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Sekimoto et al.

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[45] **Date of Patent: Sep. 30, 1997**

[54] **OPTICAL PICKUP HAVING TWO OBJECTIVE LENSES**

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[73] Assignee: **Sharp Kabushiki Kaisha**, Osaka, Japan

[21] Appl. No.: **758,010**

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[30] **Foreign Application Priority Data**

Nov. 29, 1995 [JP] Japan 7-311440

[51] **Int. Cl.**[6] **G11B 7/00**

[52] **U.S. Cl.** **369/112**; 369/110

[58] **Field of Search** 369/44.14, 44.19, 369/44.23, 44.32, 53, 54, 58, 93, 110, 112

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,550,249	10/1985	Damen et al.	369/112 X
5,097,464	3/1992	Nishiuchi et al.	369/112
5,446,565	8/1995	Komma et al.	369/112 X
5,446,721	8/1995	Sekimoto et al.	369/247

FOREIGN PATENT DOCUMENTS

63-60451	11/1988	Japan .
6-333255	12/1994	Japan .

OTHER PUBLICATIONS

Y. Sekimoto et al., "Development of Optical Pickup for Mini Disk Drives," Optical Review vol. 1, No. 2 (1994) at 174–76.

Primary Examiner—P. W. Huber
Attorney, Agent, or Firm—David G. Conlin; George W. Neuner

[57] **ABSTRACT**

An optical pickup for irradiating a first recording medium and a second recording medium with light, at least one of the substrate thickness and the refractive index of the first recording medium being different from that of the second recording medium, where the optical pickup includes: a light source for emitting the light; a polarized beam splitter for receiving the light and for transmitting at least a portion of the light while reflecting the remaining portion of the light depending on the polarization direction of the light; a first objective lens for focusing the portion of the light reflected by the polarized beam splitter onto the first recording medium; and a second objective lens for focusing the portion of the light transmitted through the polarized beam splitter onto the second recording medium.

18 Claims, 19 Drawing Sheets

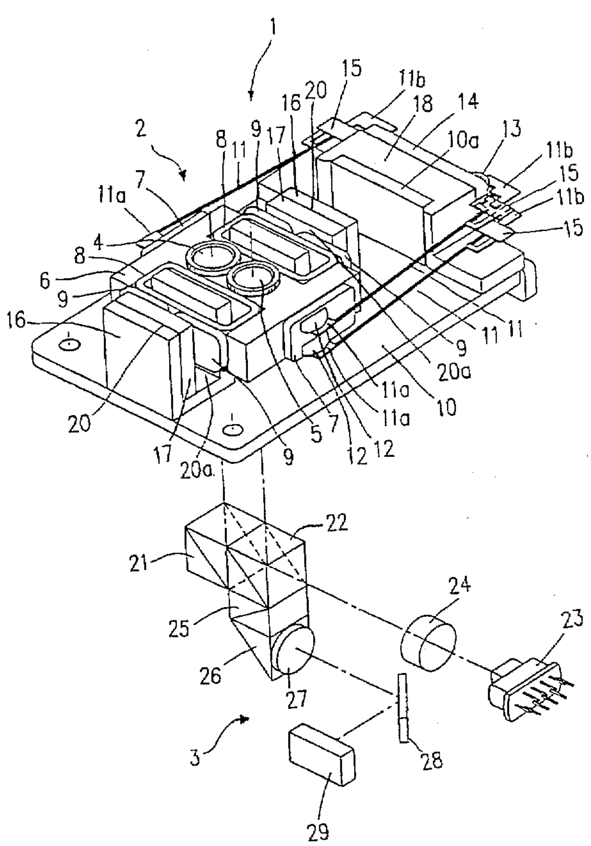

FIG. 1

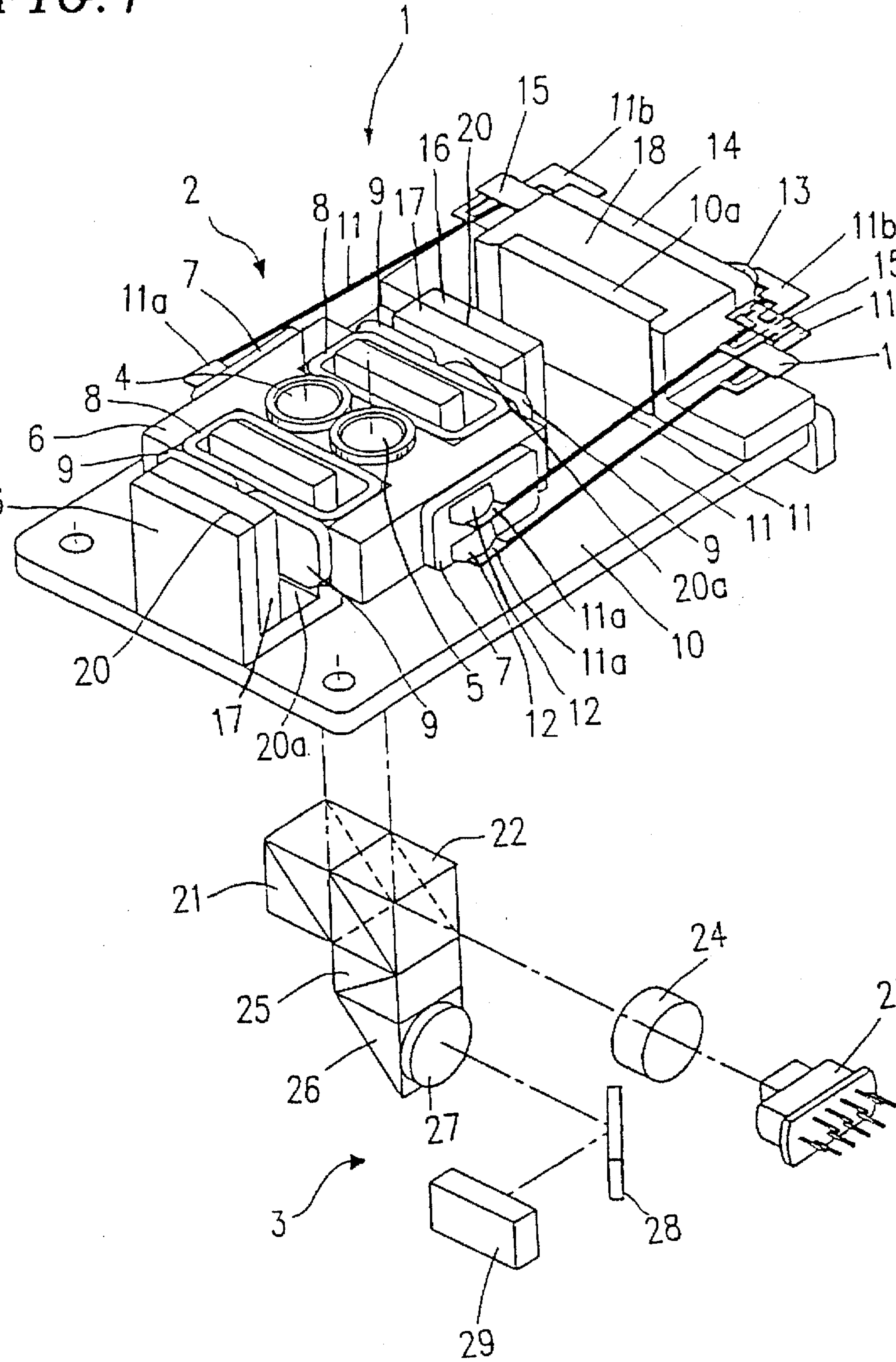
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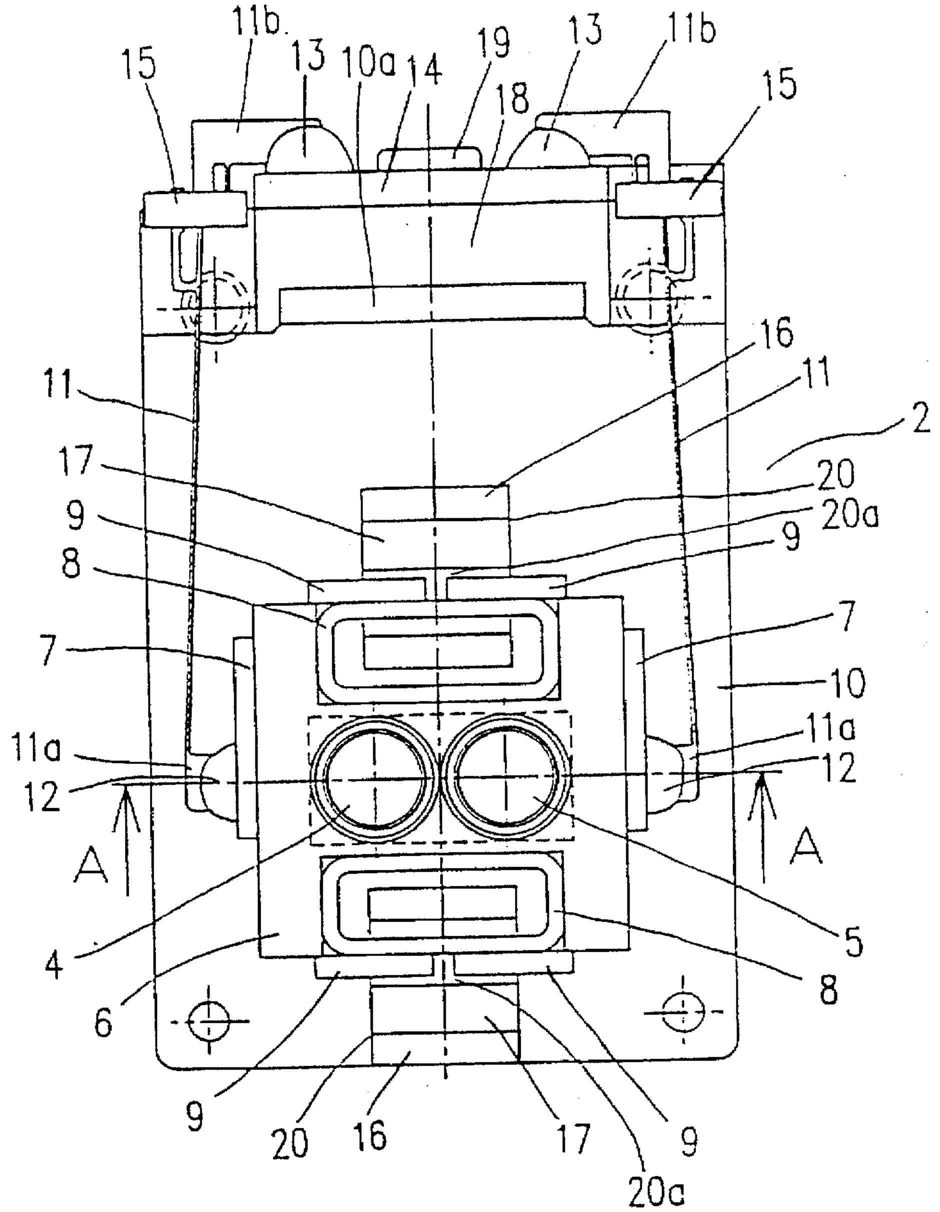
FIG. 2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16
17
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20a

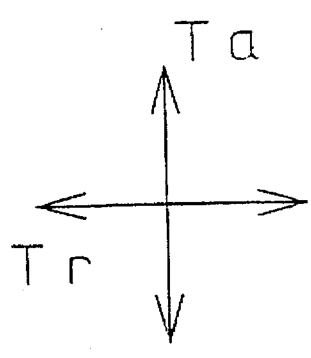

Ta
Tr

FIG. 3

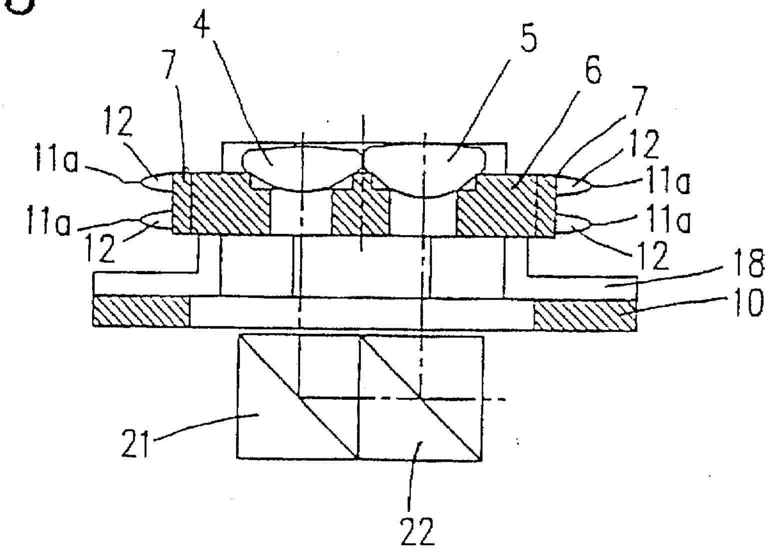


FIG. 4

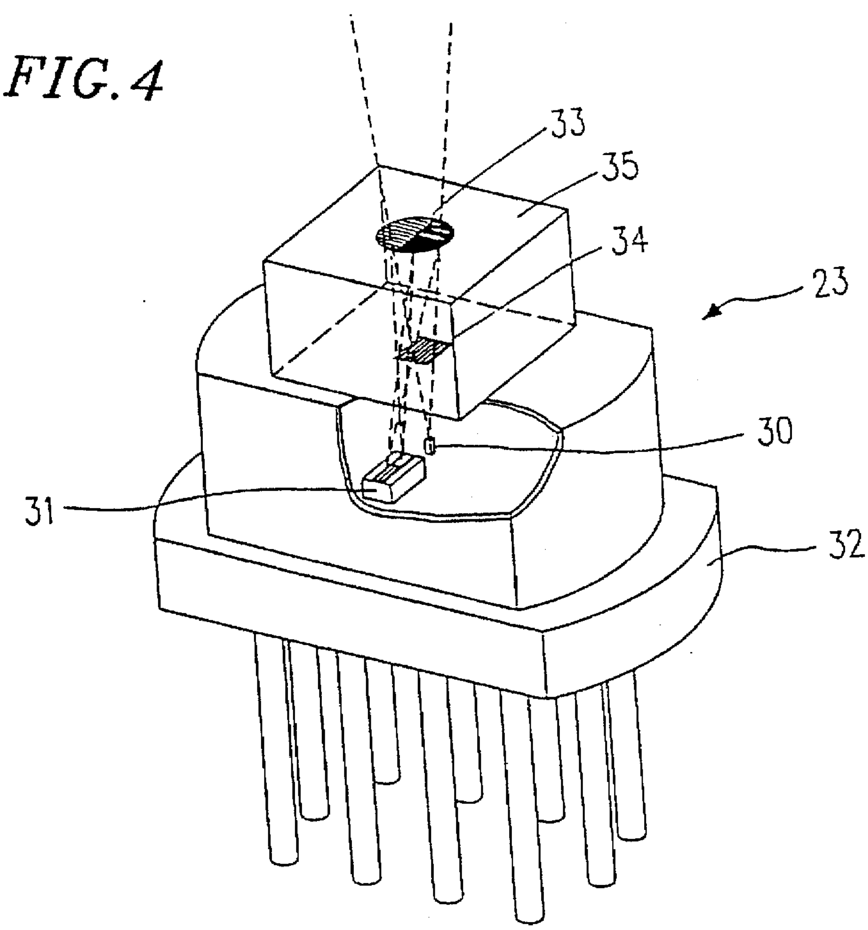
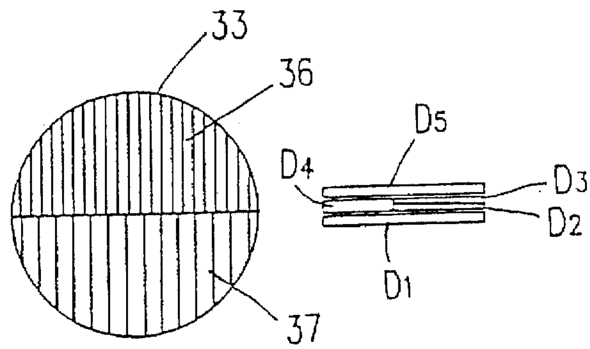


FIG. 5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D5
D4
D3
D2
D1

FIG. 6

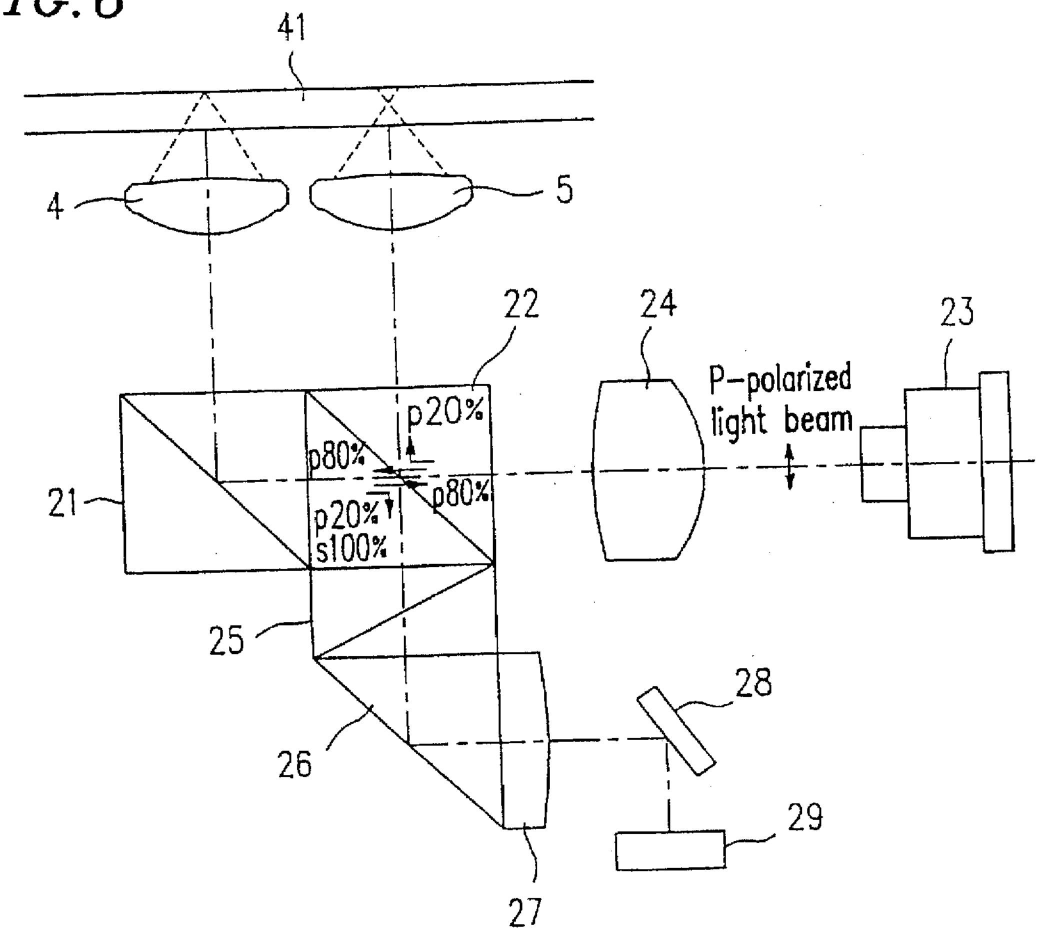
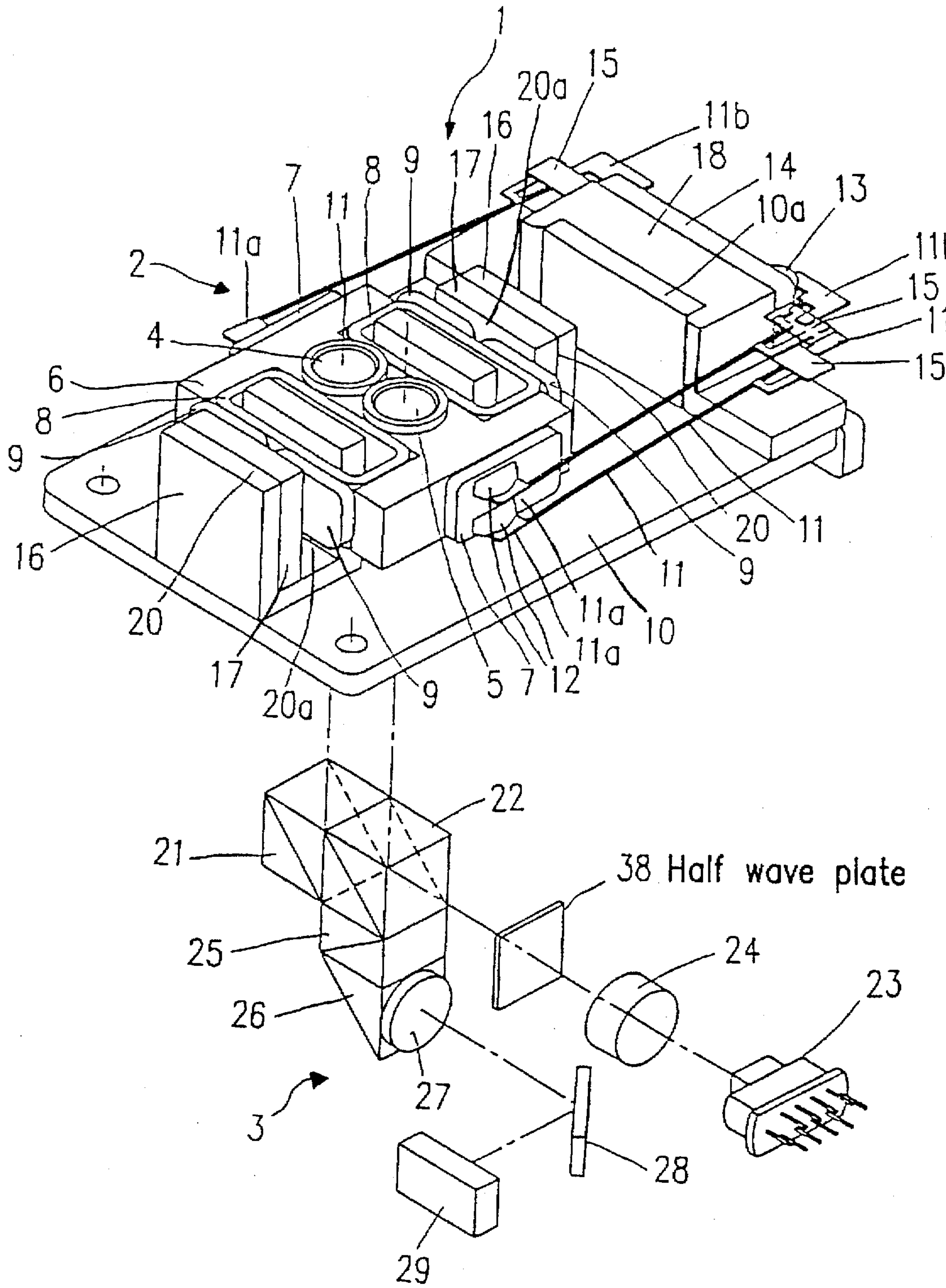

41
4
5
22
24
23
P-polarized
light beam
p20%
p80%
p80%
p20%
s100%
21
25
26
27
28
29

FIG. 7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20a
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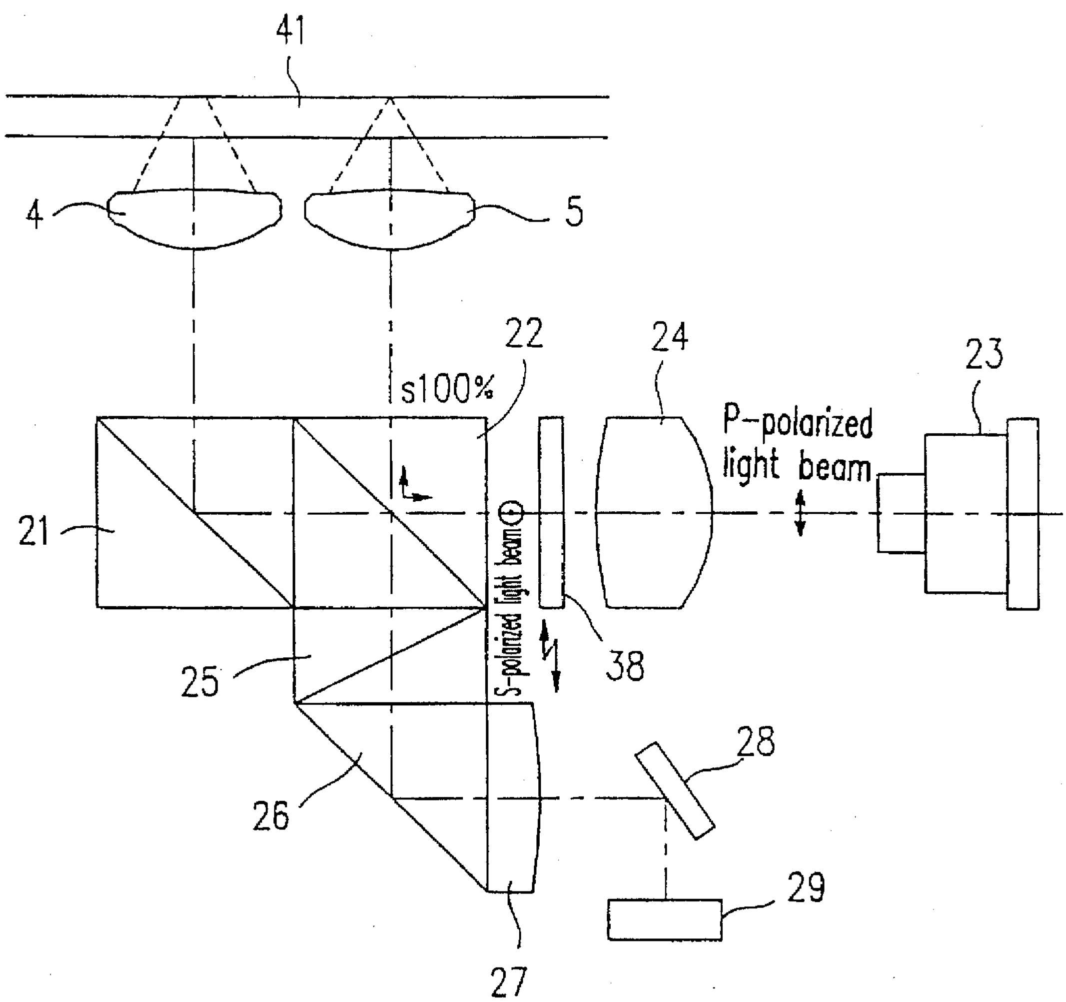
38 Half wave plate

FIG. 8


41
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23
s100%
P-polarized light beam
21
S-polarized light beam
25
38
28
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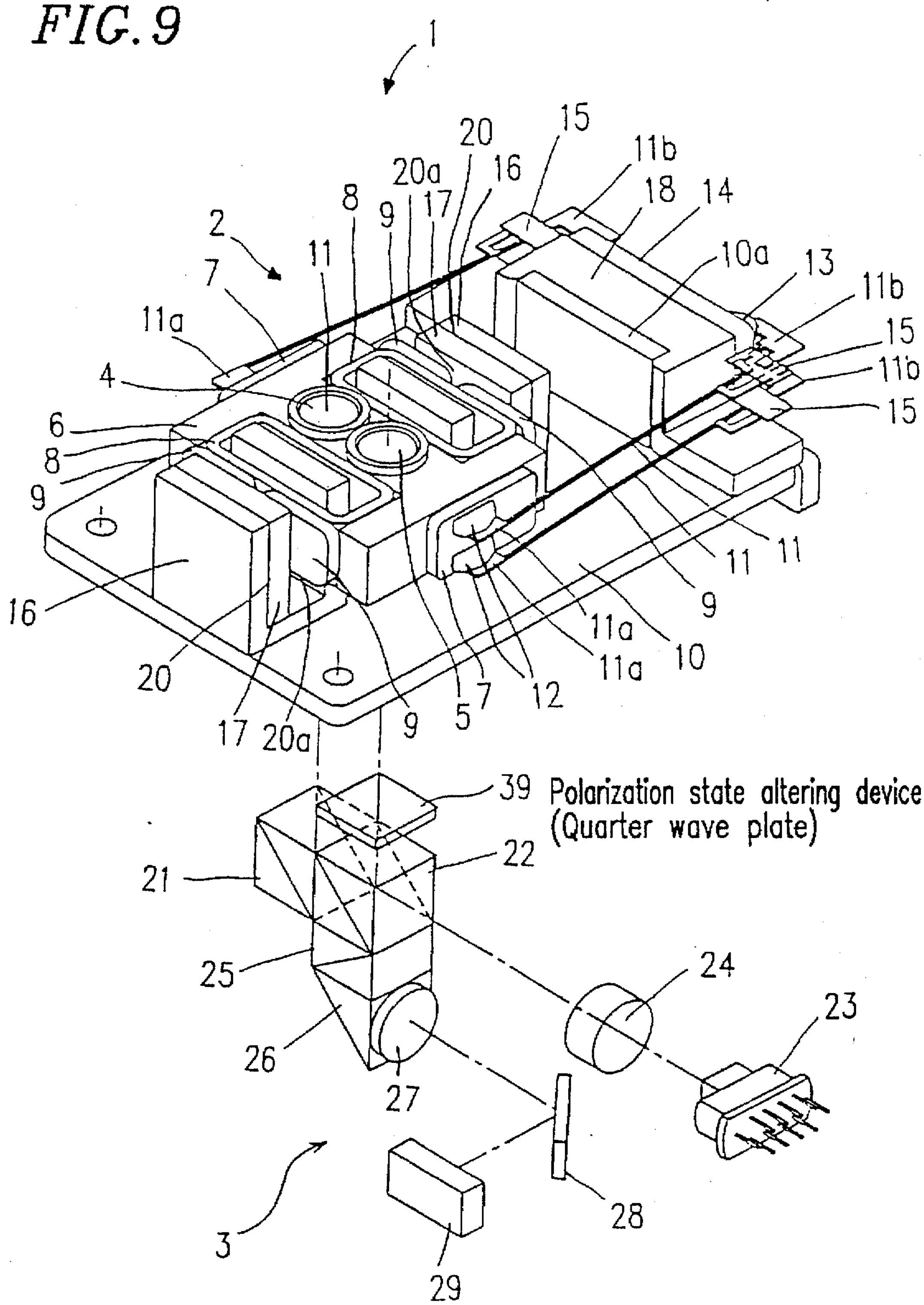
FIG. 9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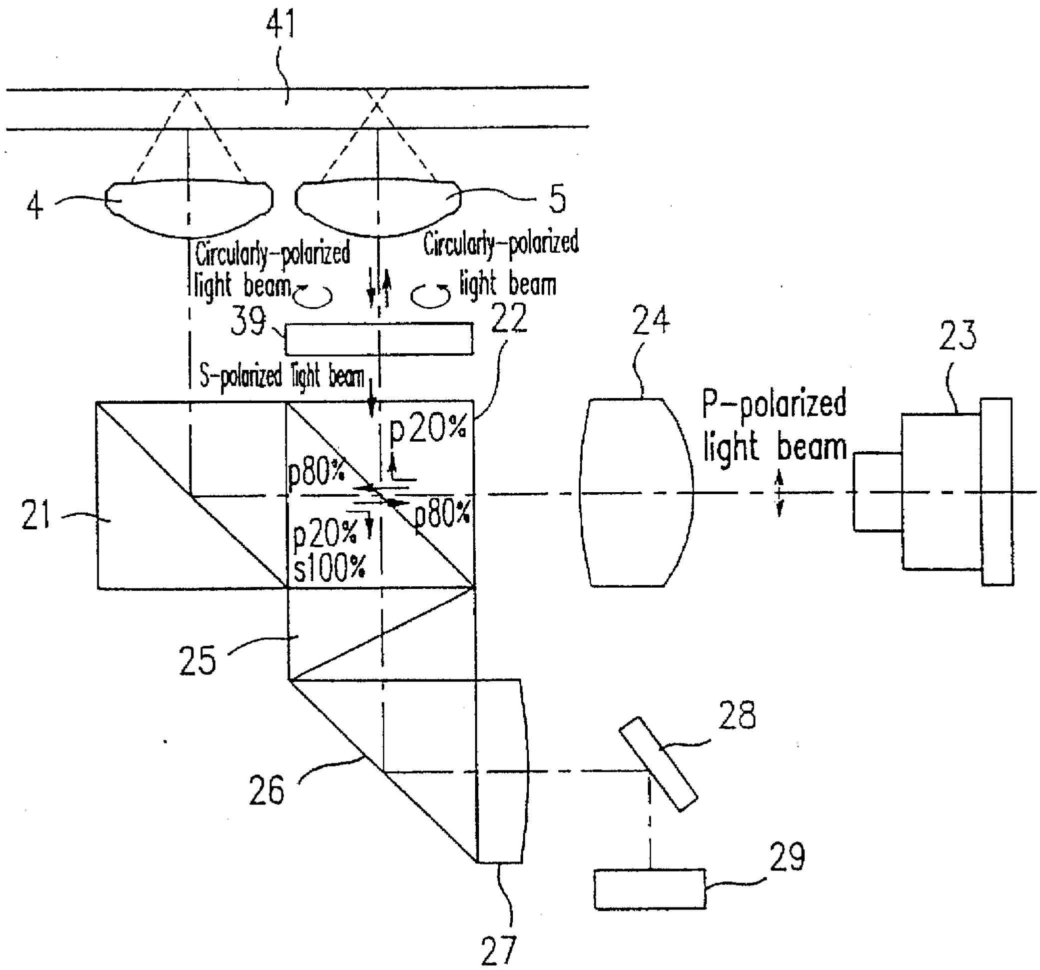
Polarization state altering device
(Quarter wave plate)

FIG. 10


41
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Circularly-polarized light beam
Circularly-polarized light beam
39
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S-polarized light beam
p20%
P-polarized light beam
p80%
p80%
21
p20%
s100%
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FIG. 11

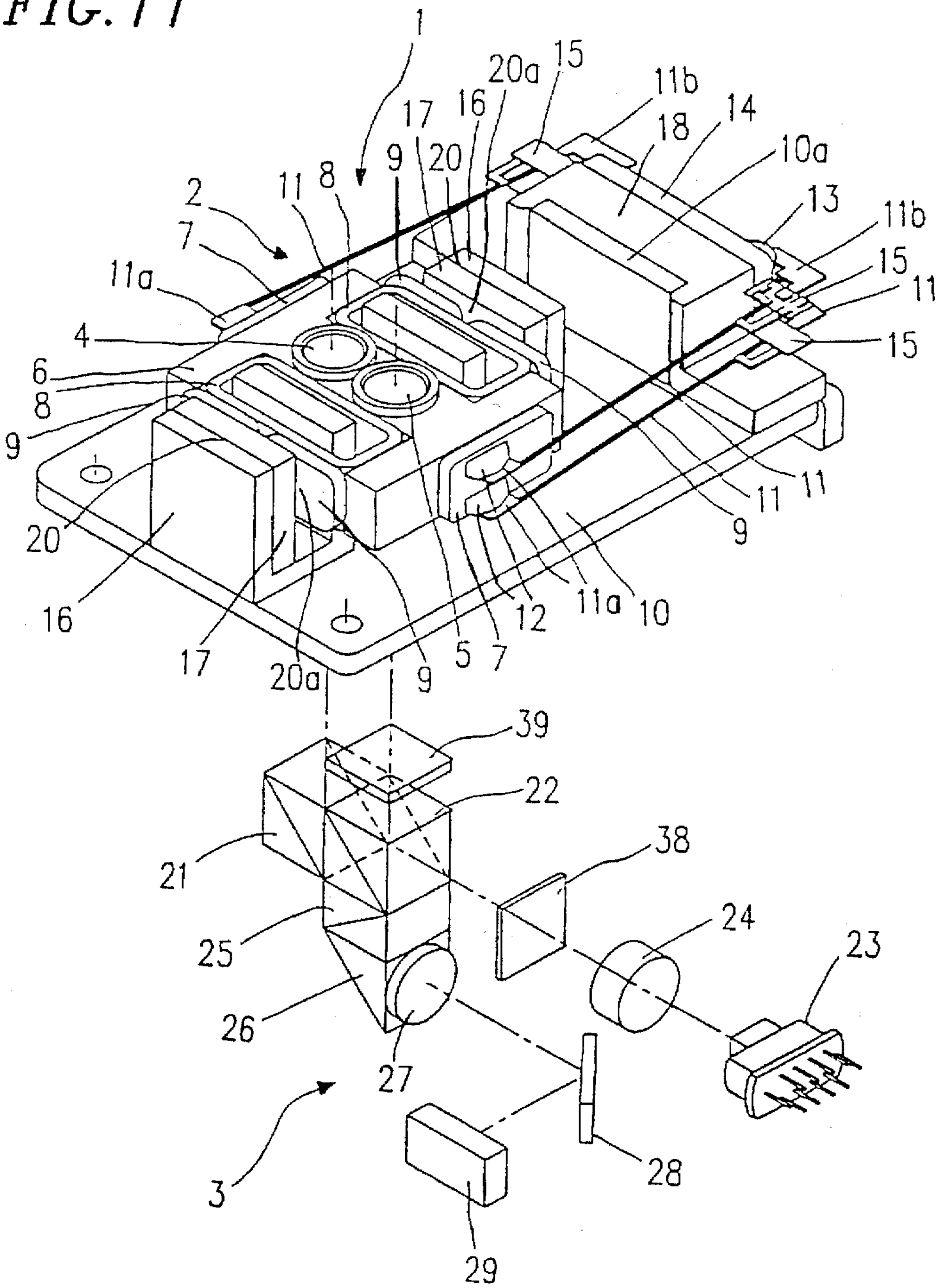
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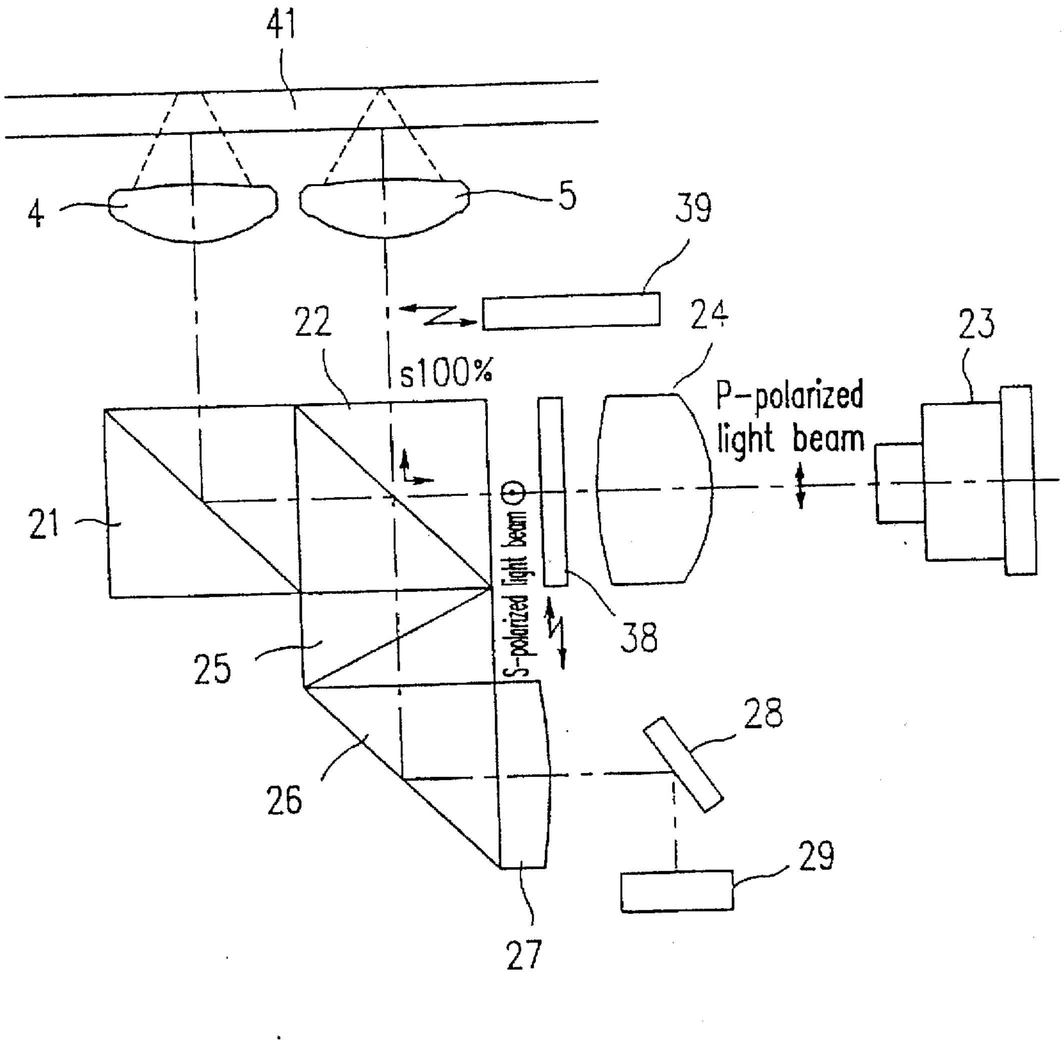
FIG. 12


41
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s100%
P-polarized
light beam
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S-polarized light beam
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FIG. 13

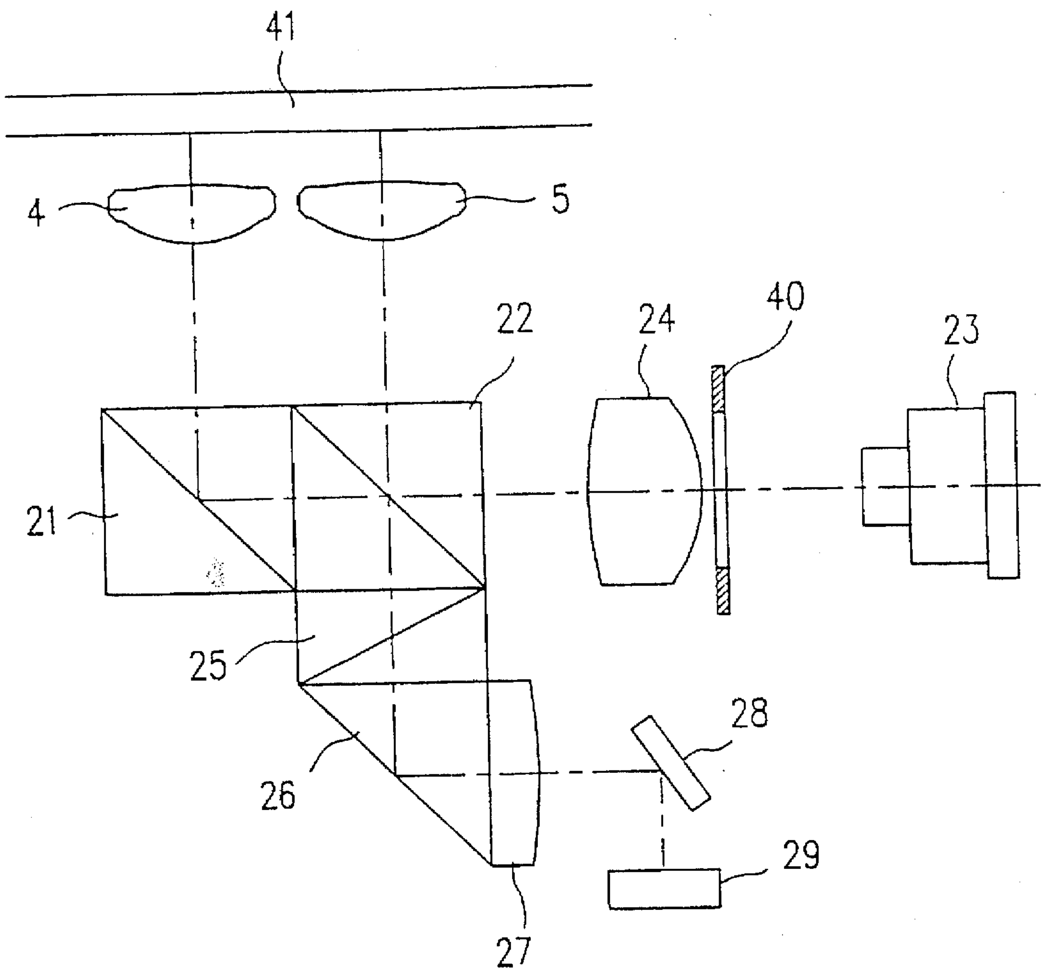
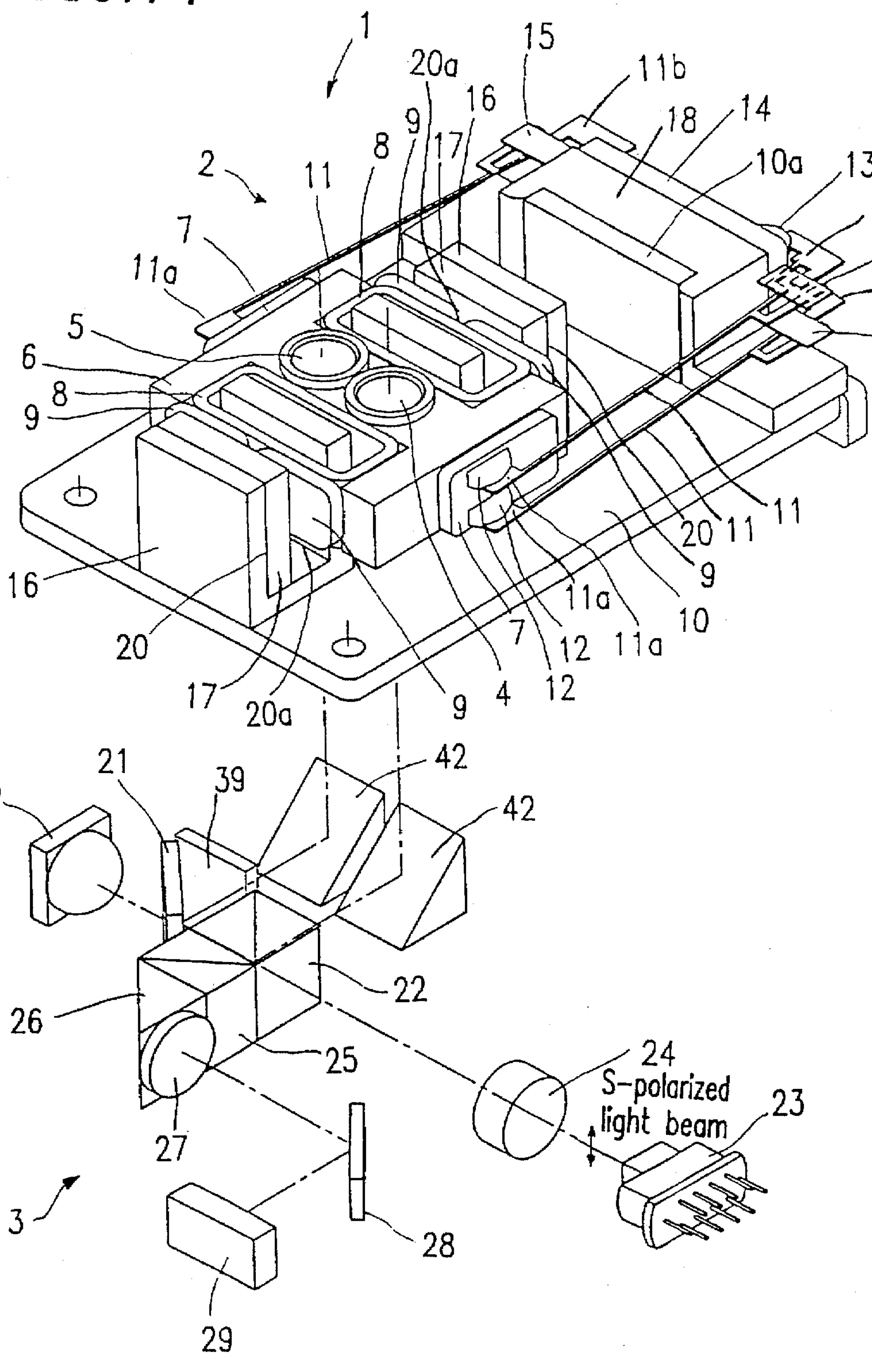


FIG. 14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S-polarized
light beam
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FIG. 15A

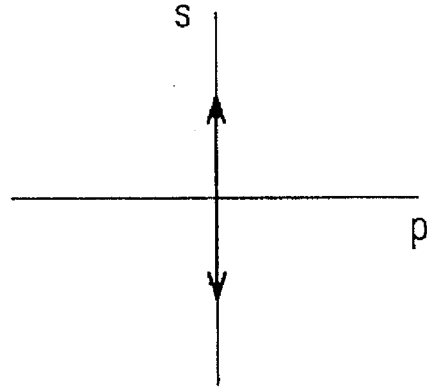

FIG. 15B

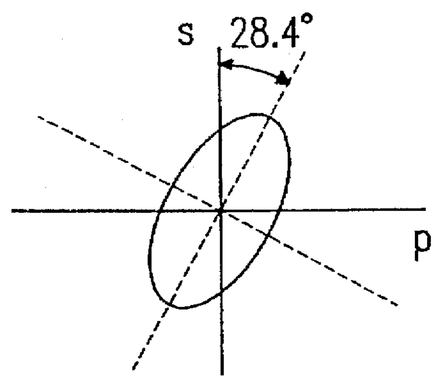

FIG. 15C

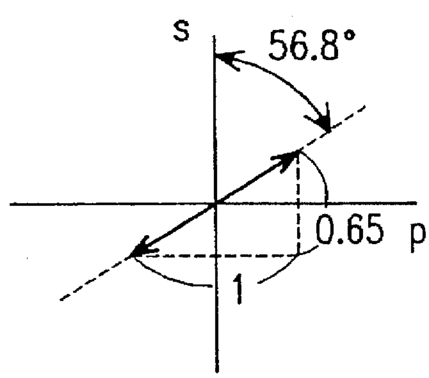

FIG. 16

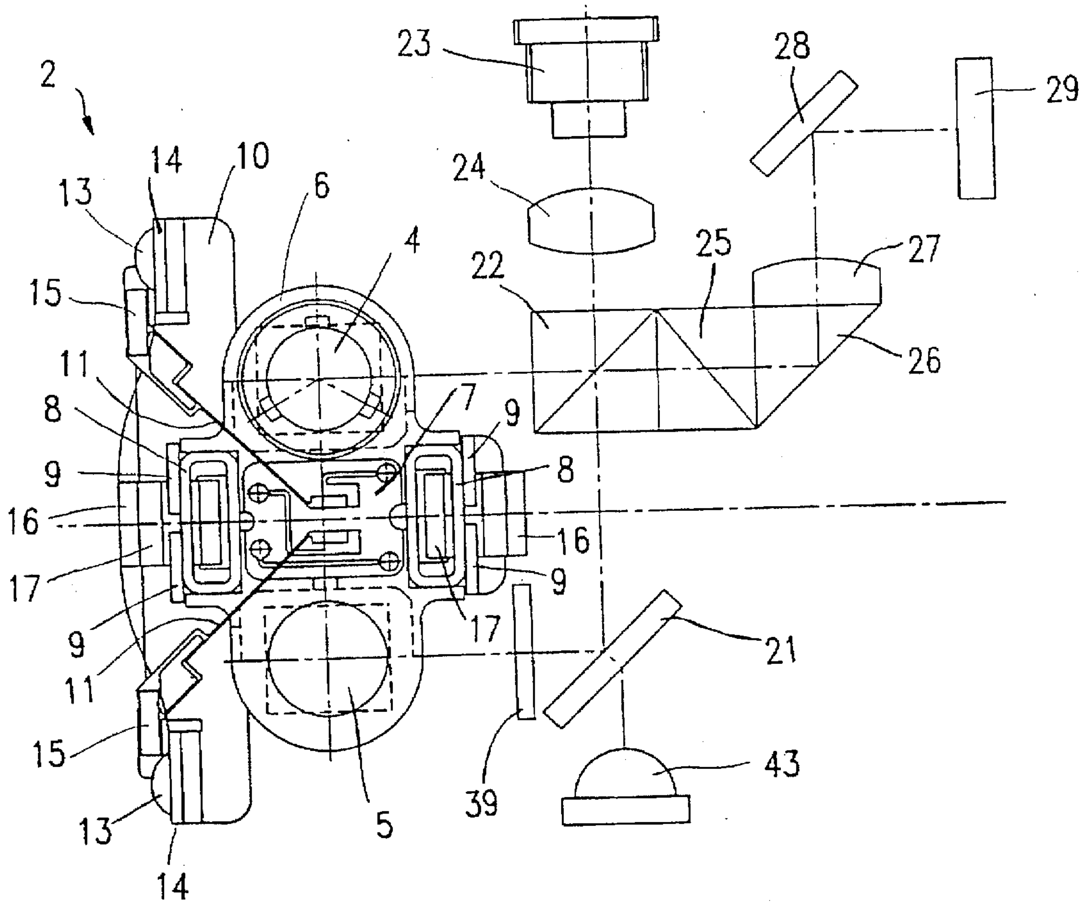
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FIG. 17

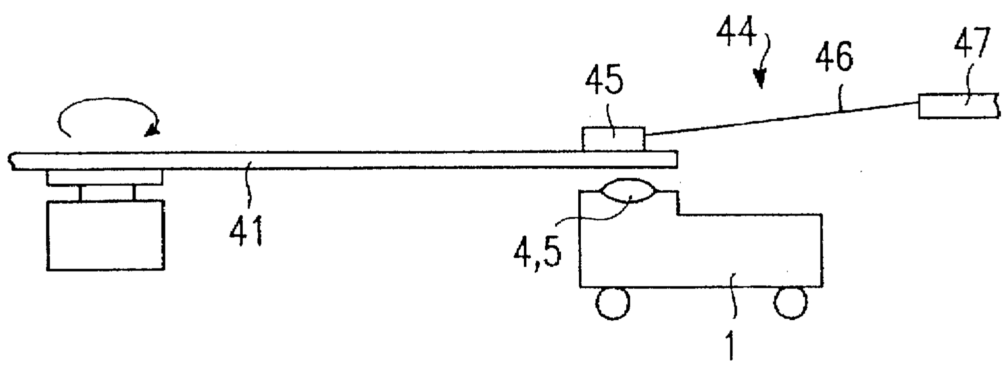


FIG. 18A

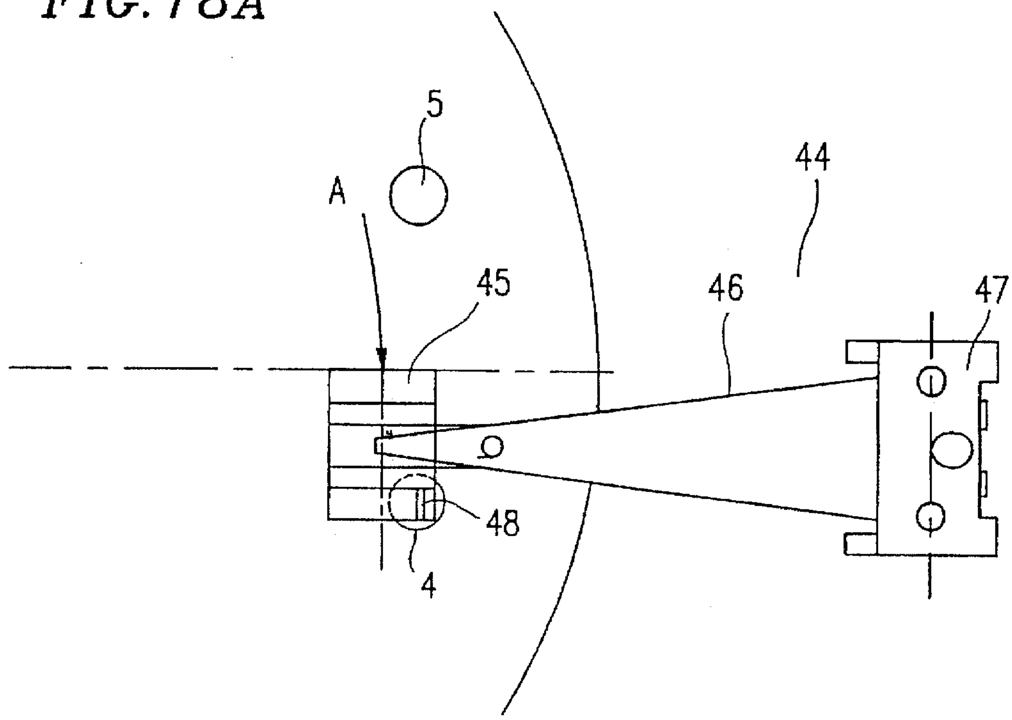


FIG. 18B

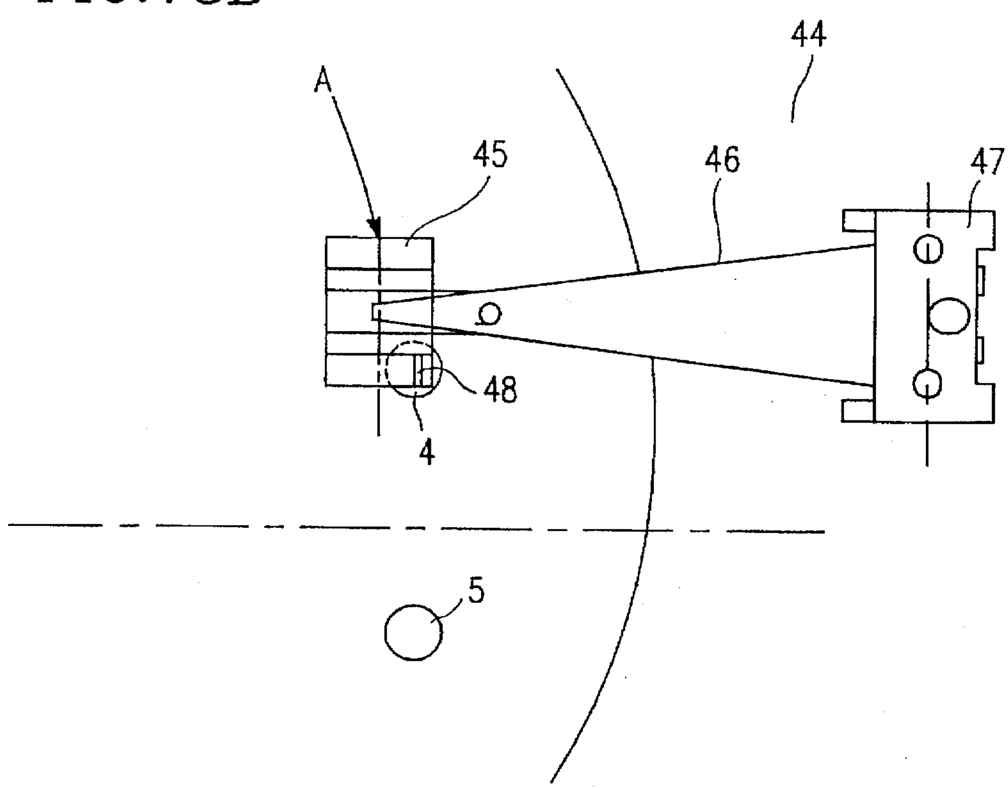


FIG. 19

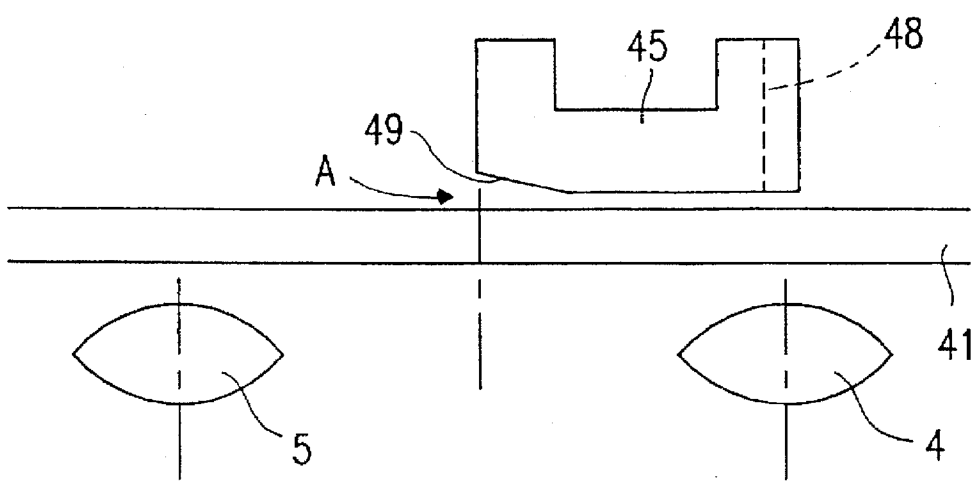
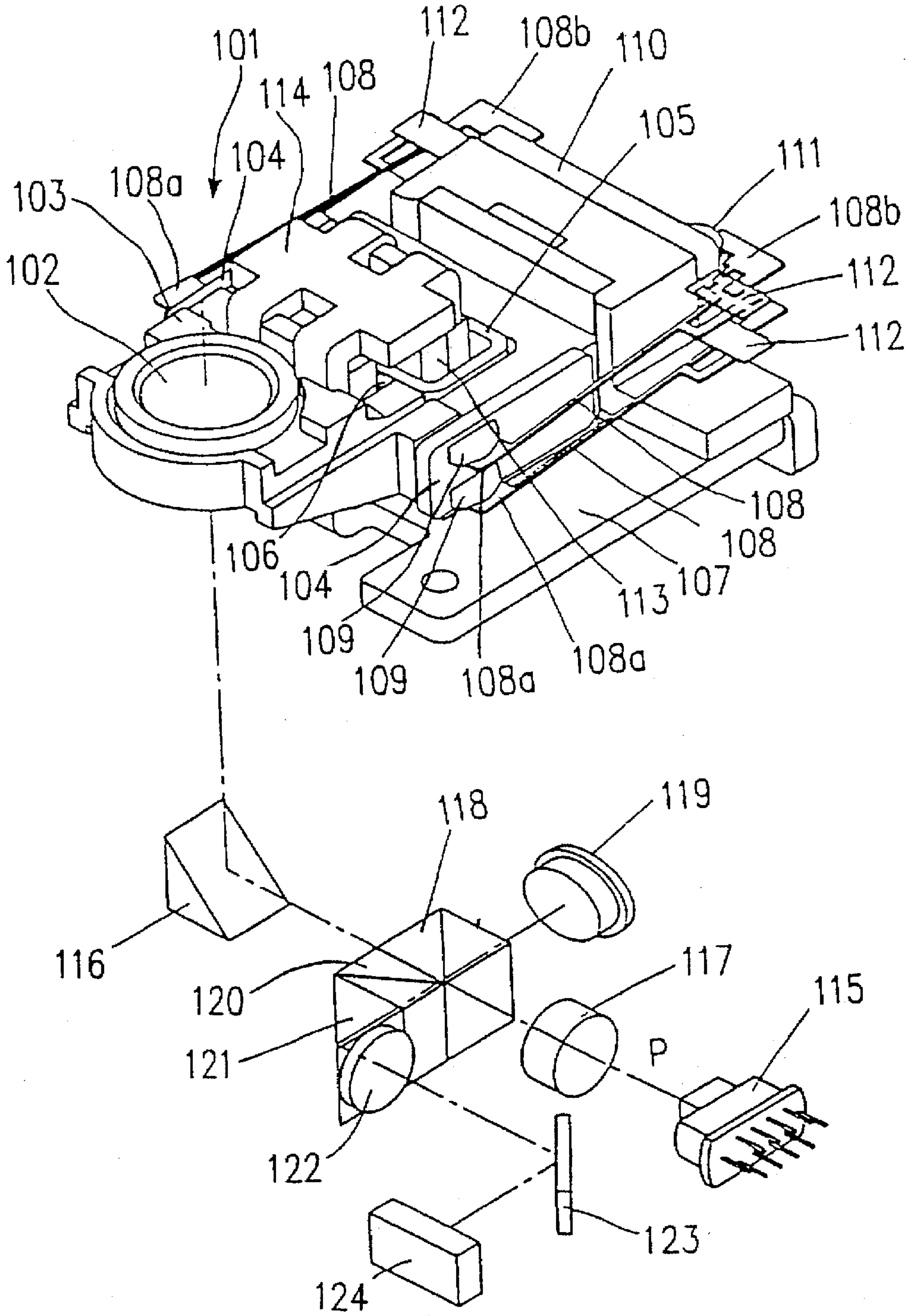


FIG. 20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108b
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108a
108a
108b
115
116
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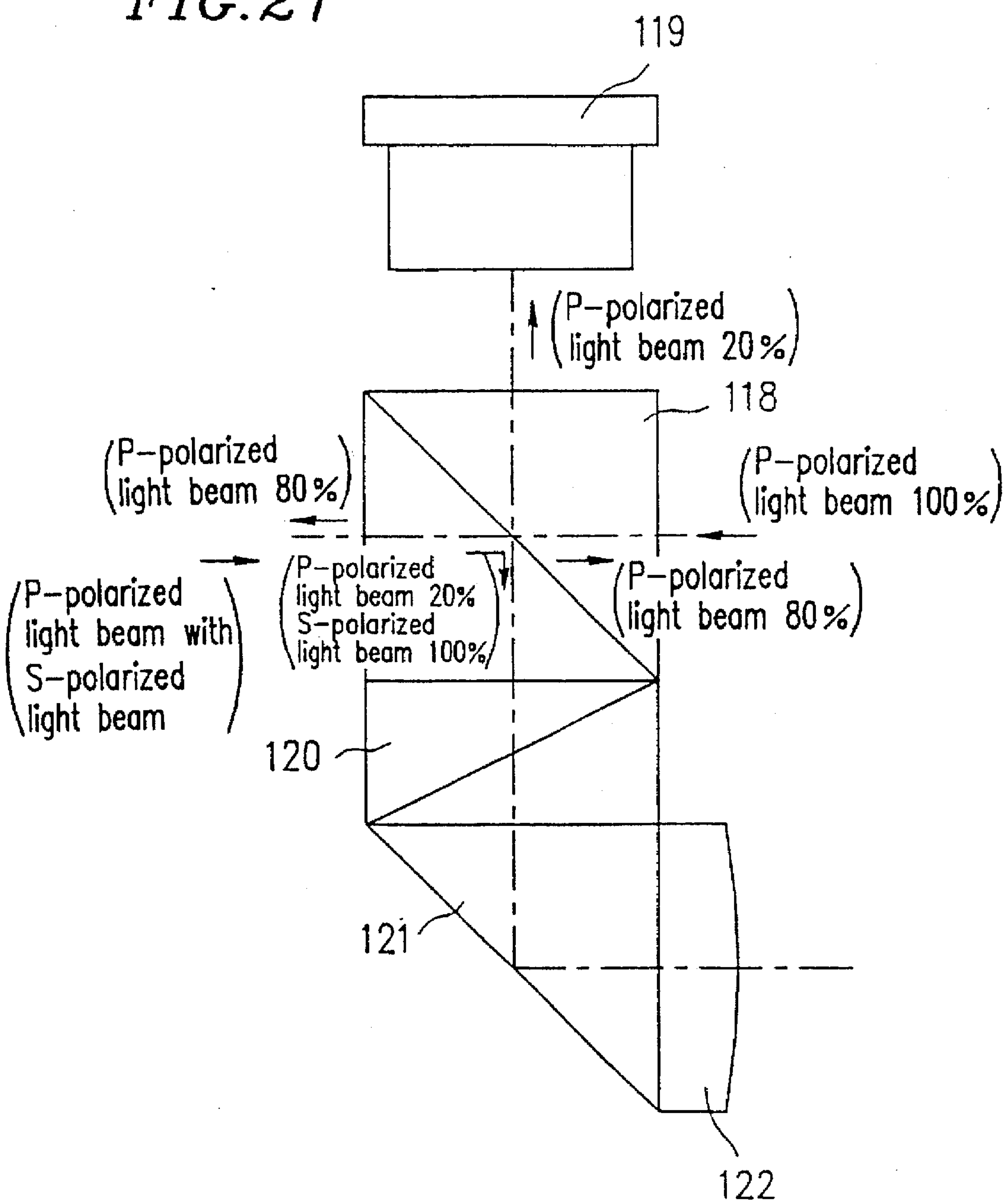
120
121
122
123
124
P

FIG. 21


119
(P-polarized light beam 20%)
118
(P-polarized light beam 80%)
(P-polarized light beam 100%)
(P-polarized light beam with S-polarized light beam)
(P-polarized light beam 20% S-polarized light beam 100%)
(P-polarized light beam 80%)
120
121
122

OPTICAL PICKUP HAVING TWO OBJECTIVE LENSES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical pickup in an optical disk apparatus, and in particular to an optical pickup which can be used for different types of optical disks having different substrate thicknesses and the like.

2. Description of the Related Art

In recent years, an optical disk apparatus is widely used as a recording/reproduction apparatus for large-capacity recording media. An optical pickup incorporated in such an optical disk apparatus typically includes: a light source for emitting a light beam; an objective lens for focusing the light beam on an optical recording medium; an optical system for guiding the light beam to the objective lens; and a mechanism for moving the objective lens in a direction perpendicular to the recording surface of the optical disk (hereinafter referred to as the "focusing direction") and in a direction parallel to a radius of the disk (hereinafter referred to as the "tracking direction").

FIG. **20** is an isometric view showing a configuration of a conventional optical pickup particularly used for a magneto-optical recording medium (e.g., a mini disk, or an "MD"). The conventional optical pickup shown in FIG. **20** includes a light source unit **115**, having a laser diode or the like, an objective lens **102** for focusing light emitted by the light source unit **115** onto the recording medium and an optical system for guiding the light from the light source unit **115** to the objective lens **102**.

In the conventional optical pickup, as shown in FIG. **20**, the objective lens **102** is accommodated in a lens holder **103** and can be moved by an objective lens driving device **101** in the focusing direction and/or the tracking direction. A substrate **104** is attached to each side surface of the lens holder **103**, onto which an end **108***a* of each elastic body **108** is secured by solder **109**. Four elastic bodies **108** support the lens holder **103** movably with respect to a base **107** in the focusing direction and the tracking direction. Another end **108***b* of the elastic bodies **108** are also secured by solder **111** onto a substrate **110** which is fixed onto the base **107**. Further, the objective lens driving device **101** includes a focusing coil **105** and a tracking coil **106**, which are secured in a hole running through a central portion of the lens holder **103**, and a permanent magnet **113**. The magnet **113** and a yoke (not shown) constitute a magnetic circuit for generating a magnetic field. By making current flowing through at least one of the coils **105** and **106**, the lens holder **103** is moved along the magnetic field lines.

Moreover, the objective lens driving device **101** further includes a damper **112** which can suppress the resonance caused by the movement of the lens holder **103** in the focusing direction and/or the tracking direction and a stopper **114**.

The lens holder **103** of the optical pickup accommodates a single objective lens **102**. A single mirror **116** is provided directly below the objective lens **102** for directing a light beam P emitted by the light source unit **115** to the objective lens **102**. In an optical path of the light beam P from the light source unit **115** to the mirror **116**, a collimator lens **117**, which collimates the light beam P, and a polarized beam splitter **118**, which transmits a part of the light beam P and reflects the remaining part thereof depending on the polarization direction. The polarized beam splitter **118** is designed, for example, to have a transmittance of about 80% for a p-polarized light beam and a reflectance of substantially 100% for an s-polarized light beam. The light beam reflected by the polarized beam splitter **118** is incident on a photodetector **119** for generating an electric signal, based on which the output power of the light source unit **115** is monitored, in accordance with the light amount of the incident light beam.

Referring to FIG. **21**, the principle of detecting the magneto-optical signals will now be described.

A laser diode of the light source unit **115** emits a linearly polarized light beam P (in this example, a p-polarized light beam). When the light beam P is incident upon the polarized beam splitter **118**, about 20% of the light beam P is reflected by the polarized beam splitter to be incident on the photodetector **119**, while the remaining portion (about 80%) of the light beam P is transmitted therethrough. The transmitted portion is incident on an optical disk (not shown) via the mirror **116** and the objective lens **102** in that order. In this example, the optical disk is a magneto-optical disk.

The light beam, which is incident on the optical disk, is reflected by an optical disk with the polarization direction thereof being slightly rotated (or inclined) due to the Kerr effect. In other words a small portion of the light beam is altered to an s-polarized component. The rotation angle is determined in accordance with a signal recorded on the position of the optical disk where the light beam is incident. Then, the light beam returns to the polarized beam splitter **118** having a reflectance of about 20% for a p-polarized light beam and a reflectance of substantially 100% for an s-polarized light beam. The light beam is reflected by the polarized beam splitter **118** with the p-polarized component thereof being reduced due to the low reflectance for a p-polarized light beam, while substantially 100% of the s-component thereof is reflected. As a result, the polarization direction of the light beam, which has already been slightly rotated due to the Kerr effect, is further rotated in the same direction. In other words, the Kerr rotation angle of the light beam increases. (In this specification, an angle by which the polarization direction of a light beam is rotated, or inclined is referred to as "the Kerr rotation angle.")

Such a light beam having the increased Kerr rotation angle is incident on an Wollaston prism **120** to be divided into two light beams. The divided light beams from the Wollaston prism **120** are then incident upon a photodetector **124** via a reflection mirror **121** and a spot lens **122**. Based on these two light beams, the signal which is recorded on the position of the optical disk where the light beam is incident can be detected.

The p-polarized component of the light beam transmitted through the polarized beam splitter **118** is incident upon the light source unit **115** where it is detected as servo signals including a focusing error signal and a tracking error signal by a photodiode included in the light source unit **115**.

There are various types of optical disks available today, e.g., a read-only-type disk such as compact disks (CDs), a write-once-type disk which allows only one write operation, and those which allow repeated write and erase operations such as a magneto-optical-type disk and a phase-change-type disk. In recent years, there have been demands for increasing the information capacity and the information density of these optical disks. To meet these demands, the wavelength of the light beams from the light source should be made shorter and the numerical aperture (NA) of the objective lens should be made larger so as to minimize the diametrical size of the beam spot. When increasing the NA of the objective lens, the substrate of the disk can be made thinner so as to minimize crosstalk and the influence of disk skew on the tracking error signal.

However, the optical pickup shown in FIG. **20** is designed for an optical disk having a certain substrate thickness and a certain refractive index. In particular, optical properties of the objective lens, such as a focal length and the like, are designed considering at least the substrate thickness and the refractive index of the optical disk so as to focus the light beam onto the optical disk in an appropriate manner for the recording, reproducing and/or erasing operation, for example in order to form a light spot having an appropriate size. Therefore, when another optical disk having a different substrate thickness and/or a different refractive index is used, the light beam cannot be focused in an appropriate manner, thereby making the optical pickup inoperative. Accordingly, the conventional optical pickup having the configuration shown in FIG. **20** cannot be used for two types of optical disks different from each other in at least one of the substrate thickness and the refractive index thereof.

In view of such a problem, it has been proposed to provide an optical pickup with two objective lenses as disclosed in Japanese Laid-Open Patent Publication No. 6-333255 (hereinafter referred to as the "first conventional example"). According to the first conventional example, two objective lenses are mounted on a movable section of an objective lens driving device. One of the two objective lenses is selectively used depending on the type of the optical disk to be used. This is realized by a beam-splitting mirror provided below the optical pickup. The beam-splitting mirror has two mirror surfaces corresponding to the two objective lenses. The mirror surface located closer to the light source is a half mirror with the other mirror surface being a reflection mirror. With such a beam-splitting mirror, a light beam from the light source can be made incident upon the two objective lenses.

There has also been a known optical pickup with two objective lenses for detecting magneto-optical signals as disclosed in Japanese Patent Publication No. 63-60451 (hereinafter referred to as the "second conventional example"). According to the second conventional example, a half-wave plate is moved so as to be alternately in and out of the light path, thereby altering the polarization direction of a light beam to be incident upon a polarized beam splitter. The light beam which passes through the polarized beam splitter is used for recording magneto-optical signals on a magneto-optical disk. The magneto-optical signals are detected based on the light beam reflected by the polarized beam splitter.

There is no description in the first conventional example as to detecting magneto-optical signals. The optical disk apparatus of the first conventional example poses a problem when used for a magneto-optical disk. That is, since the example employs the half mirror for splitting a light beam, the Kerr rotation angle is not increased, while a satisfactory C/N ratio cannot be obtained. Moreover such a half mirror greatly reduces the light amount of a light beam since the light beam passes therethrough twice via the incoming/returning light paths. (In this specification, an "incoming" light beam refers to a light beam travelling from a light source toward an optical disk, whereas a "returning" light beam refers to a light beam returning to the light source after being reflected by the optical disk.)

The second conventional example describes a method for detecting magneto-optical signals, where a half-wave plate is moved alternately in and out of the light path so as to alter the polarization direction of a light beam. Due the such a configuration, the loss of light is eliminated. However, the two divided light beams are both used for a certain type of magneto-optical disk, and cannot be used for other types of optical disks having, for example, a substrate thickness or a refractive index different from that of a magneto-optical disk. Moreover, a portion of the light beam is isolated from the returning light beam by a half mirror provided in the light path. The magneto-optical signals are detected based on the isolated portion of the returning light beam, but not on the returning light beam which passes through the polarized beam splitter. As a result, besides the additional half mirror which increases the number of the apparatus components, there is provided no effect of increasing the Kerr rotation angle.

SUMMARY OF THE INVENTION

According to an aspect of the invention, an optical pickup for irradiating a first recording medium and a second recording medium with light, wherein at least one of the substrate thickness and the refractive index of the first recording medium is different from that of the second recording medium, is provided. The optical pickup includes: a light source for emitting the light; a polarized beam splitter for receiving the light and for transmitting at least a portion of the light while reflecting the remaining portion of the light depending on the polarization direction of the light; a first objective lens for focusing the portion of the light reflected by the polarized beam splitter onto the first recording medium; and a second objective lens for focusing the portion of the light transmitted through the polarized beam splitter onto the second recording medium.

In one embodiment of the invention, the reflectance and the transmittance of the polarized beam splitter for first linearly polarized light are different from the reflectance and the transmittance of the polarized beam splitter for second linearly polarized light, the polarization direction of the first linearly polarized light being perpendicular to the polarization direction of the second linearly polarized light.

In another embodiment of the invention, the light emitted by the light source is the first linearly polarized light; and the transmittance of the polarized beam splitter for the first linearly polarized light is in a range of 60 to 80%, while the reflectance of the polarized beam splitter for the second linearly polarized light is 95% or higher. The first linearly polarized light and the second linearly polarized light have polarization directions perpendicular to each other.

In still another embodiment of the invention, at least one of the first recording medium and the second recording medium is a recording medium other than a magneto-optical recording medium.

In still another embodiment of the invention, one of the first recording medium and the second recording medium is a magneto-optical recording medium.

In still another embodiment of the invention, the first objective lens and the second objective lens are arranged substantially in a radial direction of the first recording medium or the second recording medium.

In still another embodiment of the invention, the optical pickup further includes a photodetector for receiving light reflected by the first recording medium or the second recording medium to output a signal based on the reflected light; and a first optical element provided between the light source and the polarized beam splitter for altering the polarization direction of the light, wherein light reflected by the recording medium is incident upon the photodetector via the polarized beam splitter.