US005644563A

United States Patent [19]

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[11] Patent Number: 5,644,563

[45] Date of Patent: Jul. 1, 1997

[54] **OPTICAL PICKUP SYSTEM**

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[21] Appl. No.: **478,751**

[22] Filed: **Jun. 7, 1995**

[30] **Foreign Application Priority Data**

Jun. 10, 1994 [KR] Rep. of Korea 13117/1994

[51] **Int. Cl.**[6] **G11B 7/135**

[52] **U.S. Cl.** **369/112**; 369/110; 369/109; 369/103; 369/44.23; 369/44.37

[58] **Field of Search** 369/112, 103, 369/108, 109, 110, 120, 100, 44.11, 44.12, 44.14, 44.23, 44.41, 44.37

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[57] **ABSTRACT**

An optical pickup system capable of recording/reading out information on/from a mini disc or magneto-optical disc includes a polarized beam splitter (PBS) for fully reflecting beams of S-wave component from a laser diode or reflected from the disc while partially reflecting and partially transmitting beams of P-wave component, a reflection mirror placed between the PBS and disc for reflecting the beams transmitted through the PBS toward the disc while reflecting the beams reflected from the disc toward the PBS, a first photodetector having plural split areas for detecting a focus error and a tracking error according to the beams focusing on respective split areas, a hologram element for allowing three beams from a grating to be incident to the PBS or diffracting the beams of P-wave component transmitted through the PBS to focus the diffracted beams on the first photodetector, a second photodetector having six split areas for detecting the information recorded on the disc according to the beams focusing on respective split areas thereof, and a Wollaston prism placed between the PBS and second photodetector for separating mixed beams of P-wave and S-wave components from the PBS to allow the separated beams to be incident to the second photodetector, thereby decreasing the number of optical elements to improve readout speed of the information on the disc and simplifying the structure of the optical pickup system to reduce manufacturing cost.

12 Claims, 6 Drawing Sheets

FIG. 1
prior art

FIG. 2
prior art

FIG. 3
prior art

FIG. 4
prior art

FIG. 5
prior art

FIG. 6a
prior art

FIG. 6b
prior art

FIG. 6c
prior art

FIG. 7A

FIG. 7B

FIG. 8A

FIG. 8B

FIG. 8C

FIG. 9A

FIG. 9B

FIG. 10C

FIG. 10B

FIG. 10A

FIG. 12

34
P-wave
S-wave
67% transmission
33% reflection
(P-wave)
100% reflection
(S-wave)

FIG. 11

37
S-wave
P-wave

OPTICAL PICKUP SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical pickup system, and more particularly to an optical pickup system capable of recording/reading out information on/from mini discs or magneto-optical discs.

2. Description of the Prior Art

FIG. 1 illustrates a construction of a conventional optical pickup system.

The optical pickup system shown in FIG. 1 for recording optical information on a disc **21** or reading out the optical information from the disc **21** includes a laser diode **11** which is a light source, a grating **12**, a collimator **13**, a polarizing beam splitter (hereinafter simply referred to as "PBS") **14**, a reflection mirror **15**, an objective lens **16**, a modified Wollaston prism **17**, an image-forming lens **18**, a concave lens **19** and a photodetector divided-by-eight **20**.

The grating **12** allows laser beams from the laser diode **11** to be one main beam for reading out the optical information recorded on the disc **21** and detecting a focus error and to be two sub-beams for detecting a tracking error of the disc **21**. The collimator **13** makes the one main beam and two sub-beams passed through the grating **12** be parallel beams.

The PBS **14** fully reflects 100% of the S-wave component of the beams incident from the collimator **13** while reflecting some P-wave component and transmitting the other P-wave component to the reflection mirror **15**. Also, the S-wave component of the beams reflected from the disc **21** is totally reflected to the Wollaston prism **17**, and the P-wave component is partially reflected to the Wollaston prism **17** and partially transmitted.

The reflection mirror **15** reflects the three beams having P-wave component passed through the PBS **14** toward the disc **21**, or reflects the three beams having P-wave and S-wave components reflected from the disc **21** to the PBS **14**.

The objective lens **16** focuses the three beams having P-wave component reflected via the reflection mirror **15** onto the disc **21**, or again alters the three beams having mixed P-wave and S-wave component reflected from the disc **21** to be parallel beams.

The Wollaston prism **17** receives the three beams reflected from the disc **21** via the PBS **14**. In addition, as shown in FIG. **4**, the main beam is separated into beams of S-wave, P-wave and (P+S)-wave components and the sub-beams are separated into beams of P-wave and S-wave components. Then, five beams of the separated three main beams and two sub-beams are incident to the image-forming lens **18**.

The image-forming lens **18** is for concentrating five beams passed through the Wollaston prism **17**. The concave lens **19** having a toric surface increases the angle of the beam passed through the image-forming lens **18** and, at the same time, produces astigmatism to the main beam passed through the image-forming lens **18** to detect the focus error.

The photodetector **20** divided-by-eight is partitioned into eight split areas as shown in FIG. **2**, in which the central split areas a, b, c and d of the eight split areas are used for being focused by the beam of (S+P)-wave component separated from the main beam incident from the concave lens **19**, so that the focus error is detected by a signal detected in the areas a, b, c and d. The areas e and f on the upper and lower portions of the areas a, b, c and d are for being focused by the beams of the P-wave and S-wave components respectively separated from the sub-beams, so that the tracking error is monitored by a difference between signals detected in the areas e and f. The areas i and j on the right and left of the areas a, b, c and d are for being focused by the beams of S-wave and P-wave components separated from the main beam, so that the optical information recorded on the disc **21** is read out by a signal detected on the areas i and j.

The operation of the conventional optical pickup system having the above-mentioned construction will be described with reference to FIGS. **2** to **6** as below.

The laser beams from the laser diode **11** which is the light source are diffracted into a main beam L1 and two sub-beams L2 and L3. The three beams L1 to L3 of the main beam and sub-beams are altered into the parallel beams by the collimator **13** to be incident to the PBS **14**.

The PBS **14** reflects 100% of the S-wave component of the three beams and half of the P-wave component. The remaining 50% of the P-wave component are is transmitted. Therefore, the S-wave components of the incident beams are totally reflected by the PBS **14**, and the P-wave component is partially reflected and partially transmitted by the PBS **14** to be incident to the reflection mirror **15**. The reflection mirror **15** receives the beams of P-wave component from the PBS **14** to reflect the incident beams toward the disc **21**, and the reflected beams focus onto the disc **21** via the objective lens **16**.

As illustrated in FIG. **3**, the three beams L1 to L3 of one main beam and two sub-beams focus on tracks **21-1** of the disc **21**. Among the three beams, the main beam L1 is used for reading out the information and detecting the focus error, and two sub-beams L2 and L3 are used for detecting the tracking error. The three beams focusing on the tracks **21-1** of the disc **21** are reflected from the disc **21** while containing information required for reading out the optical information recorded on the disc **21** and detecting the focus error and tracking error. Here, the recorded optical information denotes pit information or kerr rotation by the magnetization direction.

At this time, the beams of P-wave component focus onto the disc **21**, but the property differs in accordance with the presence and absence of the information on the tracks **21-1** of the disc **21**. In more detail, if the information is not recorded on the track **21-1** of the disc **21**, the beam reflected from the disc has the P-wave component without including the S-wave component, but the beam from the disc **21** is the mixed beam having both S-wave and P-wave components when the track **21-1** of the disc **21** has the information thereon.

The three beams reflected from the disc **21** via the objective lens **16** are incident to the PBS **14** by means of the reflection mirror **16**. The PBS **14** reflects all S-wave component of the incident beams to the Wollaston prism **17**, reflects 50% of P-wave component to the Wollaston prism **17**, and transmits 50% of P-wave component. Accordingly, all S-wave component of the beams reflected from the disc **21** are reflected by the PBS **14** to be incident to the Wollaston prism **17**, and only half of P-wave component is reflected by the PBS **14** to be incident to the Wollaston prism **17**.

As shown in FIG. **4**, the Wollaston prism **17** separates the incident main beam into three beams of S-wave, P-wave and (S+P)-wave components. Also, the sub-beams are separated into two beams of P-wave and S-wave components. Thereafter, the three beams reflected from the disc **21** are separated into the five beams via the Wollaston prism **17** to be incident to the concave lens **19** via the image-forming lens **18**.

The concave lens **19** which has the toric surface for producing the astigmatism increases the angles between respective five beams incident from the image-forming lens **18** and, simultaneously produces the astigmatism with respect to the main beam for detecting the focus error. The five beams passed through the concave lens **19** focus onto the photodetector **20** divided-by-eight as shown in FIG. **5**.

Therefore, in accordance with the shapes of the five beams focusing on respective areas of the photodetector **20** divided-by-eight, the tracking error and focus error are detected, and the information recorded on the optical disc **21** is read out.

To begin with, a tracking error signal TES by means of the sub-beams is detected by the beams focusing on the split areas e and f of the photodetector **20** divided-by-eight, which is given by the following equation (1).

$$TES=Se-Sf \quad (1)$$

where reference symbols Se and Sf respectively denote electrical signals of the beams focusing on the split areas e and f of the photodetector **20** divided-by-eight.

On the other hand, a focus error signal FES is detected by the beams focusing on the split areas a, b, c and d, which is expressed as:

$$FES=(Sa+Sc)-(Sb+Sd) \quad (2)$$

where reference symbols Sa, Sb, Sc and Sd respectively denote electrical signals of the beams focusing on the split areas a, b, c and d of the photodetector **20** divided-by-eight.

FIG. **6** illustrates the pattern variation of the beams focusing on the split areas a, b, c and d of the photodetector **20** divided-by-eight, in which the shape of the beam focusing on each split area varies in accordance with the change of the distance between the disc **21** and objective lens **16**. That is, respective focusing patterns of the beams onto the split areas a, b, c and d are illustrated that no focus error appears by the normal spacing of the objective lens **16** from the disc **21**, as shown in FIG. **6**A, but the focus error appears due to a remote distance between the objective lens **16** and disc **21**, as shown in FIG. **6**B or a close distance between the objective lens **16** and disc **21** as shown in FIG. **6**C.

In case of a magneto-optical disc, information of grooves formed in the disc is detected by constituting a signal system such as:

Address in Pregroove (ADIP)=(Sa+Sd)−(Sb+Sc) or Absolute Time in Pregroove (ATIP).

As can be noted in the above equations (1) and (2), the tracking error signal TES becomes zero and the focus error signal FES equals zero when neither the tracking error nor the focus error occur.

The information recorded on the disc **21** is read out by means of the main beam of S-wave component focusing on the split area i of the photodetector **20** divided-by-eight and the main beam of P-wave focusing on the split area j thereof.

When a magneto-optical signal (kerr rotation by the magnetization direction) is read out, the optical information is read out by a signal difference of the beams focusing on the split areas i and j as defined by:

$$\text{Optical Information Signal (magneto-optical signal)}=Si-Sj \quad (3)$$

Meanwhile, a pit signal having an uneven shape recorded on the disc **21** is read out by variation of the amount of the beams focusing on the split areas i and j of the photodetector **20** divided-by-eight as shown in the following equation:

$$\text{optical information signal (pit signal)}=Si+Sj$$

where the reference symbols Si and Sj respectively denote electrical signals of the beams focusing on the split areas i and j of the photodetector **20** divided-by-eight.

However, the conventional optical pickup system as described above has drawbacks. More specifically, since the astigmatism has heretofore used for detecting a focus error by means of three beams, a concave lens having the toric surface which is expensive and is difficult in fabricate is employed to generate the astigmatism. Moreover, a modified Wollaston prism involving a fastidious fabrication process is utilized to separate a mixed beam of (P+S)-wave component for detecting the focus error from a main beam reflected from a disc. In order to allow beams from a laser diode to be partially incident to the disc or beams reflected from the disc to be partially incident to the modified Wollaston prism, a pentagonal polarized beam splitter is applied which is also difficult to be fabricated.

As the result, the conventional optical pickup system involves problems of complicated structure and expensive manufacturing cost since numerous optical elements are used for reading out information recorded on the disc which includes expensive elements which are difficult to fabricating. Furthermore, the increased number of optical elements raises the inherent weight of the optical pickup system to lengthen access time for reading out the information recorded on the disc, thereby delaying the speed of reading out the information.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an optical pickup system capable of recording/reading out information on/from a disc in a three beam system by means of a hologram divided-by-two.

It is another object of the present invention to provide an optical pickup system for improving readout speed of information recorded on a disc by reducing the number of optical elements.

It is still another object of the present invention to provide an optical pickup system having a simple structure capable of reducing manufacturing cost.

To achieve the above and other objects of the present invention, an optical pickup system includes a laser diode used as a light source, and a polarized beam splitter which totally reflects beams of S-wave component emitted from the laser diode or reflected from the disc, and partially reflects beams of P-wave component while partially transmitting the beams of P-wave component. In addition, a grating placed between the laser diode and polarized beam splitter classifies the beams from the laser diode into one main beam and two sub-beams to allow the three beams to be incident to the polarized beam splitter. A reflection mirror placed between the polarized beam splitter and disc reflects the beams transmitted through the polarized beam splitter toward the disc, and reflects the beams reflected from the disc toward the polarized beam splitter. An objective lens placed between the reflection mirror and disc focuses the beams reflected by the reflection mirror or allows the beams reflected from the disc to be parallel beams, and a first photodetector having a plurality of split areas is used for detecting a focus error and a tracking error in accordance with the beams focusing on respective split areas. A hologram element divided-by-two placed between the grating and polarized beam splitter is formed of two semi-circular holograms for allowing the three beams from the grating to be incident to the polarized beam splitter or diffracting the beams of P-wave component transmitted through the polar-

ized beam splitter to focus the diffracted beams on the first photodetector, in which one of the holograms has a reference light position at a light-emitting point of the laser diode and an object light position set before passing the first photodetector, and the other of the hologram has a reference light position at the light-emitting point of the laser diode and an object light position set after passing the first photodetector. Furthermore, a second photodetector having partitioned six split areas is employed for detecting the information recorded on the disc in accordance with the beams focusing on respective split areas thereof, and a Wollaston prism placed between the polarized beam splitter and second photodetector separates mixed beams of P-wave and S-wave components from the polarized beam splitter to allow the separated beams to be incident to the second photodetector.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. **1** is a view showing a construction of a conventional optical pickup system;

FIG. **2** shows the structure of the photodetector divided-by-eight in the conventional optical pickup system of FIG. **1**;

FIG. **3** shows focusing states of three beams on the disc of FIG. **1**;

FIG. **4** is a view showing the separated states of the S-wave and P-wave by means of the prism of FIG. **1**;

FIG. **5** shows focusing states of the five beams onto the photodetector divided-by-eight of FIG. **2**;

FIGS. **6A–6C** show a focusing state of the beam in accordance with the distance between the disc and objective lens of FIG. **1**, wherein

FIG. **6A–6C** show a state of maintaining normal distance between the disc and objective lens,

FIG. **6B** shows a state of setting the disc to be distant from the objective lens, and

FIG. **6C** shows a state of setting the disc to be near to the objective lens;

FIGS. **7A–7B** show a construction of one embodiment of an optical pickup system according to the present invention, wherein

FIG. **7A** is the construction of the optical pickup system shown in the x-z direction at the central point of the disc, and

FIG. **7B** is the construction of the optical pickup system shown in the x-y direction at the central point of the disc;

FIG. **8A** shows a construction of the hologram laser unit of FIG. **7**;

FIG. **8B** is a detailed view of the hologram element shown in FIG. **8A**;

FIG. **8C** is a detailed view of the photodetector divided-by-six shown in FIG. **8A**;

FIG. **9** is a view showing the diffraction of the laser beams by means of the hologram module of FIG. **8**;

FIGS. **10A–10C** show a focusing state of the laser beams in accordance with the distance between the disc and objective lens of FIG.**7**, wherein

FIG. **10A** shows a state of maintaining normal distance between the disc and objective lens,

FIG. **10B** shows a state of setting the disc to be distance from the objective lens, and

FIG. **10C** shows a state of setting the disc to be near to the objective lens;

FIG. **11** is a view showing the separated state of the S-wave and P-wave by means of the prism of FIG. **7**; and

FIG. **12** is a view showing the polarized states of the S-wave and P-wave by the polarized beam splitter of FIG. **7**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. **7A–7B**, an embodiment of an optical pickup system according to the present invention includes a collimator **33**, a polarized beam splitter (hereinafter referred to as "PBS") **34**, a reflection mirror **35**, an objective lens **36**, a prism **37**, a focusing lens **38**, a photodetector **39** divided-by-two, an actuator **42** and a hologram laser unit **40**.

The hologram laser unit **40** has a laser diode **31** being a light source, a grating **43** for allowing the laser beams from the laser diode **31** to be formed into three beams comprising one main beam and two sub-beams, a hologram element **32** for making the three beams from the grating **43** be incident to the PBS **34** via the collimator **33** or beams reflected from a disc **44**, and a photodetector **41** divided-by-six for focusing the beam diffracted by the hologram element **32**.

The collimator **33** permits the three beams incident from the grating **43** to be parallel beams or the main beam of P-wave component transmitted through the PBS **34** to be incident to the hologram element **32** divided-by-two.

The PBS **34** which is positioned between the reflection mirror **35** and collimator **33** in the x-z direction and between the reflection mirror **35** and Wollaston prism **37** in the x-y direction receives the three parallel beams passed through the collimator **33** to fully reflect the S-wave component, reflect 33% of the P-wave component and transmit the remaining 67% of the P-wave component.

In other words, since the a PBS **34** has the reflection ratio of 7:3 to 6:4 with respect to the beams of P-wave component, the S-wave component of the beams passed through the collimator **33** is fully reflected, and 33% of P-wave component is reflected while the remaining 67% of P-wave component is transmitted to the reflection mirror **35**. Meantime, the S-wave component of the beams reflected from the disc **44** is fully reflected to the Wollaston prism **37**, 33% of the P-wave component is reflected to the Wollaston prism **37**, and the remaining 67% of the P-wave component is transmitted to the hologram element **32** divided-by-two.

The reflection mirror **35** disposed between the PBS **34** and objective lens **36** reflects the beams of P-wave component passed through the PBS **34** to the objective lens **36** to focus them on the disc **44**, and reflects the beams reflected from the disc **44** via the objective lens **36** to the PBS **34**. Here, the beams reflected from the reflection mirror **35** toward the disc **44** includes only the P-wave component, and the beams reflected from the disc **44** toward the PBS **34** is the mixed beam having the S-wave according to the existence of information on the disc **44**.

The Wollaston prism **37** placed between the PBS **34** and focusing lens **38** separates the mixed beam having S-wave and P-wave incident from the PBS **34** into beams of P-wave component and S-wave component to make the separated beams be incident to the focusing lens **38**. As illustrated in FIG. **11**, the beams of P-wave component and S-wave component are separated by maintaining a certain angle. In the conventional technique, the (S+P)-wave obtained by mixing S-wave component and P-wave component is uti-

lized for detecting a focus error, so that the S-wave, P-wave and (S+P)-wave are separated from the main beam by means of the modified Wollaston prism. Whereas, in the optical pickup system according to the present invention, the beams of S-wave and P-wave are utilized for detecting the focus error, so that just the S-wave and P-wave are separated by means of a general Wollaston prism.

The focusing lens **38** positioned between the Wollaston prism **37** and photodetector **39** divided-by-two focuses the beam of P-wave component and beam of S-wave component separated from the prism **37** onto the photodetector **39** divided-by-two. The beams of S-wave component and P-wave component from the Wollaston prism **37** focus on the photodetector **39** divided-by-two succeeding the focusing lens **38** via the focusing lens **38**, which are consequently used for monitoring information recorded on the disc.

FIG. **8**A shows a construction of the hologram laser unit of FIGS. **7**A–**7**B, FIG. **8**B is a detailed view of the hologram element shown in FIG. **8**A, and FIG. **8**C is a detailed view of the photodetector divided-by-six shown in FIG. **8**A.

When the beams from the laser diode **31** are incident to the PBS **34**, the laser diode **31** is provided in such a manner that an activation layer thereof is to be parallel with the xy plane to allow the beams to be P-polarized.

The hologram element **43** divided-by-two functions by permitting the three beams from the grating **32** to be incident to the collimator **33**, or diffracting the beams of P-wave component reflected from the disc **44** prior to being transmitted through the PBS **34** to focus the diffracted beams on the photodetector **41** divided-by-six.

As shown in FIG. **8**C, the photodetector **41** divided-by-six is formed of first to fourth split areas PDa to PDd respectively having a prescribed size arranged in the horizontal direction, and fifth and sixth split areas PDe and PDf of the same size as summing the first to fourth split areas PDa to PDd while being arranged on the upper and lower portions of them. The first and second split areas PDa and PDb, and the third and fourth split areas PDc and PDd are spaced by a predetermined distance d1, and a distance d2 between the second and third split areas PDb and PDc is arranged to be wider than the distance d1.

As shown in FIG. **8**B, the hologram element **32** divided-by-two is formed of two semi-circular holograms H1 and H2, and the site of a reference light of the two holograms H1 and H2 is set as a light-emitting point of the laser diode. The site of an objective light of the hologram H1 of the hologram element **32** divided-by-two is set to a point Q1 before passing through the photodetector **41** divided-by-six, and that of the hologram H2 is set to a point Q2 after passing through the photodetector **41** divided-by-six.

Referring now particularly to FIG. **9**, once the beams focusing toward the light-emitting point of the laser diode **31** are incident to the hologram element **32** divided-by-two, the laser beams incident to the hologram H1 focus onto the point Q1 before passing through the fourth split area PDd of the photodetector **41** divided-by-six, i.e., onto the site between the photodetector **41** divided-by-six and hologram element **32** divided-by-two, and the laser beams incident to the hologram H2 focus onto the point Q2 at the site after passing through the second split area PDb of the photodetector **41** divided-by-six.

Therefore, the beams diffracted by the hologram element **32** divided-by-two focus on the photodetector **41** divided-by-six as shown in FIG. **10**A, in which the main beam diffracted by the hologram H1 focuses on the fourth split area PDd contacting the boundary plane of the third and fourth split areas PDc and PDd of the photodetector **41** divided-by-six (refer to B2 shown in FIG. **10**A), and the main beam diffracted by the hologram H2 focuses on the second split area PDb contacting the boundary plane of the first and second split areas PDa and PDb of the photodetector **41** divided-by-six (refer to B1 of FIG. **10**A).

The operation of the optical pickup system having the above-mentioned construction will be described with reference to FIGS. **8**A to **12** as below.

The laser beams from the laser diode **31** are classified into the three beams of one main beam and two sub-beams via the grating **43** to be incident to the collimator **33** through the hologram element **32** divided-by-two.

The three beams incident to the collimator **33** are transformed into the parallel beams to be incident to the PBS **34**. Then, the PBS **34** having the reflection ratio of 7:3 to 6:4 with respect to the beams of P-wave component fully reflects the S-wave component of the incident three beams, reflects 33% of the P-wave component, and transmits remaining 67% of the P-wave to the reflection mirror **35**.

Thereafter, the reflection mirror **35** reflects the incident beams of P-wave component to change the advancing direction of the beams toward the disc **44**. The three beams reflected through the reflection mirror **35** focus on the disc **44** by means of the objective lens **36**.

The beams focusing on the disc **44** are reflected therefrom to be the parallel beams via the objective lens **36** and then reflected to the PBS **34** via the reflection mirror **35**. At this time, the beams reflected from the disc **44** are mixed beams having both the P-wave and S-wave.

If information is recorded on the disc **44**, the beams incident to the PBS **34** include the P-wave component together with the S-wave component. In case of no information on the disc **44**, only the P-wave exists in the incident beams without including the S-wave component.

The S-wave component in the beams incident to the PBS **34** is fully reflected via the PBS **34** to be incident to the Wollaston prism **37**, and 67% of the P-wave component is transmitted to be incident to the collimator **33** while 33% thereof is reflected to be incident to the Wollaston prism **37**.

The Wollaston prism **37** receives the mixed beam of 100% reflected S-wave component and 33% reflected P-wave component, and separates the incident mixed beam into the beams of P-wave component and S-wave component which maintain a certain angle to each other as shown in FIG. **12**. Since the focus error is not detected by using the beam of mixing (S+P)-wave in the optical pickup system according to the present invention, there is no need to separate the (P+S)-wave by means of the modified Wollaston prism as in the conventional technique. Consequently, in the present invention, the general Wollaston prism **37** is employed to only separate the P-wave and S-wave maintaining the certain angle to each other.

The beams separated by the Wollaston prism **37** focus onto the photodetector **39** divided-by-two via the focusing lens **38**.

The information recorded on the disc **44** is read out by the beams focusing on the photodetector **39** divided-by-two, which is detected by a signal difference of two split areas PDi and PDj of the photodetector **39** divided-by-two when the information recorded on the disc **44** is a magneto-optical signal (kerr rotation by the magnetization direction). This is expressed by the following equation (5).

$$\text{Optical Information Signal (magneto-optical signal)} = Si - Sj \quad (5)$$

where reference symbols Si and Sj respectively denote electrical signals on the split areas PDi and PDj of the photodetector **39** divided-by-two.

In case of a pit signal having an uneven shape recorded on the disc **44** is detected by the variation of the amount of the beams focusing on the split areas as defined in the following equation.

$$\text{Optical Information Signal (Pit Signal)}=Si+Sj \quad (6)$$

Now, the detecting operation of a tracking error signal and a focus error signal will be described.

The three beams having 67% of P-wave component transmitted through the PBS **34** are incident to the hologram element **32** divided-by-two via the collimator **33**, and the three beams of P-wave component are diffracted through the hologram element **32** to focus onto the photodetector **41** divided-by-six to be used for detecting the focus error signal and tracking error signal.

In more detail, the three beams transmitted through the PBS **34** focus toward a light-emitting surface of the laser diode **31** by means of the collimator **33**. The three beams focusing toward the light-emitting surface of the laser diode **31** are incident to the hologram element **32** divided-by-two placed between the objective lens **36** and laser diode **31** to serve as a reference light of the two holograms H1 and H2 of the hologram element **32** divided-by-two.

Thus, as shown in FIG. **9**, the beams focus onto points Q1 and Q2 by the holograms H1 and H2 to reproduce an object light which is then detected by the photodetector **41** divided-by-six, thereby detecting the tracking error and focus error.

When the main beam of P-wave component is incident to the hologram element **32** divided-by-two via the collimator **33**, the main beam focuses the point Q1 before passing through the fourth split area PDd of the photodetector **41** divided-by-six by means of the hologram H1, so that the section of the beam cut by the photodetector **41** divided-by-six is placed on the fourth split area PDd while contacting the boundary plane of the third and fourth split areas PDc and PDd as shown in FIG. **10**A. Also, the main beam focuses on the point Q2 after passing through the second split area PDb of the photodetector **41** divided-by-six by the hologram H2, so that the section of the beam cut by the photodetector **41** divided-by-six is placed on the second split are PDb while contacting the boundary plane of the first and second split areas PDa and PDb as shown in FIG. **10**A.

As described above, the focus error is detected by the main beam focusing onto the first to fourth split areas PDa to PDd of the photodetector **41** divided-by-six by the holograms H1 and H2. When the focus error does not occur, the distance between the objective lens **36** and disc **44** is properly maintained to form the beams shaped as half moons of the same size on the second and fourth split areas PDb and PDd of the photodetector **41** divided-by-six as shown in FIG. **10**A.

If the disc **44** is placed distant from the objective lens **36**, the points Q1 and Q2 focused by the holograms H1 and H2 become near to each other. Thus, as shown in FIG. **10**B, the size of the beam focusing on the fourth split area PDd by the hologram Hi is increased to affect onto the third split area PDc, but the size of the beam focusing onto the second split area PDb by the hologram H1 is decreased not to affect on the first split area PDa.

On the other hand, if the disc **44** is near to the object lens **36**, the points Q1 and Q2 focused by the holograms HI and H2 become distant from each other. Thus, as shown in FIG. **10**C, the size of the beam focusing on the fourth split area PDd by the hologram Hi is decreased not to affect on the third split area PDc, but the size of the beam focusing onto the second split area PDb by the hologram H2 is increased to expand to the first split area PDa.

The focus error signal is obtained by the following equation:

$$FES=(Sa+Sd)-(Sb+Sc) \quad (7)$$

where reference symbols Sa, Sb, Sc and Sd respectively denote electrical signals on the split areas PDa, PDb, PDc and PDd of the photodetector **41** divided-by-six.

When the focus error does not exist, the focus error signal FES equals zero in the above equation because the amount of beams incident to the first and fourth split areas PDa and PDd of the photodetector **41** divided-by-six are the same as the beams incident to the second and third split areas PDb and PDc, as shown in FIG. **10**A. When the objective lens **36** is distant from the disc **44**, the amount of the beams incident to the first and fourth split areas PDa and PDd of the photodetector **41** divided-by-six is greater than that of the beams incident to the second and third split areas PDb and PDc, as shown in FIG. **10**B, so that the focus error signal FES is smaller than zero. Meanwhile, when the objective lens **36** is near to the disk **44**, the amount of beams incident to the first and fourth split areas PDa and PDd is smaller than that incident to the second and third split areas PDb and PDc as shown in FIG. **10**C, the focus error FES is larger than zero.

In this way, if the focus error appears due to improper distance between the disc **44** and objective lens **36**, the focus error can be corrected by moving objective lens **36** up-and-down direction, using the actuator **42** in accordance with the focus error signal FES.

Hereinafter, the correction of the tracking error according to the present invention will be described.

The tracking error signal TES is detected by the sub-beams of P-wave component diffracted by the hologram H1 and H2 and then focusing on the fifth and sixth split areas PDe and PDf of the photodetector **41** divided-by-six, which is given by the following equation (8).

$$TES=Se-Sf \quad (8)$$

When tracking error occurs, the actuator **42** is used to move the objective lens **36** in the right-to-left direction, thereby correcting the tracking error.

On the other hand, the information with respect to grooves formed in the disc is constituted such that:

Address in Pregroove (ADIP)=(Sa+Sb)−(Sc+Sd) or by Absolute Time in Pregroove (ATIP), thereby reading out the information with respect to the grooves.

In the optical pickup system according to the present invention as described above, a hologram element divided-by-two is employed to correct a tracking error and a focus error and read out information with respect to grooves formed in a disc, so that magneto-optical signal or optical information (pit) signal recorded on the disc can be accurately detected. Furthermore, optical elements such as a concave lens is not utilized to decrease the number of optical elements employed. In addition to these, a polarized beam splitter and a Wollaston prism easier to be fabricated than those of the conventional technique are used, thereby simplifying the structure of the optical pickup system and reducing manufacturing cost thereof.

While the present invention has been particularly shown and described with reference to particular embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be effected therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An optical pickup system capable of reading out/recording information from/on a disc comprising:

a laser diode used as a light source;

a polarized beam splitter for totally reflecting beams of an S-wave component of the light emitted from said laser diode or reflected from said disc, and partially reflecting beams of a P-wave component while partially transmitting said beams of the P-wave component;

a grating placed between said laser diode and said polarized beam splitter for classifying said beams from said laser diode into one main beam and two sub-beams to allow the three beams to be incident to said polarized beam splitter;

a reflection mirror placed between said polarized beam splitter and said disc for reflecting the beams transmitted through said polarized beam splitter toward said disc, and reflecting the beams reflected from said disc toward said polarized beam splitter;

an objective lens placed between said reflection mirror and said disc of focusing the beams reflected by said reflection mirror onto said discs and for causing the beams reflected from said disc to form parallel beams;

a first photodetector having a plurality of split areas for detecting a focus error and a tracking error in accordance with the beams focusing on respective split areas;

a hologram element divided-by-two placed between said grating and said polarized beam splitter, said hologram element being formed of two semicircular holograms for allowing said three beams from said grating to be incident to said polarized beam splitter or diffracting said beams of said P-wave component transmitted through said polarized beam splitter to focus the diffracted beams on said first photodetector, one of said holograms having a reference light position at light-emitting point of said laser diode and an object light position set before passing said first photodetector, the other of said holograms having a reference light position at said light-emitting point of said laser diode and an object light position set after passing said first photodetector;

a second photodetector being partitioned into six split areas for detecting said information recorded on said disc in accordance with the beams focusing on respective split areas thereof; and

a Wollaston prism placed between said polarized beam splitter and said second photodetector for separating mixed beams of P-wave and S-wave components from said polarized beam splitter to allow the separated beams to be incident to said second photodetector.

2. An optical pickup system as claimed in claim 1, further comprising an actuator for moving said objective lens in an up an down or left and right direction with respect to said disc, to correct a focus error signal or a tracking error signal.

3. An optical pickup system as claimed in claim 1, wherein, when the disc surface is defined as the xy-plane and the direction perpendicular to said disc is set as the z-axis, an activation layer of a semiconductor laser is provided to be parallel to said xy-plane for P-polarizing beams incident from said laser diode to said polarized beam splitter.

4. An optical pickup system as claimed in claim 1, wherein said beams of P-wave and S-wave components are separated by said Wollaston prism while maintaining a regular angle to each other.

5. An optical pickup system as claimed in claim 1, wherein said first photodetector is formed of first to fourth split areas of the same size along the horizontal direction and fifth and sixth split areas of a size the same as the sum of said first to fourth areas altogether respectively arranged on the upper and lower portions of said first to fourth split areas, a distance between said first and second split areas being the same as a distance between said third and fourth split areas but shorter than a distance between said second and third split areas.

6. An optical pickup system as claimed in claim 5, wherein said focus error signal is detected by a signal difference between the beams focusing on said first and fourth split areas and the beams focusing on said second and third split areas of said photodetector divided-by-six.

7. An optical pickup system as claimed in claim 5, wherein said tracking error signal is detected by a signal difference between the beams focusing on said fifth and sixth split areas of said photodetector divided-by-six.

8. An optical pickup system as claimed in claim 5, wherein information with respect to grooves in said disc is detected by a signal difference between the beams focusing on said first and second split areas and the beams focusing on said third and fourth split areas of said photodetector divided-by-six.

9. An optical pickup system as claimed in claim 1, wherein said second photodetector is a photodetector divided-by-two having two split areas.

10. an optical pickup system as claimed in claim 9, wherein, when said information on said disc is magneto-optical information, which is detected by a signal difference between the beams focusing on said split areas of said photodetector divided-by-two.

11. An optical pickup system as claimed in claim 9, wherein, when said information on said disc is pit information, said optical information on said disc is detected by variation of the amount of the beams focusing on respective split areas of said photodetector divided-by-two.

12. An optical pickup system as claimed in claim 1, wherein the reflection ratio of said P-wave component of said polarized beam splitter is 7:3 to 6:4.

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