(ii) A weak point inherent in production of control beams by the diffraction element, that is, vulnerability to variation in the wavelength of light source can be eliminated in accordance with the invention by making the linear boundary of the photodetector coincident with the direction of the spatial carrier frequency of a partial hologram corresponding to each spot image and by differentially detecting the control beams.

(iii) In contrast to the prior art wherein the positional adjustment of the photodetector is generally required to be performed with extraordinarily high accuracies in any of three axial directions, the present invention can mitigate requirement of accuracies remarkably and besides permit fabrication of a highly reliable OPUH apparatus through such a simplified adjusting process as rotating the diffraction element or photodetector.

(iv) The diffraction element used in the present invention is of a simple superposed zone-plates type and many diffraction elements of high diffraction efficiency can be duplicated with extremely high accuracies.

(v) An optical disc driver using the OPUH apparatus of the invention fulfilling the above advantages can operate stably with a light source of semiconductor laser even in environments where the temperature varies to a great extent.

(vi) A compact solid-state light source such as a semiconductor laser can be formed integrally with photodetectors with less mechanical accuracy than that required conventionally, and the use of the integrally formed parts can simplify the fabrication process of OPUH apparatus and improve reliability of the overall apparatus.

(vii) The prior art faces a problem that offset components due to the influence of the diffraction pattern image corresponding to the track groove are superimposed, as noises, upon the focusing detection signal. The present invention, however, permits remarkable noise suppression by making the direction of the linear boundary of photodetector substantially orthogonal to the direction of the track groove projected on the photodetector surface.

(viii) In the conventional focusing detection based on differential detection of two-focal-point images, two different detection surfaces are used or the images are detected on a single detection surface of a photodetector having a simple, single aperture. Contrarily, the present invention uses two photodetectors of three-domain structure, preferably, in an integrated form to thereby widen the dynamic range of focusing detection, improve the utilization efficiency of light flux and ensure simultaneous detection of a tracking detection signal.

Thus, the present invention can provide a OPUH apparatus which is compact, light, highly reliable, inexpensive and suitable for mass production.

Claims

1. An optical pickup head apparatus comprising:

a light source (1) for emitting a beam;

imaging optics (2, 3) for focusing the beam into a small spot;

a diffraction element (6), disposed in an optical path on which the beam passing through said optics is reflected from a given optical storage medium (4) or diffracted thereby, for producing two wave fronts (61, 62) of the same diffraction order and having different focal points in one half of the off-axis region relative to the optical axis (Z) of said optics (2, 3); and

photodetector means (51, 52) for receiving beams of the two wave fronts (61, 62) from the diffraction element (6);

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be high.

While the embodiments of Figs. 11 to 12b are described by referring to the slit-like grating areas 671 and 672, a grating pattern being able to maintain the radius of curvature of a wave front incident upon the diffraction element 6 and to change only the travelling direction of the wave front may be formed to cover the entire area of the diffraction element 6, as well known in the art of holography.

As described above, in the OPUH apparatus according to the invention, a plurality of wave fronts produced from the diffraction element are used for light beam control and far-field patterns of a spot focused on the optical disc are differentially detected by means of the photodetectors, thereby attaining the following meritorious effects.

(i) While in the prior art apparatus the diffraction element plays the part of a beam splitter and the higher order diffraction component including ± first-order diffraction components appearing on the forward path is focused on the optical disk, the defocusing pattern occurs in the present invention to reduce power density by orders of two as compared to the prior art example to thereby prevent unnecessary recording and defective servo operation.

(ii) A weak point inherent in production of control beams by the diffraction element, that is, vulnerability to variation in the wavelength of light source can be eliminated in accordance with the invention by making the linear boundary of the photodetector coincident with the direction of the spatial carrier frequency of a partial hologram corresponding to each spot image and by differentially detecting the control beams.

(iii) In contrast to the prior art wherein the positional adjustment of the photodetector is generally required to be performed with extraordinarily high accuracies in any of three axial directions, the present invention can mitigate requirement of accuracies remarkably and besides permit fabrication of a highly reliable OPUH apparatus through such a simplified adjusting process as rotating the diffraction element or photodetector.

(iv) The diffraction element used in the present invention is of a simple superposed zone-plates type and many diffraction elements of high diffraction efficiency can be duplicated with extremely high accuracies.

(v) An optical disc driver using the OPUH apparatus of the invention fulfilling the above advantages can operate stably with a light source of semiconductor laser even in environments where the temperature varies to a great extent.

(vi) A compact solid-state light source such as a semiconductor laser can be formed integrally with photodetectors with less mechanical accuracy than that required conventionally, and the use of the integrally formed parts can simplify the fabrication process of OPUH apparatus and improve reliability of the overall apparatus.

(vii) The prior art faces a problem that offset components due to the influence of the diffraction pattern image corresponding to the track groove are superimposed, as noises, upon the focusing detection signal. The present invention, however, permits remarkable noise suppression by making the direction of the linear boundary of photodetector substantially orthogonal to the direction of the track groove projected on the photodetector surface.

(viii) In the conventional focusing detection based on differential detection of two-focal-point images, two different detection surfaces are used or the images are detected on a single detection surface of a photodetector having a simple, single aperture. Contrarily, the present invention uses two photodetectors of three-domain structure, preferably, in an integrated form to thereby widen the dynamic range of focusing detection, improve the utilization efficiency of light flux and ensure simultaneous detection of a tracking detection signal.

Thus, the present invention can provide a OPUH apparatus which is compact, light, highly reliable, inexpensive and suitable for mass production.

Claims

1. An optical pickup head apparatus comprising:

a light source (1) for emitting a beam;

imaging optics (2, 3) for focusing the beam into a small spot;

a diffraction element (6), disposed in an optical path on which the beam passing through said optics is reflected from a given optical storage medium (4) or diffracted thereby, for producing two wave fronts (61, 62) of the same diffraction order and having different focal points in one half of the off-axis region relative to the optical axis (Z) of said optics (2, 3); and

photodetector means (51, 52) for receiving beams of the two wave fronts (61, 62) from the diffraction element (6);

characterised

in that said two wave fronts (61, 62) are respectively focused upon two planes which are respectively located forwardly and backwardly of a plane (111) perpendicular to said optical axis (Z) and containing a focusing point of the 0-order diffracted beam produced from said differential element (6); and

in that said photodetector means includes first (51) and second (52) photodetectors, respectively having a plurality of linear element boundaries (B) extending in one or the other direction which are coincident with or substantially parallel to a radial line (X) with a center (10) located at a focal point of a 0-order diffraction beam produced from said diffraction element (6), for receiving said two wave fronts (61, 62) on their coplanar detection surface which is disposed substantially at a center between the focal point of one (61) of said two wave fronts and the focal point of the other (62) of said two wave fronts.

2. An optical pickup head apparatus according to Claim 1 wherein said diffraction element is a Fourier transform hologram (6).

3. An optical pickup head apparatus according to Claim 1 wherein said diffraction element is a reflection type hologram (66) having its holographic surface disposed obliquely at an angle of about 45° to the direction of the beam emitted from said light source.

4. An optical pickup head apparatus according to Claim 1 wherein each of said first and second photodetectors has three elements (510, 511, 512; 520, 521, 522) defined by two linear element-boundaries (B) extending in a direction which is coincident with or substantially parallel to a radial line from the center (10) located at the focal point for the 0-order diffraction beam produced from said diffraction element (6).

5. An optical pickup head apparatus according to Claim 1 wherein said optics (2, 3) is disposed such that on the photodetector surface upon which tracks in said optical storage medium (4) are projected, the direction of the projected track is substantially orthogonal to the direction of substantially parallel element boundaries of each of said first and second photodetectors (51, 52).

6. An optical pickup head apparatus according to Claim 1, further comprising a third photodetector (77) on the coplanar detection surface (73) for receiving the 0-order diffraction beam from said diffraction element (661).

7. An optical pickup head apparatus according to Claim 6 wherein said third photodetector (77) is a two-element photodetector and said optics (2,3,20) is disposed such that the direction of a linear element-boundary (B_2) is substantially orthogonal to the linear element-boundaries, which are parallel to each other or mutually inclined to make a small angle therebetween, of each of said first and second photodetectors (51, 52).

8. An optical pickup head apparatus according to Claim 1, wherein said diffraction element (6) has two off-axis Fresnel-zone-plate like patterns respectively having focal distances of about $\pm f_z$ for the first-order diffraction beam of a main wavelength of said light source (1), wherein

$$\frac{1}{f_c} - \frac{1}{f_z} = \frac{1}{f_c + \delta}$$

and

$$\frac{1}{f_c} + \frac{1}{f_z} = \frac{1}{f_c - \delta}$$

stand where f_c is the focusing radius of the 0-order diffraction beam transmitting through or reflected

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from said diffraction element toward said photodetectors or the focal distance of a focusing lens, and 2δ, δ being a constant, is the distance between said two different focal points and related to f_c by $2\delta < f_c$.

9. An optical pickup head apparatus according to Claim 8 wherein the distance 2δ between said two different focal points is defined by,

$$\frac{f_c}{50} \lesssim 2\delta \lesssim \frac{f_c}{5}$$

10. An optical pickup head apparatus according to Claim 8 wherein two Fresnel-zone-plates having focal distances $\pm f_z$ of substantially the same absolute value and optical axes separated by a predetermined distance are superposed on each other for formation of a phase-type diffraction element.

11. An optical pickup head apparatus according to Claim 1, wherein the direction of the linear element-boundary (B) of each of said first and second photodetectors (51, 52) is substantially coincident or parallel with the direction of the spatial carrier frequency of a diffraction element pattern for production of said first and second wave fronts (61, 62).

12. An optical pickup head apparatus according to Claim 11, wherein said first and second photodetectors (51, 52) have linear element-boundaries which are mutually inclined to make an angle of about 45° therebetween.

13. An optical pickup head apparatus according to Claim 11, wherein said first and second photodetectors (51, 52) are photodiodes integrated on the same substrate.

14. An optical pickup head apparatus according to Claim 11, wherein said first and second photodetectors (51, 52) are integrated photodiodes and said light source (1) comprised of a semiconductor laser or a solid-state light source equivalent thereto is disposed integrally with the integrated photodiodes near a point at which extensions of linear element-boundaries of said photodiodes are crossed.

15. An optical pickup head apparatus according to Claim 1, wherein a diffraction element (6, 661) produces two wave fronts respectively having indexes of curvature which are of negative and positive curvatures different from the index of curvature of the incident wave front.

16. An optical pickup head apparatus according to Claim 15, wherein said diffraction element (661) has two parallel grating areas (671, 672) having slit-like apertures, and said apparatus includes at least two three-element photodetectors (51, 52), the direction of the linear element-boundary of each of said two three-element photodetectors being coincident with the direction of said grating areas.

Patentansprüche

1. Optische Aufnahmekopfvorrichtung mit:
einer Lichtquelle (1) zum Emittieren eines Strahls;
einer Abbildungsoptik (2, 3) zum Fokussieren des Strahls auf einen kleinen Fleck;
einem auf einem optischen Weg, auf dem der durch die Optik führende Strahl von einem vorgegebenen optischen Speichermedium (4) reflektiert oder von diesem gebeugt wird, angeordneten Beugungselement (6) zum Erzeugen von zwei Wellenfronten (61, 62) der gleichen Beugungsordnung und mit zwei verschiedenen Fokalpunkten in einer Hälfte des bezüglich der optischen Achse (Z) der Optik (2, 3) außeraxialen Bereichs; und
einer Fotoempfängereinrichtung (51, 52) zum Empfang von Strahlen der beiden Wellenfronten (61, 62) von dem Beugungselement (6);
dadurch gekennzeichnet,
daß die beiden Wellenfronten jeweils in zwei Ebenen fokussiert werden, die jeweils vor und hinter einer

zu der optischen Achse (Z) senkrechten und einen Fokalpunkt des von dem Beugungselement (6) erzeugten gebeugten Strahls der nullten Beugungsordnung enthaltenden Ebene (111) angeordnet sind; und

daß die Fotoempfängereinrichtung einen ersten (51) und einen zweiten (52) Fotoempfänger umfaßt, die jeweils eine Mehrzahl von sich in der einen oder der anderen mit einer radialen Linie (X) mit einem an einem Fokalpunkt des von dem Beugungselement (6) erzeugten Strahls der nullten Beugungsordnung angeordneten Zentrum (10) zusammenfallenden oder zu dieser im wesentlichen parallelen Richtung ausdehnenden Elementbegrenzungen (B) aufweisen, zum Empfang der beiden Wellenfronten auf ihrer in einer Ebene liegenden Empfängeroberfläche, die im wesentlichen im Zentrum zwischen dem Fokalpunkt der einen (61) der beiden Wellenfronten und dem Fokalpunkt der anderen (62) der beiden Wellenfronten angeordnet ist.

2. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der das Beugungselement ein Fourier-Transformations-Hologramm (6) ist.

3. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der das Beugungselement ein Hologramm (66) vom Reflexionstyp ist, dessen holographische Oberfläche mit einem Winkel von etwa 45° bezüglich der Richtung des von der Lichtquelle emittierten Strahls geneigt angeordnet ist.

4. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der sowohl der erste als auch der zweite Fotoempfänger drei Elemente (510, 511, 512; 520, 521, 522) aufweist, die durch zwei lineare Elementbegrenzungen (B) festgelegt sind, welche sich in einer Richtung ausdehnen, die mit einer von dem am Fokalpunkt des von dem Beugungselement (6) erzeugten gebeugten Strahls der nullten Beugungsordnung angeordnetem Zentrum (10) ausgehenden radialen Linie zusammenfällt oder zu dieser im wesentlichen parallel ist.

5. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der die Optik (2, 3) derartig angeordnet ist, daß auf der Fotoempfängeroberfläche, auf die die Spuren in dem optischen Speichermedium (4) abgebildet werden, die Richtung der abgebildeten Spur im wesentlichen senkrecht zu der Richtung im wesentlichen paralleler Elementbegrenzungen von sowohl dem ersten als auch dem zweiten Fotoempfänger (51, 52) ist.

6. Optische Aufnahmekopfvorrichtung nach Anspruch 1, mit einem zusätzlichen dritten Fotoempfänger (77) auf der in einer Ebene liegenden Empfängeroberfläche (73) zum Empfangen des gebeugten Strahls der nullten Beugungsordnung von dem Beugungselement (661).

7. Optische Aufnahmekopfvorrichtung nach Anspruch 6, bei der der dritte Fotoempfänger (77) ein Zwei-Element-Fotoempfänger ist und die Optik (2, 3, 20) derartig angeordnet ist, daß die Richtung einer linearen Elementbegrenzung (B_2) im wesentlichen senkrecht zu den linearen Elementbegrenzungen von sowohl dem ersten als auch dem zweiten Fotoempfänger (51, 52) verläuft, die zueinander parallel sind oder zur Bildung eines kleinen Winkels zwischen ihnen gegeneinander geneigt sind.

8. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der das Beugungselement (6) zwei außeraxiale Fresnelzonenplattenartige Muster aufweist, die jeweils eine Brennweite von etwa $\pm f_z$ für den gebeugten Strahl der ersten Beugungsordnung einer Hauptwellenlänge der Lichtquelle (1) aufweisen, bei der die Beziehungen

$$\frac{1}{f_c} - \frac{1}{f_z} = \frac{1}{f_c + \delta}$$

und

$$\frac{1}{f_c} + \frac{1}{f_z} = \frac{1}{f_c - \delta}$$

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bestehen, bei denen f_c der Fokalradius des in Richtung auf die Fotoempfänger durch das Beugungselement hindurchgehende oder von diesem reflektierten gebeugten Strahls der nullten Beugungsordnung oder die Brennweite einer fokussierenden Linse ist, und 2δ, wobei δ eine konstante ist, die Entfernung zwischen den beiden unterschiedlichen Brennpunkten ist und zu f_c durch $2\delta < f_c$ in Beziehung steht.

9. Optische Aufnahmekopfvorrichtung nach Anspruch 8, bei der die Entfernung 2δ zwischen den beiden unterschiedlichen Brennpunkten bestimmt ist durch

$$\frac{f_c}{50} \lesssim 2\delta \lesssim \frac{f_c}{5}$$

10. Optische Aufnahmekopfvorrichtung nach Anspruch 8, bei der zwei Fresnelzonenplatten mit Brennwerten $\pm f_z$ von im wesentlichen dem gleichen Absolutwert und durch eine vorher festgelegte Entfernung voneinander getrennten optische Achsen zur Bildung eines phasenartigen Beugungselements übereinandergelegt sind.

11. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der die Richtung der linearen Elementbegrenzung (B) von sowohl dem ersten als auch dem zweiten Fotoempfänger (51, 52) im wesentlichen mit der Richtung der räumlichen Trägerfrequenz eines Beugungselementmusters zur Bildung der ersten und zweiten Wellenfront (61, 62) zusammenfällt oder dazu parallel ist.

12. Optische Aufnahmekopfvorrichtung nach Anspruch 11, bei der der erste und zweite Fotoempfänger (51, 52) lineare Elementbegrenzungen aufweist, die gegeneinander geneigt sind, um einen Winkel von etwa 45° zwischen ihnen zu bilden.

13. Optische Aufnahmekopfvorrichtung nach Anspruch 11, bei der der erste und zweite Fotoempfänger (51, 52) auf demselben Substrat integrierte Fotodioden sind.

14. Optische Aufnahmekopfvorrichtung nach Anspruch 11, bei der der erste und zweite Fotoempfänger (51, 52) integrierte Fotodioden sind und die einen Halbleiterlaser oder eine dazu gleichwertige Festkörperlichtquelle umfassende Lichtquelle (1) integral mit den integrierten Fotodioden in der Nähe eines Punktes angeordnet ist, an dem die Ausdehnungen der linearen Elementbegrenzungen der Fotodioden sich kreuzen.

15. Optische Aufnahmekopfvorrichtung nach Anspruch 1, bei der ein Beugungselement (6, 661) zwei Wellenfronten erzeugt, die jeweils Krümmungsindizes aufweisen, die von dem Krümmungsindex der einfallenden Wellenfront negative und positive Krümmungen bilden.

16. Optische Aufnahmekopfvorrichtung nach Anspruch 15, bei der das Beugungselement (661) zwei Gittergebiete (673, 672,) mit schlitzartigen Öffnungen umfaßt und die Vorrichtung zumindest zwei Drei-Element-Fotoempfänger (51, 52) beinhaltet, wobei die Richtung der linearen Elementbegrenzung von jedem Der beiden Drei-Element-Fotoempfänger mit der Richtung der Gittergebiete zusammenfällt.

Revendications

1. Appareil à tête de lecture optique, comprenant
   une source lumineuse (1) pour émettre un faisceau,
   une optique de formation d'image (2, 3) pour focaliser le faisceau en un petit point lumineux;
   un élément de diffraction (6), disposé dans un trajet optique suivant lequel le faisceau qui passe à travers ladite optique est réfléchi à partir d'un support de mémorisation optique donné (4) ou est diffracté par celui-ci, pour produire deux fronts d'onde (61, 62) du même ordre de diffraction et ayant des foyers différents dans une moitié de la région hors axe par rapport à l'axe optique (Z) de ladite optique (2, 3); et
   des moyens photodétecteurs (51, 52) pour recevoir des faisceaux des deux fronts d'onde (61, 62)

en provenance de l'élément de diffraction (6);

caractérisé

en ce que les deux fronts d'onde (61, 62) sont focalisés respectivement sur deux plans qui sont situés respectivement en avant et en arrière d'un plan (111) perpendiculaire audit axe optique (Z) et contenant un foyer du faisceau diffracté d'ordre 0 produit par ledit élément de diffraction; et

en ce que lesdits moyens photodétecteurs comprennent un premier photodétecteur (51) et un second photodétecteur (52), présentant chacun plusieurs limites linéaires (B) d'éléments s'étendant dans l'une ou l'autre de directions qui coïncident avec ou sont essentiellement parallèles à une ligne radiale (X) dont un point central (10) est situé au foyer d'un faisceau diffracté d'ordre 0 produit par ledit élément de diffraction (6), pour recevoir les deux fronts d'onde (61, 62) sur leur surface coplanaire de détection qui est disposée essentiellement au milieu entre le foyer de l'un (61) des deux fronts d'onde et le foyer de l'autre (62) des deux fronts d'onde.

2. Appareil à tête de lecture optique selon la revendication 1, dans lequel ledit élément de diffraction est un hologramme à transformation de Fourier.

3. Appareil à tête de lecture optique selon la revendication 1, dans lequel ledit élément de diffraction est un hologramme du type à réflexion (66) dont la surface holographique est disposée obliquement avec un angle d'environ 45° par rapport à la direction du faisceau émis par ladite source lumineuse.

4. Appareil à tête de lecture optique selon la revendication 1, dans lequel chacun desdits premier et second photodétecteurs présente trois éléments (510, 511, 512; 520, 521, 522) définis par deux limites linéaires (B) d'éléments s'étendant dans une direction qui coïncide avec ou est essentiellement parallèle à une ligne radiale issue du point central (10) situé au foyer du faisceau diffracté d'ordre 0 produit par ledit élément de diffraction (6).

5. Appareil à tête de lecture optique selon la revendication 1, dans lequel ladite optique (2, 3) est disposée de sorte que, sur la surface des photodétecteurs sur laquelle sont projetées des pistes dudit support de mémorisation optique (4), la direction de la piste projetée soit sensiblement orthogonale à la direction des limites essentiellement parallèles des éléments de chacun desdits premier et second photodétecteurs (51, 52).

6. Appareil à tête de lecture optique selon la revendication 1, comprenant en outre un troisième photodétecteur (77) sur la surface coplanaire de détection (73), pour recevoir le faisceau diffracté d'ordre 0 issu dudit élément de diffraction (661).

7. Appareil à tête de lecture optique selon la revendication 6, dans lequel ledit troisième photodétecteur (77) est un photodétecteur à deux éléments et ladite optique (2, 3, 20) est disposée de sorte que la direction d'une limite linéaire (B_2) d'éléments soit essentiellement orthogonale aux limites linéaires d'éléments, qui sont parallèles entre elles ou inclinées mutuellement en formant entre elles un petit angle, de chacun desdits premier et second photodétecteurs (51, 52).

8. Appareil à tête de lecture optique selon la revendication 1, dans lequel ledit élément de diffraction (6) présente deux réseaux hors axe semblables à ceux d'une plaque zonale de Fresnel, ayant respectivement des distances focales d'environ $\pm f_z$ pour le faisceau de diffraction de premier ordre d'une longueur d'onde principale de ladite source lumineuse (1), les équations

$$\frac{1}{f_c} - \frac{1}{f_z} = \frac{1}{f_c + \delta}$$

et

$$\frac{1}{f_c} + \frac{1}{f_z} = \frac{1}{f_c - \delta}$$

étant satisfaites, f_c étant le rayon de focalisation du faisceau diffracté d'ordre 0 qui passe à travers ledit élément de diffraction ou est réfléchi par celui-ci vers lesdits photodétecteurs, ou la distance focale d'une lentille de focalisation, et 2δ (δ étant une constante) étant la distance entre les deux foyers différents et étant lié à f_c par la relation $2\delta < f_c$.

9. Appareil à tête de lecture optique selon la revendication 8, dans lequel la distance 2δ entre lesdits deux foyers différents est définie par

$$\frac{f_c}{50} \lesssim 2\delta \lesssim \frac{f_c}{5} .$$

10. Appareil à tête de lecture optique selon la revendication 8, dans lequel deux plaques zonales de Fresnel ayant des distances focales $\pm f_z$ qui ont essentiellement la même valeur absolue et des axes optiques séparés par une distance prédéterminée sont superposées mutuellement pour la formation d'un élément de diffraction de type en phase.

11. Appareil à tête de lecture optique selon la revendication 1, dans lequel la direction de la limite linéaire (B) d'éléments de chacun desdits premier et second photodétecteurs (51, 52) coïncide essentiellement avec ou est parallèle à la direction de la fréquence porteuse spatiale d'un réseau d'éléments de diffraction pour la production desdits premier et second fronts d'onde (61, 62).

12. Appareil à tête de lecture optique selon la revendication 11, dans lequel lesdits premier et second photodétecteurs (51, 52) présentent des limites linéaires d'éléments qui sont inclinées mutuellement en formant entre elles un angle d'environ 45°.

13. Appareil à tête de lecture optique selon la revendication 11, dans lequel lesdits premier et second photodétecteurs (51, 52) sont des photodiodes intégrées sur le même substrat.

14. Appareil à tête de lecture optique selon la revendication 11, dans lequel lesdits premier et second photodétecteurs (51, 52) sont des photodiodes intégrées et ladite source lumineuse (1), constituée par un laser à semiconducteur ou une source lumineuse à solide équivalente, fait corps avec les photodiodes intégrées prés d'un point où les prolongements des limites linéaires d'éléments desdites photodiodes se croisent.

15. Appareil à tête de lecture optique selon la revendication 1, dans lequel un élément de diffraction (6, 661) produit deux fronts d'onde ayant respectivement des indices de courbure qui ont des courbures négatives et positives différentes de l'indice de courbure du front d'onde incident.

16. Appareil à tête de lecture optique selon la revendication 15, dans lequel ledit élément de diffraction (661) comporte deux zones formant réseaux parallèles (671, 672) présentant des ouvertures en fente, et en ce que ledit appareil contient au moins deux photodétecteurs à trois éléments (51, 52), la direction des limites linéaires d'éléments des deux photodétecteurs à trois éléments coïncidant avec la direction des dites zones formant réseaux.