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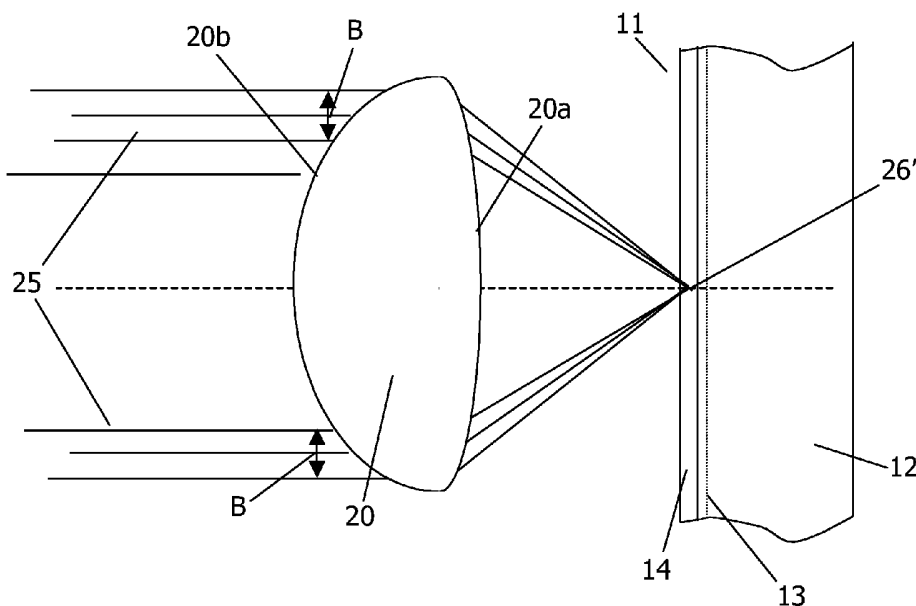
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(54) Title: OBJECTIVE LENS SYSTEM FOR WRITING LABELS ON AN OPTICAL RECORD CARRIER



(57) Abstract: An objective lens system (20) is described which is designed for to scanning an information layer (13) of an optical record carrier (12) by a radiation beam (25). The objective lens system comprises an annular area (B) that is designed for focusing an annular part of the radiation beam (25) onto a label-layer (14) of the optical record carrier such that improved label-writing is obtained.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Objective lens system for writing labels on an optical record carrier

TECHNICAL FIELD

The invention relates to an objective lens suitable for scanning an information layer of an optical record carrier and for label-writing onto that optical record carrier; the invention also relates to an optical pickup applying such an objective lens and an optical
5 recording apparatus comprising such an optical pickup.

BACKGROUND OF THE INVENTION

Dedicated printers that can print labels with desired information onto an adhesive label for an optical record carrier have been available. Sticking such an adhesive
10 label onto the label side of an optical record carrier (optical storage medium) needs care and attention, as the high rotational speeds of record carriers in nowadays optical data storage apparatus (or optical data drive) require high balance accuracies of the disc. An off-centered or wrinkled adhesive label may lead to damage of the drive or shattered discs.

There are also printers that can print directly onto the label surface of an
15 optical record carrier. Both types of label printing require additional equipment for label-writing and thus increase cost for the consumer.

Recently CD-recorders and or DVD-recorders have come available that are capable of writing images directly on to the optical record carrier in the CD or DVD recorder using radiation source of the optical pickup unit for writing into or onto a label area.

20 In US20020191517 a label-writing system is disclosed in an optical data storage apparatus in which a label can be written on an optical record carrier having a visible light characteristic changing layer, or label-layer, that is visible through a transparent protective layer from the label surface. The recording of the image is achieved by exposing the label-layer with a laser beam from the label surface side of the record carrier. The label is
25 formed by means of writing marks with diameters of about tens of microns with the writing laser on tracks separated about 50-100 μ m. Having the optical record carrier with such a label-layer inverted in the optical data storage apparatus, the label-layer can be accessed by the laser beam of the optical pickup in the optical data drive.

In US20040136291 an optical pickup for such a label-writing system is disclosed. Requirements on the focusing actuator for such a label-writing capable optical data storage apparatus are given. Although the title of the application refers to an optical pickup with dual focal length, there are only requirements disclosed on the total movable range (in focus direction) of the objective lens by the focus actuator to be able to focus the laser beam onto a label-layer and onto an information layer in an optical record carrier. No disclosures are given on requirements for the objective lens itself.

Both US 20020191517 and US20040136291 relate to optical data storage apparatus capable of reading/writing data from/onto an information layer of an optical record carrier such as a CD or DVD disc and being capable of writing an image into a label-layer on an optical record carrier (e.g. CD or DVD) having such a label-layer. The label-layer is accessible by the laserbeam of the optical data drive when the optical recording medium is positioned inverted in the optical data drive.

Both US 6,771,297 and US 6,778,205, having the same assignee, discloses a label printing system for a disc storage medium including a thermally-sensitive layer (e.g. a label-layer) formed on an upper portion of the storage medium. This thermally sensitive layer changes color when heated by the radiation beam out of the writing laser in the system. The system may be integrated in the optical data drive.

This optical data drive may be for example a CD-recorder or a DVD recorder. Nowadays most of such optical data recorders are capable of reading and/or writing on optical record media with different formats such as CD-ROM, CD-R(W), DVD-ROM and DVD+R(W).

The data on an optical recording medium is stored in an information layer. The information layer of a disc is protected by a transparent cover layer (sometimes referred to a substrate), which has a predetermined thickness. Different formats of optical recording media have different thickness of the cover layer, for example the cover layer thickness of a CD disc is approximately 1.2mm, of a DVD disc approximately 0.6mm and of a BD disc approximately 0.1mm. When scanning an optical record carrier of a certain format, the radiation beam is focused to a point on the information layer that is to be readout. As the radiation beam passes through the cover layer of the record carrier a spherical aberration is introduced into the radiation beam. The amount of spherical aberration introduced depends on the thickness of the cover layer, the wavelength of the radiation beam, and the numerical aperture of the objective lens focusing this radiation beam. For CD readout and/or recording a numerical aperture of about 0.50 is used and a wavelength of approximately 785nm; for

DVD this is respectively 0.65 and approximately 660nm and for BD respectively 0.85 and approximately 405nm. The spherical aberration introduced by the passage through the cover layer can be corrected for in the design of the objective lens. For scanning different discs with different cover layer thickness, the radiation beam needs to be corrected with a different amount of spherical aberration before passing through the cover layer and focused onto an information layer.

Due to diffraction limits a focused radiation spot is not a perfect point. However, in optical data drives, it is desirable that the spot is limited by diffraction, and not by the effect of aberrations. Typically, an allowance in the root mean square of the optical path difference (OPD) of approximately 0.07λ , (where λ is the wavelength of the relevant radiation beam) in total is allowed for wavefront aberrations, such that the system is diffraction limited. It can be convenient to express the OPD in $m\lambda$ (where $0.001\lambda = 1\text{ m}\lambda$). A budget of approximately 30-40 $m\lambda$ of aberration is permitted for the total wavefront aberration of the objective lens system from this total allowance.

The available optical data storage apparatuses with the capability of label-writing make use of such standard CD objective lenses or DVD/CD compatible lenses. The objective lenses are only being designed and optimized for reading/writing data through a specific transparent substrate thickness from and/or into an information layer of a CD and/or DVD. Examples of such a CD/DVD compatible objective lenses making use of diffractive structures for wavelength dependent optical characteristics are disclosed in US 6,636,365 and US 6,614,600. An example of a CD/DVD compatible objective lens making use of non-periodic phase structures for wavelength dependent optical characteristics is disclosed in the article by B.H.W. Hendriks et al., "Application of non-periodic phase structures in optical systems", Appl. Opt. 40 (2001) pp.6548-6560.

Presently the label-writing enabled optical data drives are applying such standard objective lenses for writing a label into a label-layer on an optical record carrier as disclosed in the cited documents, the amount of aberrations in the spot on the label-layer are very large: about several λ s peak-peak (or more than about 400 $m\lambda$ W_{rms} (wavefront aberration in λ as root-mean-square value)). The resulting diameter of the spot can be in the order of several tens of μm .

Such a large or highly aberrated spot for label-writing has many disadvantages. Large aberrations will reduce the intensity in the spot. This also has a negative impact on the laser temperature and its expected life, as higher and longer laser pulses are required for writing the marks in the label-layer. A large or highly aberrated spot also makes

it difficult to perform accurate focusing during label-writing as the focusing detection system of the optical pickups are designed for focused spots of much smaller dimensions.

It is an object of the invention to obtain an objective lens, and an optical pickup and optical data storage apparatus using the same suitable for label-writing with improved label-writing speeds.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided an objective lens system having a center area adapted for scanning in cooperation with at least one radiation beam an information layer of at least one type of optical record carrier, the at least one type of optical record carrier having a recordable label-layer for writing a label, the objective lens system having at least a first and second lens surface, in which the at least one of the at least first and second lens surface comprises an annular area that is adapted to focus at least one radiation beam onto said label-layer.

Using the objective lens system according to the invention will make it possible to create a focused spot onto the label-layer in the neighborhood of the aberrated spot created by the part of the radiation beam that passed the other lens areas as the latter areas are optimized for the readout/recording through a cover layer such as for CD or DVD discs. The annular area may focus the corresponding part of the radiation beam to a size about equal to that of the aberrated spot created by the part of the radiation beam that passed the other lens areas, thereby increasing the intensity in the spot. When the annular area is designed to focus the corresponding part of the radiation beam to a smaller spot both the intensity in the spot as well as the label-writing resolutions can be improved.

The light intensity in the spot used for the label-writing is increased. This has the advantage that recording speed for the label-writing may be increased. It may also be possible to reduce the light power emitted by the semiconductor laser during the label-writing process and therefore increasing the expected life of the semiconductor laser and thus of the optical scanning device used for label-writing.

According to another aspect of the invention the center area of the objective lens system is generating in cooperation with at least one radiation beam a best focus onto the label-layer, this best focus is having a first dimension, the light spot simultaneously generated by the annular area in cooperation with this at least one radiation beam onto said label-layer is having a second dimension and the second dimension is smaller than the first dimension.

The center area of the objective lens system is creating a light spot with a best focus on the label-layer as the radiation beam transmitted by the center area towards the label-layer is highly aberrated with spherical aberration as the center area is designed to focus a scanning spot for scanning an information layer of an optical record carrier through a transparent, protection layer (cover layer). The light spot generated by the radiation beam transmitted by the annular area on the label-layer has preferably smaller dimensions than the best focus dimension generated by the center area. Such dimension can be expressed in, for example, full width half maximum (FWHM), $1/e^2$ -diameter of the light intensity, etc. With this smaller light spot generated by the annular area a higher intensity can be achieved which enables higher label writing speeds.

In accordance with yet another aspect of the present invention, there is provided an objective lens system for scanning in cooperation with at least one radiation beam an information layer of at least one type of optical record carrier, the at least one type of optical record carrier having a recordable label-layer for writing a label, the objective lens system having at least a first and second lens surface, the at least one of the at least first and second lens surface comprises an annular area that is adapted to focus at least one radiation beam onto said label-layer, in which the at least one radiation beam to be focused onto said label-layer is having a wavefront aberration that is less than $400m\lambda W_{rms}$.

By optimizing the wavefront aberration of the focusing beam onto the label-layer to an optical quality better than a wavefront aberration of $400m\lambda W_{rms}$, the light spot generated by the annular area will have about the same aberrations or less than the light spot generated by the center area on the label-layer. The intensity the significantly increases and the writing speed can be increased.

Preferably the design of the annular area is adapted such that the optical quality of the radiation spot is even better, e.g. less than $200m\lambda W_{rms}$ or even more preferred less than $50m\lambda W_{rms}$, which becomes comparable to the optical quality of an objective lens in a diffraction limited optical data scanning system.

By improving the optical quality of the radiation spot on the label-layer the focusing characteristics of the optical pickup using the objective lens according to the invention are improved compared to the state of the art. An improved optical quality of the radiation spot on the label-layer will also improve the optical quality of its image on the photodetector in the optical pickup used for tracking and focusing to an information layer. Therefore tracking and focusing on the label-layer during writing may be improved.

Combined with the smaller radiation spot also the label-writing accuracy may be increased.

In accordance with another aspect of the present invention, there is provided an objective lens system for scanning an information layer of an optical record carrier in cooperating with a radiation beam having a wavelength λ_1 , the optical record carrier having a label-layer, the objective lens system comprising at least a center area and at least one annular area, the center area being designed for generating at least a diffraction limited focus within a numerical aperture on an information layer of the optical record carrier through a transparent substrate, and the at least one annular area being designed to focus a at least a part of the corresponding radiation beam onto a label-layer of the optical record carrier.

In accordance with another aspect of the present invention, there is provided an objective lens for scanning an information layer of a first optical record carrier in cooperating with a radiation beam having a first wavelength and for scanning an information layer of a second optical record carrier in cooperating with a second radiation beam having a second wavelength, the first and second optical record carrier having a label-layer, the objective lens system comprising at least a center area and at least one annular area, the center area being designed for generating at least a diffraction limited focus within a first numerical aperture on the information layer of the first optical record carrier through a transparent substrate, and the at least one annular area being designed to focus a corresponding part of the first radiation beam onto a label-layer of the first or second optical record carrier.

In accordance with another aspect of the present invention, there is provided an objective lens system for scanning an information layer of a first optical record carrier in cooperating with a radiation beam having a first wavelength and for scanning an information layer of a second optical record carrier in cooperating with a second radiation beam having a second wavelength, the first and second optical record carrier having a label-layer, the objective lens system comprising at least a center area and at least one annular area, the center area being designed for generating at least a diffraction limited focus within a first numerical aperture on an information layer of the first optical record carrier through a transparent substrate of a first thickness and within a different second numerical aperture on an information layer in a second optical record carrier through a transparent substrate of a different second thickness, and the at least one annular area being designed to focus a corresponding part of the second radiation beam onto a label-layer of the first or second optical record carrier.

As multiple format optical data recorders are available for consumer and well as data applications there is the possibility to do the label-writing on suitable disc with one, two or three different wavelengths (depending on the type of optical data recorder and on the wavelength sensitivity of the label-layer). For example, a common DVD data-recorder has two radiation sources for writing a CD or a DVD. For writing CD-R or RW a radiation source having a wavelength of approximately 785nm is used in combination with an objective lens having a numerical aperture of about 0.50 at that wavelength, while for writing a DVD a radiation source having a wavelength of about 660nm is used in combination with an objective lens having a numerical aperture of approximately 0.65. The objective lens for writing the CD may be the same as for writing a DVD, i.e. a CD//DVD compatible objective lens. In a BD data-recorder three wavelengths may be present (~405nm, ~660nm and ~785nm). There may be two or a single objective lens present in the applied optical scanning device. The two or single objective lens may be optimized according to the invention for creating a focus spot onto the label-layer of a suitable optical record carrier, for one, two or three wavelengths. With two or three available wavelengths and e.g. a mixture of different wavelength sensitive materials in the label-layer a color or even full-color label may be written.

These and further examples as well as further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which are made with reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

Fig. 1A, B: schematic representation of the focusing characteristics of a conventional lens focusing a radiation beam onto an information layer (Fig. 1A) and onto a label-layer (Fig. 1B),

Fig. 2A, B: Schematic representation of the focusing characteristics of an objective lens according to a first embodiment of the invention on an information layer (Fig. 2A) and on a label-layer (Fig. 2B),

Fig. 3A, B, C: Schematic representation of the focusing characteristics of an objective lens according to a second embodiment of the invention on an information layer of a first optical record carrier (Fig. 3A), on an information layer of a second optical record carrier (Fig. 3B), and on a label-layer of a first or second optical record carrier (Fig. 3C),

Fig. 4 A, B, C. Schematic representation of the focusing characteristics of an objective lens according to a third embodiment of the invention on an information layer of a first optical record carrier (Fig. 4A), on an information layer of a second optical record carrier (Fig. 4B), and on a label-layer of a first or second optical record carrier (Fig. 4C),

5 Fig. 5 A, B: A schematic representation of possible segmentations of the annular area on a surface of the objective lens according to an embodiment of the invention, Fig 5A showing rotationally alternating segments, and Fig. 5B showing annular alternating segments,

10 Fig. 6: A schematic view of an optical scanning device using an objective lens according to an embodiment of the invention,

Fig. 7: A schematic view of the imaged light distributions on the photodetector of an optical scanning device according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

15 Fig. 1A shows an objective lens system 10 as used in an optical pickup of an optical recording device 9 (or drive such as, for example, a CD-recorder) that is designed for scanning an information layer 11 in an optical record carrier 13 (or disc such as, for example, a CD). The objective lens system may consist of a single optical element or multiple optical elements forming a multi-element objective lens. The objective lens 10 focuses a radiation
20 beam 15 through a transparent substrate 12 onto the information layer of the optical record carrier to be scanned. The objective lens 10 is designed such that it compensates for the spherical aberration that is introduced in the radiation beam 15 when passing transparent substrate 12 of the disc 11: the scanning spot 16 is designed to be diffraction limited. This compensation is fixed for a specific thickness of the substrate 12, a specific refractive index
25 of the substrate and for a specific wavelength of the radiation beam 15. By using commonly known techniques, data may be read from or written onto an information layer 13 in the disc 11.

When, as depicted in Fig. 1B, the disc 11 is suited with a label-layer 14, an image (for example a picture or text or alike) may be written onto the label-layer when the
30 drive is equipped with suitable software. The disc 11 has to be inserted into the drive with the label-layer facing the objective lens 10. As the objective lens 10 is compensating a fixed amount of spherical aberration corresponding to the thickness of the transparent substrate 12, the resulting light spot 16' (first light spot) will be highly aberrated, as now the radiation beam will not pass the transparent substrate. The diameter of such a resulting spot is several

tens of micrometers. Due to the low intensity level in the spot the writing speed for writing an image in the photosensitive label-layer 14 is low. As an example, writing speeds for CD-R discs in commonly available CD recorders is at 48x, while the writing speed for images in currently available label-writing equipped CD-recorders is below 1x.

5 In Figures 2A and 2B a first embodiment according to the invention is schematically shown: an objective lens system according to claim 1 for scanning an information layer 13 of an optical record carrier in cooperating with a radiation beam 25 having a wavelength λ_1 , the optical record carrier 11 having a label-layer 14, the objective lens system comprising at least a center area A and at least one annular area B, the center
10 area being designed for generating at least a diffraction limited focus 26 within a numerical aperture NA1 on an information layer of the optical record carrier through a transparent substrate 12, and the at least one annular area B being designed to focus at least a part of the corresponding radiation beam in a second light spot onto a label-layer 14 of the optical record carrier 11. The focusing is in this respect not limited to create a diffraction-limited second
15 light spot, but to create a second light spot that has preferably equal or smaller dimensions than the first light spot.

 The annular area B may be located on the any of the available surfaces 20a, 20b of the objective lens.

 An objective lens according to this first embodiment and schematically shown
20 in Fig 2A and 2B may be designed for use in a CD-recorder including the label-writing function. In a CD-recorder it is possible to read and write data from an information layer of a CD. In a standard CD-recorder an objective lens is used that is designed to operate in cooperation with a radiation beam having a wavelength of about 785nm and an optical record carrier (CD) having a transparent (cover) layer thickness of about 1.2mm. Such a lens has at
25 least a first and second surface and may be for example a plastic or glass bi-aspherical lens and can be of a finite or infinite conjugate. The lens is focusing the radiation beam onto an information layer in the disc with a numerical aperture of about 0.50 (corresponding to center area A).

 An objective lens 20 according to this first embodiment for a CD-recorder
30 having the label-writing functionality, has on at least one of the first and second surface 20a, 20b, outside the center area A, an annular area B that is designed to focus the corresponding annular part of the incident radiation beam into spot a 26' onto the label-layer 14 of a CD 11 comprising such a label-layer. The annular area B may run up to an effective numerical aperture of 0.60, or preferably 0.65, but may also extend to higher values of numerical

aperture. The design and focusing of the annular area B may, for example, be based on refraction and then having different aspherical coefficients and/or radius compared to the aspherical coefficients and radius of the center area A. The design and focusing of the annular area may also, as another example, be based on an optical structure in or on a surface of the objective lens having a diffractive effect, for example a blazed grating profile. The diffraction efficiency of such a diffractive structure may be such that at least a part of the incident beam corresponding to the annular area is designed to focus on the label-layer. The optical structure may also be a non-periodic phase structure.

The focus or second light spot created by such an annular area on the label-layer preferably is designed to have a W_{rms} of less than $400m\lambda$, more preferably less than $200m\lambda$ W_{rms} and even more preferably less than $50m\lambda$ W_{rms} . The focus (first light spot) created (simultaneously) by the center area A on the label-layer will be highly aberrated as the corresponding part of the focused radiation beam will comprise a correction for spherical aberration corresponding to the thickness of the transparent layer 12. The diameter of the focused spot by the annular area B on the label-layer may thus be equal and preferably smaller than the focused spot on the label-layer generated by the center area A.

As is obvious the above description on the first embodiment may also be described in relation to an objective lens designed for reading and/or writing a DVD in a DVD recorder that is suitable for label-writing. The radiation beam will then have a wavelength of approximately 660nm and the objective lens is designed to compensate the spherical aberration introduced in the radiation beam when passing within a numerical aperture of about 0.65 a transparent substrate of 0.6mm thickness. The numerical aperture (NA) of about 0.65 will then define the center area A on one of the lens surfaces and the annular area B will start from the NA $\sim$ 0.65 upwards.

In general, the label-layer on the optical record carrier, such as a according to the formats of CD, DVD or BD, may be protected by a label-substrate with a thickness L (e.g. a cover layer of a transparent material), through which the annular part of the radiation beam has to be focused. The annular area may correct for the spherical aberration introduced in the focused radiation beam when passing through the label-substrate. This thickness L may be smaller than the thickness d_1 of the transparent substrate covering the information layer in the optical record carrier. It may also be possible that the label-layer itself has a certain thickness and that the annular area B of the objective lens is designed to focus at a position within the label-layer.

In Figures 3A, 3B and 3C a second embodiment according to the invention is schematically shown: an objective lens 30 according to claim 1 for scanning an information layer 13 of a first optical record carrier 11 in cooperating with a radiation beam 35 having a first wavelength λ_1 and for scanning an information layer of a second optical record carrier 31 in cooperating with a second radiation beam 37 having a second wavelength λ_2 , the first and second optical record carrier having a label-layer 14 (34), the objective lens system 30 comprising at least a center area A and at least one annular area C, the center area A being designed for generating at least a diffraction limited focus 34 within a first numerical aperture NA1 on the information layer 13 of the first optical record carrier 11 through a transparent substrate 12, and the at least one annular area C being designed to focus a corresponding part 35' of the first radiation beam 35 onto a label-layer 14 (34) of the first 11 or second 31 optical record carrier.

A lens system according to this second embodiment may be used in a Combi-drive that has to be capable of writing a label into a label-layer of an optical record carrier. A Combi-drive is an optical data recorder that can read and write data from or to an information layer of a CD disc using a radiation beam having a wavelength of about 785nm, and can also read data from (and not write data to) a DVD disc using a radiation source having a wavelength of about 655nm. The radiation source with which a label can be written onto a CD disc or a DVD disc is in a Combi the radiation source having the wavelength of about 785nm as this is the high power laser.

Figures 3A and 3B also apply to an objective lens usable in a standard Combi-drive. As depicted in Fig. 3A, in a standard Combi-drive most commonly an objective lens is used that has a center area A that is designed to operate in cooperation with a first radiation beam 35 having a wavelength of about 785nm and an optical record carrier 11 (CD) having a transparent substrate 12(cover) thickness of about 1.2mm. Such a lens has at least a first 30a and second 30b surface and may be for example a plastic or glass bi-aspherical lens and can be of a finite or infinite conjugate. The lens is focusing the radiation beam 35 onto an information layer 13 in the disc 11 within a numerical aperture of about 0.50 (corresponding to the center area). This numerical aperture of about 0.50 relates to a functional area on both surfaces of the objective lens and is also determining the effective diameter of the radiation beam to be focused onto the information layer. As is shown in Fig. 3B, such a lens also comprises an outer area C that is designed to operate in cooperation with a second radiation beam 37 having a wavelength of about 655nm and an optical record carrier 34 (such as a DVD disc) having a transparent substrate 32(cover) thickness of about 0.6mm to create a

focus on an information layer of the DVD disc. The numerical aperture of such an outer area runs from the about 0.50 up to about 0.60 for a DVD read device. To avoid reading and/or writing a CD disc with the first radiation beam with light passing through the annular area C, the outer area C is designed to bend away these rays of radiation from the focus position 34 defined by the center area. Most commonly these rays reach the information layer of the CD disc in a more or less circular pattern around the designed focus of the center area of the lens for the first wavelength. The lens may also be designed such that the center area (up to the numerical aperture for CD of about 0.50) can also contribute to the focusing of the second radiation beam when scanning a DVD disc (see Fig. 3B). Lens designers and makers of such objective lenses usually apply optical structures, such as for example diffractive structures or non-periodic phase structures, in both the center area as well as outer area for the DVD/ CD-compatibility.

In Figure 3C a lens according to this second embodiment is shown. At least one of the first 30a and second 30b lens surface comprises an annular area C outside the corresponding numerical aperture of about 0.50 (center area A) that is designed to focus the corresponding annular part of the incident first radiation beam 35' onto the label-layer 14 of a CD disc or the label-layer 34 of a DVD disc. The annular area C may run up to the effective numerical aperture of 0.60 as is applied for reading a DVD disc in combination with the second radiation beam 37. The annular area C may also be optimized for both reading (scanning) the DVD disc in combination with center area A as depicted in Fig. 3B. It is also possible that the annular area C extends to higher values of numerical apertures than about 0.60 in which case the possible additional optimization for scanning a DVD with the second radiation beam is done only up to a numerical of about 0.60.

An objective lens according to this second embodiment can also be used for improving the label-writing performance in DVD-writers (or Dual-Writers or Combo's) having the feature to write labels in a label-layer of a CD or DVD with a 785nm radiation beam. Then it has to be taken into account that the numerical aperture used for recording of a DVD is most commonly approximately 0.65. In DVD-Writer a CD can be read and written using a radiation beam with wavelength of approximately 785nm and DVD can be read and written using a radiation beam with wavelength of approximately 660nm.

With adapted values for wavelength, numerical apertures and cover layer thicknesses the above descriptions for an objective lens according to the second embodiment is also applicable for an objective lens of a BD-writer with DVD-read compatibility.

The design of and focusing by the annular area may, for example, be based on refraction and then having different aspherical coefficients and/or radius compared to the aspherical coefficients and radius of the center area. The design and focusing of the annular area may also be based on an optical structure in or on the objective lens having a for
5 example a diffractive effect, for example a blazed grating profile. The diffraction efficiency of such a diffractive structure is then such that at least a part of the incident beam corresponding to the annular area is designed to focus on the label-layer. Also non-periodic phase structures may be used.

In general, the label-layer on the optical record carrier, such as a according to
10 the formats of CD, DVD or BD, may be protected by a label-substrate with a thickness L (e.g. a cover layer of a transparent material), through which the annular part of the radiation beam has to be focused. The annular area may correct for the spherical aberration introduced in the focused radiation beam when passing through the label-substrate. This thickness L may be smaller than the thickness d1 of the transparent substrate covering the information layer in
15 the first optical record carrier, or smaller than a thickness d2 of the transparent substrate covering the information layer in the second optical record carrier.

A third embodiment according to the invention is an objective lens system according to claim 1 for scanning an information layer of a first optical record carrier in cooperating with a radiation beam having a first wavelength λ_1 and for scanning an
20 information layer of a second optical record carrier in cooperating with a second radiation beam having a second wavelength λ_2 , the first and second optical record carrier having a label-layer, the objective lens system comprising at least a center area and at least one annular area, the center area being designed for generating at least a diffraction limited focus within a first numerical aperture on an information layer of the first optical record carrier
25 through a transparent substrate of a first thickness d1 and within a different second numerical aperture on an information layer in a second optical record carrier through a transparent substrate of a different second thickness d, and the at least one annular area being designed to focus a corresponding part of the second radiation beam onto a label-layer of the first or second optical record carrier.

30 In this embodiment the center area may be designed to generate a diffraction limited focus on both the first record carrier in cooperation with the first radiation beam having λ_1 and on the second record carrier in cooperation with the second radiation beam having λ_2 .

The center area may comprise refractive and/or diffractive structures to obtain this compatibility according known techniques as for example described in US 6,636,365 and US 6,614,600 for the diffractive structures or for non-periodic phase structures e.g. in the article by B.H.W. Hendriks et al., "Application of non-periodic phase structures in optical systems", Appl. Opt. 40 (2001) pp.6548-6560. The center area may thus also comprise annular area.

The at least one annular area is optimized to create a focus in cooperation with the second radiation beam onto the label-layer of a suitable first or second type optical record carrier (for example a CD or a DVD) for writing a label. Preferably this at least one annular area is located outside the center area.

A lens system according to this third embodiment may be a lens to be used in a DVD-Videorecorder in which a CD can be read using a low power laser having a wavelength of approximately 785nm, and a DVD can be read and written using a high power laser having a wavelength of approximately 660nm. As schematically shown in Figs 4A, 4B and 4C the center area A may then be designed to create a diffraction-limited focus 46 of a 785nm radiation beam 45 within a numerical aperture of e.g. 0.45 onto the information layer 13 of a CD 11, and also to create a diffraction-limited focus 48 of a 660nm radiation beam 47 within a numerical aperture of e.g. 0.65 onto an information layer 33 of a DVD 31. With a substantially same focal length for both radiation beams the center area A' for the second radiation beam 47 will be larger than for the first radiation beam 45. Center area A' will thus have a slightly larger diameter than center area A. The objective lens 40 then comprises an annular area C outside the center area A' (so, for example for $NA > 0.65$) that is designed to focus a part of the second radiation beam 47' onto a label-layer 34 or 14 of respectively the DVD 31 or CD 11 that is adapted to have an image written by a focus radiation beam having a wavelength of approximately 660nm.

An objective lens according to this third embodiment can also be used for improving the label-writing performance in DVD-writers (or Dual-Writers or Combo's) having the feature to write labels in a label-layer of a CD or DVD with a 660nm radiation beam. In DVD-Writer a CD can be read and written using a radiation beam with wavelength of approximately 785nm and DVD can be read and written using a radiation beam with wavelength of approximately 660nm. In this case the center area A' extends up to a corresponding numerical aperture of about 0.50 to 0.55.

With adapted values for wavelength, numerical aperture and cover layer thickness the above descriptions related to the third embodiment may also apply to an

objective lens for a BD/DVD-writer with label-writing functionality using a 405nm and/or 660nm wavelength radiation beam in combination with a label-layer on a record carrier (such as BD or DVD) that has an appropriate sensitivity for one or both of the wavelengths.

5 The design and focusing of the annular area may, for example, be based on refraction and then having different aspherical coefficients and or radius compared to the aspherical coefficients and radii of the center area. The design and focusing of the annular area may, as another example, also be based on an optical structure in or on the objective lens having a diffractive effect, for example a blazed grating profile. The diffraction efficiency of such a diffractive structure is then such that at least a part of the incident beam corresponding
10 to the annular area is designed to focus on the label-layer.

In general, the label-layer on the optical record carrier, such as a according to the formats of CD, DVD or BD, may be protected by a label-substrate with a thickness L (e.g. a cover layer of a transparent material), through which the annular part of the radiation beam has to be focused. The annular area may correct for the spherical aberration introduced
15 in the focused radiation beam when passing through the label-substrate. This thickness L may be smaller than the thickness d1 of the transparent substrate covering the information layer in the first optical record carrier, or smaller than a thickness d2 of the transparent substrate covering the information layer in the second optical record carrier.

When considering an objective lens according to the invention for application
20 in a suitable BD recorder with possible compatibility for CD and/or DVD the above given descriptions are also considered to be valid. E.g. an objective lens according to the invention for a suitable "BD only" recorder is comparable with above described the objective lens for the suitable CD-R drive, an objective lens according to the invention for a suitable BD recorder capable reading and/or writing BD and of reading DVD is comparable with the
25 above described objective lens for the suitable Combi-drive, and an objective lens according to the invention for a suitable BD recorder that can also write DVD and/or CD is comparable with the above description of the objective lens for the suitable Dual-Writer or Combi-drive. Of course it is required to adapt the numerical apertures and wavelengths accordingly. It is also obvious that only a single radiation source may be used for writing onto a label-layer of
30 a BD, DVD or CD suited with such a label-layer. This depends amongst others on the wavelength sensitivity of the label-layer on the disc. Using the three different wavelengths in for example a BD/DVD/CD data recorder (such as a TripleWriter) may make it possible to write multi color labels when the label-layer is adapted to have three different wavelength sensitivity ranges with three color-effects after writing (e.g. yellow, cyan and magenta).

A BD objective lens according to the invention to be used in a BD-drive capable of writing an image into a label-layer of an optical record carrier with a 785nm radiation source may have an annular area, extending from about NA 0.50 upwards, that is designed to focus at least part of the 785nm radiation beam onto the label-area of a BD, DVD or other optical record carrier having a suitable label-layer. The annular area may extend up to a numerical aperture of 0.85 (which is the NA used for scanning BD), but may extend even beyond that. The annular area may also be optimized (at least partially) for scanning another type of record carrier, such as for example, a DVD with a 660nm radiation beam and/or a BD with a 405nm radiation beam. The required compatibility may be derived by, for example, applying appropriate refractive and/or diffractive optical structures, or non-periodic phase structures as disclosed in the prior art, such as, for example, US 6,636,365, US 6,614,600 and the article by B.H.W. Hendriks et al., "Application of non-periodic phase structures in optical systems", Appl. Opt. 40 (2001) pp.6548-6560.

It may also be possible that the annular area is (or is also) designed to focus a 660nm radiation beam onto a suitable label-layer. Then the annular area (or part of it) designed for this extends from a corresponding numerical aperture of approximately 0.65 upwards (as for e.g. the Dual Writer) to 0.85 or even larger values. An annular area related to label-writing with a 405nm radiation source onto a suitable label-layer may extend from a corresponding numerical aperture of approximately 0.85 upwards. The description of such a lens is analogue to the description with reference to Fig. 4C and the third embodiment.

As described in relation to the previous example and embodiments, the annular area designed to focus a corresponding part of a radiation beam onto a label-layer of an optical record carrier may also be designed to focus another radiation beam available in the optical scanning device onto an information layer of an optical record carrier. Although previously reference has been made to known compatibility techniques such as refractive, diffractive or non-periodic phase structures, it may also be possible that such an option is derived by segmenting the annular area or part of the annular area as, for example, schematically depicted in Fig. 5 A and B. The lens surface comprising the annular area, for example 40a, has a center area A designed for scanning one or more formats of optical record carriers (as discussed above) and comprises an annular area at least partly designed for the label-writing functionality. The segments D may for example be designed for the label-writing functionality, while the segments E are designed for scanning of an information layer in one or more optical record carriers. It is obvious that other layouts with, for example, more segments or annular segments, etc. are possible.

The focused radiation beam for writing into the label-layer is preferably having a wavefront aberration better than $400\text{m}\lambda W_{\text{rms}}$. More preferred, the wavefront aberration is less than $200\text{m}\lambda W_{\text{rms}}$ and even more preferred less than $50\text{m}\lambda W_{\text{rms}}$.

A fourth embodiment of an objective lens according to the invention may be described as an objective lens system that has at least a first and second lens surface, designed for scanning with a first radiation beam within a first numerical aperture an information layer in a first record carrier through a first substrate having a first thickness d_1 , the first radiation beam having a first wavelength λ_1 , the lens comprises an annular area on at least one of the at least first and second lens surface corresponding to an annular part of said first radiation beam outside said first numerical aperture, where the annular lens area is at least partly optimized for generating a focus onto the label-layer of said first optical record carrier.

A lens according to the description in the previous paragraph may thus be designed for writing a label into a label-layer of a suitable optical record carrier of a for example CD disc in suitable CD-recorder or Combi-drive or Combo-drive with the radiation source having a wavelength of about 785nm, but also a CD-disc in a suitable Combo-drive using the radiation source with the wavelength of about 660nm. Such a description may also match an objective lens description that is designed for writing a label into a label-layer of a suitable optical record carrier of a DVD disc in suitable DVD-recorder. So, the label is written with a radiation beam of the same wavelength as the information layer of the record carrier is scanned or written.

A fifth embodiment of an objective lens according to the invention may be described as an objective lens system according to the forth embodiment that is further designed for scanning with a second radiation beam within a second numerical aperture an information layer of a second record carrier through a second substrate having a second thickness d_2 different from said first substrate thickness d_1 , said radiation beam having a second wavelength λ_2 different from said first wavelength λ_1 , characterized in that the annular area is at least partly optimized for generating a focus in cooperation with said first radiation beam onto the label-layer of said second optical record carrier. An example of partly optimization is an alternating structure that is e.g. 50% optimized for focusing the first radiation beam on a label-layer and 50% optimized for focusing the second radiation beam on the information layer of the second record carrier. It is obvious that also other optimizations are possible.

Using an objective lens according to this fifth embodiment in an optical drive, the label on the second record carrier is written with a radiation beam having a different wavelength than the radiation beam used for scanning an information layer in the second optical record carrier. An objective lens according to this description may be designed for writing a label into a label-layer of a suitable optical record carrier of, for example, a DVD with radiation beam having a wavelength of about 785nm, or a BD with a 660nm or 785nm radiation beam.

A more general way to describe an objective lens according to the invention is that it is an objective lens system for scanning in cooperation with at least one radiation beam an information layer of at least one type of optical record carrier, the at least one type of optical record carrier having a recordable label-layer for writing a label, the objective lens system having at least a first and second lens surface, characterized in that at least one of the at least first and second lens surface comprises an annular area that is adapted to focus at least one radiation beam onto said label-layer. The recordable label-layer may be recordable only once e.g. based on a dye material similar as applied for example in CD-R or DVD+R media, or rewritable e.g. such as a phase change material as applied for example in CDRW or DVD+RW media.

The focused radiation beam for writing into the label-layer is preferably having a wavefront aberration better than $400\text{m}\lambda W_{\text{rms}}$. More preferred, the wavefront aberration is less than $200\text{m}\lambda W_{\text{rms}}$ and even more preferred less than $50\text{m}\lambda W_{\text{rms}}$.

Fig. 6 schematically shows an optical scanning device 600 applying an objective lens 60 according to an embodiment of the invention. For a general basic description of the functioning of optical scanning devices for optical storage applications reference is made to chapter 2 of the book by Bouwhuis et al., "Principles of Optical Disc Systems", (Adam Hilger Ltd), ISBN 0-85274-785-3.

A brief description with reference to Fig. 6 is as follows. In Fig. 6 the optical layout of a Dual Writer is schematically shown. When scanning a CD (read or write), a first radiation source 62 (e.g. a semiconductor laser) emits a radiation beam 63 having for example a first wavelength of about 785nm. The radiation beam is partially reflected by a beamsplitter 64 towards a collimator lens 65 that transforms the emitted divergent radiation beam into a collimator beam towards the objective lens 60. This objective lens may be a single lens or a multiple element lens system. The objective lens has a center area designed to focus the radiation beam within a first numerical aperture of about 0.50 into a diffraction limited scanning spot onto an information layer in the optical record carrier 61. The scanning

spot is reflected by the optical record carrier into the optical system, via the objective lens 60 to the collimator lens 65 and focused onto a photodetector system 66. Using appropriate electronics, the data signal as well as servo-signals may be derived from the photodetector system. Most commonly the focus error servo signal is generated by means of the astigmatic
5 focusing method, and the tracking error servo signal by means of the 3 spots tracking method. Other methods known by the skilled person are also possible (such as spotsize detection and Foucault method for focusing, or push-pull method or differential phase detection method for tracking). The servo signals are used to keep the scanning spot in focus on the track of the information layer being scanned, e.g. by adjusting the position of the
10 objective lens along the optical axis with respect to the position of the information layer in the disc and/or by adjusting the position of the objective lens with respect to the tracking direction of the track of data on the information layer in the disc. For an example of a more detailed description reference is made to the above-mentioned book by Bouwhuis et al. When scanning a DVD the second radiation source 67 is emitting a second radiation beam 68
15 having a wavelength of about 660nm, which is partly reflected by beamsplitter 69 towards the collimator lens 65. The collimator is transforming the divergent emitted radiation beam into a parallel radiation beam towards the objective lens 60. The center area of the objective lens 60 may also be designed, according to known techniques, to focus the radiation beam within a first numerical aperture of about 0.65 into a diffraction limited scanning spot onto an
20 information layer in the optical record carrier 61 (in this case a DVD disc). The scanning spot is reflected by the optical record carrier into the optical system, via the objective lens 60 to the collimator lens 65 and focused onto a photodetector system 66.

The annular area of the objective lens between the corresponding first numerical aperture of about 0.50 and second numerical aperture of about 0.65 is designed not
25 designed to create a focus onto an information layer of the first record carrier in cooperation with the first radiation beam.

For creating (writing) an image in the label-layer of a suitable optical record carrier the first or second radiation source may be used depending on the wavelength sensitivity of the label-layer material. For creating an image in the label-layer the optical
30 record carrier has to be inserted in the drive with the label-layer facing the objective lens (e.g. upside down).

When the system is designed to write labels using the 785nm wavelength laser, the objective lens 60 should according to the second embodiment of the invention have

an annular area between corresponding to $\sim 0.50 < \text{NA} < \sim 0.65$ that is also designed to focus onto the label-layer of a suitable optical record carrier.

When the system is designed to write images into the label-layer using the 660nm wavelength laser, the objective lens 60 should according to the third embodiment of the invention have an annular area corresponding to $\text{NA} > \sim 0.65$ that is also designed to focus onto the label-layer of a suitable optical record carrier.

When the system is designed to write images into the label-layer with both a 785nm and a 660nm radiation source the objective lens according to the invention will have, for example, a center area corresponding to $\text{NA} < \sim 0.50$ that may be designed for scanning both the first and second optical record carrier with respectively the first and second wavelength, an annular area corresponding to $\sim 0.50 < \text{NA} < \sim 0.65$ that is optimized for focusing a corresponding part of the second radiation beam onto an information layer of the second optical record carrier as well as designed for focusing the corresponding part of the first radiation beam onto a label-layer of a suitable optical record carrier, and an annular area corresponding to $\text{NA} > \sim 0.65$ designed for focusing the corresponding part of the second radiation beam onto a label-layer of a suitable optical record carrier.

For other types of disc drives comparable descriptions can be given using the embodiments of the objective lenses according to the invention.

For all described examples of objective lenses according to the invention the center area A of the objective lens system is creating in cooperation with the radiation beam (25, 35, 45) a light spot, i.e. a best focus, on the label-layer that is highly aberrated as this center area A is designed to focus a scanning spot for scanning an information layer of an optical record carrier through a transparent, protection layer (cover layer). This high aberration level consists mainly of third and higher order spherical aberration and causes this best focus to have a large first dimension on the label-layer. Due to the large size the intensity distribution in this best focus, e.g. average intensity per μm^2 , will be too low for high-speed label-writing.

The light spot generated simultaneously on the label-layer by the annular area B or C of the objective lens system in cooperation with the radiation beam (25, 35, 45), has by design preferably a smaller second dimensions than the highly aberrated best focus as generated by the center area. These smaller dimensions result in higher intensity levels per μm^2 and may thus enable high-speed label-writing.

The dimension of a light spot can be expressed in, for example, full width half maximum (FWHM), $1/e^2$ -diameter of the light intensity, etc. Both the first and second

focused light-spot may not be a circular light spot due to e.g. non-rotational-symmetric aberrations. For comparison the dimension of the light spot may then be interpreted as, for example, the surface area dimension based on e.g. the multiplication of two orthogonal FWHM dimensions or of two orthogonal $1/e^2$ -diameters of the light spots in respectively the shortest and the longest dimension. In an optical data drive this is preferably referring to dimensions in the tangential (along the track direction) and radial (perpendicular to tangential) directions.

When scanning a first or second optical record carrier in, for example, a Dual-Writer, the image of the scanning spot 78' is imaged by the optical system onto the photodetector 66' for generating focusing and tracking error signals, as is depicted schematically in Fig. 7. The photodetector configuration shown in Fig. 7 is an example of a quadrant-detector layout corresponding to an astigmatic focusing system. Other photodetector configurations are also possible depending on the choice of the designer of the optical scanning device, e.g. additional photodetectors for tracking corresponding to the three-spots tracking method, a detector configuration corresponding to the spot-size detection focusing method, etc. When scanning a CD with a 785nm radiation beam the light passing the annular area designed to focus a 785nm radiation beam onto the label-layer will generate a certain auxiliary light distribution on the scanned information layer; this may be a circular or ring shaped light distribution. In Fig. 2A this is schematically shown for a CD-Recorder application, but this may also be used as schematic view for a Dual-Writer apparatus in which an objective lens according to the invention is applied suited for label-writing using the 785nm radiation beam. Similar to the design requirements for e.g. CD/DVD compatible objective lenses, the auxiliary light distribution is not used for scanning the information layer, as it may generate errors in the data signal or errors and/or offsets in the servo signals. In the design of the optical structures of the annular area such requirement has to be taken into account. Also the auxiliary light distribution on the scanned information layer will be imaged onto the photodetector as imaged auxiliary light distribution 78''. Both the design of the photodetector 66' layout and dimensions as well as the imaged auxiliary light distribution 78'' on the photodetector has preferably to be such that the imaged auxiliary light distribution is not imaged on the photosensitive areas of the photodetector configuration that is used for data and or servo signal generation. The same preferences are valid for an optical scanning device and apparatus in which a radiation beam of another wavelength is used for label-writing in combination with one of the suitable objective lenses according to the invention.

In an optical data storage apparatus (drive) adapted for label-writing with an optical scanning device comprising an objective lens according to the invention the heat dissipation in the laser controller may be reduced as laser pulses for writing the image on the label-layer may be shortened in time as well as in applied laser power. An advantage of this reduced heat dissipation is that the lifetime of the drive can be increased. As also the label-writing speed can be increased, the image may be recorded in a much shorter time.

Another advantage is that the drive can generate higher resolution label images as the label-writing spot is reduced in size, which enhances the label-layer scanning resolution. It also may improve the tracking and focusing characteristics of the servo signal generation, which may lead to an additional increase in image resolution written in the label-layer.

The objective lens system according to the invention may comprise multiple elements or a single lens element. The annular area may be integrated on one of the lens surfaces of the single lens element. This single lens element may be of plastic, glass or other suitable material. The annular area may also be located at one of the elements of a multi element objective system, for example, on a separate plate between a collimator lens and a single or multiple element objective lens. Preferably the plate comprising the annular area is fixed to the single or multi element objective lens. Such a plate is part of the objective system and it is thus to be understood that when referring to a lens surface comprising the annular area, such a lens surface may also be flat.

It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one of more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS:

1. An objective lens system (20, 30, 40, 60) having a center area (A) adapted for scanning in cooperation with at least one radiation beam (25, 35, 45) an information layer (13, 33) of at least one type of optical record carrier (11, 31), the at least one type of optical record carrier having a recordable label-layer (14, 34) for writing a label, the objective lens system having at least a first (20a, 30a, 40a) and second (20b, 30b, 40b) lens surface, characterized in that at least one of the at least first and second lens surface comprises an annular area (B, C) that is adapted to focus at least one radiation beam into a light spot (26', 36', 48') onto said label-layer.
2. The objective lens system of claim 1, the center area (A) generating in cooperation with at least one radiation beam (25, 35, 45) a best focus (16') onto the label-layer, this best focus (16') having a first dimension, the light spot (26', 36', 48') simultaneously generated in cooperation with this at least one radiation beam onto said label-layer having a second dimension, characterized in that the second dimension is smaller than the first dimension.
3. An objective lens system according to claim 1 or 2, the at least one radiation beam to be focused onto said label-layer having a wavefront aberration, characterized in that the wavefront aberration is less than $400m\lambda W_{rms}$.
4. An objective lens system according to claim 1 or 2, characterized in that said wavefront aberration is less than $50 m\lambda W_{rms}$.
5. An objective lens system according to claim 1 further designed for scanning with a first radiation beam (25, 35) within a first numerical aperture an information layer (13) of a first optical record carrier (11) through a first substrate (12) having a first thickness $d1$, said first radiation beam having a first wavelength $\lambda1$, the annular area (B, C) corresponding to an annular part of said first radiation beam outside said first numerical aperture,

characterized in that the annular area is at least partly optimized for generating a focus (26') onto the label-layer of said first optical record carrier.

6. An objective lens system according to claim 5 further designed for scanning with a second radiation beam (37) within a second numerical aperture an information layer (33) of a second record carrier (31) through a second substrate (32) having a second thickness d_2 different from said first substrate thickness d_1 , said radiation beam having a second wavelength λ_2 different from said first wavelength λ_1 , characterized in that the annular area (C) is at least partly optimized for generating a focus (36') in cooperation with said first radiation beam onto the label-layer of said second optical record carrier.

7. An objective lens system according to claim 1 for scanning an information layer (13) of an optical record carrier in cooperating with a radiation beam (25) having a wavelength λ_1 , the optical record carrier (11) having a label-layer (14), the objective lens system comprising at least a center area (A) and at least one annular area (B), the center area being designed for generating at least a diffraction limited focus (26) within a numerical aperture NA1 on an information layer of the optical record carrier through a transparent substrate (12), and the at least one annular area (B) being designed to focus at least a part of the corresponding radiation beam onto a label-layer (14) of the optical record carrier (11).

8. An objective lens system (30) according to claim 1 for scanning an information layer (13) of a first optical record carrier (11) in cooperating with a radiation beam (35) having a first wavelength λ_1 and for scanning an information layer of a second optical record carrier (31) in cooperating with a second radiation beam (37) having a second wavelength λ_2 , the first and second optical record carrier having a label-layer (14, 34), the objective lens system (30) comprising at least a center area (A) and at least one annular area (C), the center area (A) being designed for generating at least a diffraction limited focus (34) within a first numerical aperture NA1 on the information layer (13) of the first optical record carrier (11) through a transparent substrate (12), and the at least one annular area (C) being designed to focus a corresponding part (35') of the first radiation beam (35) onto a label-layer (14,34) of the first (11) or second (31) optical record carrier.

9. An objective lens system according to claim 1 for scanning an information layer of a first optical record carrier in cooperating with a radiation beam having a first

wavelength λ_1 and for scanning an information layer of a second optical record carrier in cooperating with a second radiation beam having a second wavelength λ_2 , the first and second optical record carrier having a label-layer, the objective lens system comprising at least a center area and at least one annular area, the center area being designed for generating
5 at least a diffraction limited focus within a first numerical aperture on an information layer of the first optical record carrier through a transparent substrate of a first thickness d_1 and within a different second numerical aperture on an information layer in a second optical record carrier through a transparent substrate of a different second thickness d_2 , and the at least one annular area being designed to focus a corresponding part of the second radiation
10 beam onto a label-layer of the first or second optical record carrier.

10. An objective lens system according to any preceding claim in which the annular area or at least one annular area has a segmented structure.

15 11. An optical scanning device comprising an objective lens system according to any one of the preceding claims.

12. An optical recording apparatus comprising an optical scanning device according to claim 11.

20

13. A method for writing a label in a label-layer of an optical record carrier, the method comprising the step of focusing a radiation beam onto a label-layer with an objective lens system having an annular area (B, C) that is adapted to focus said radiation beam onto said label-layer.

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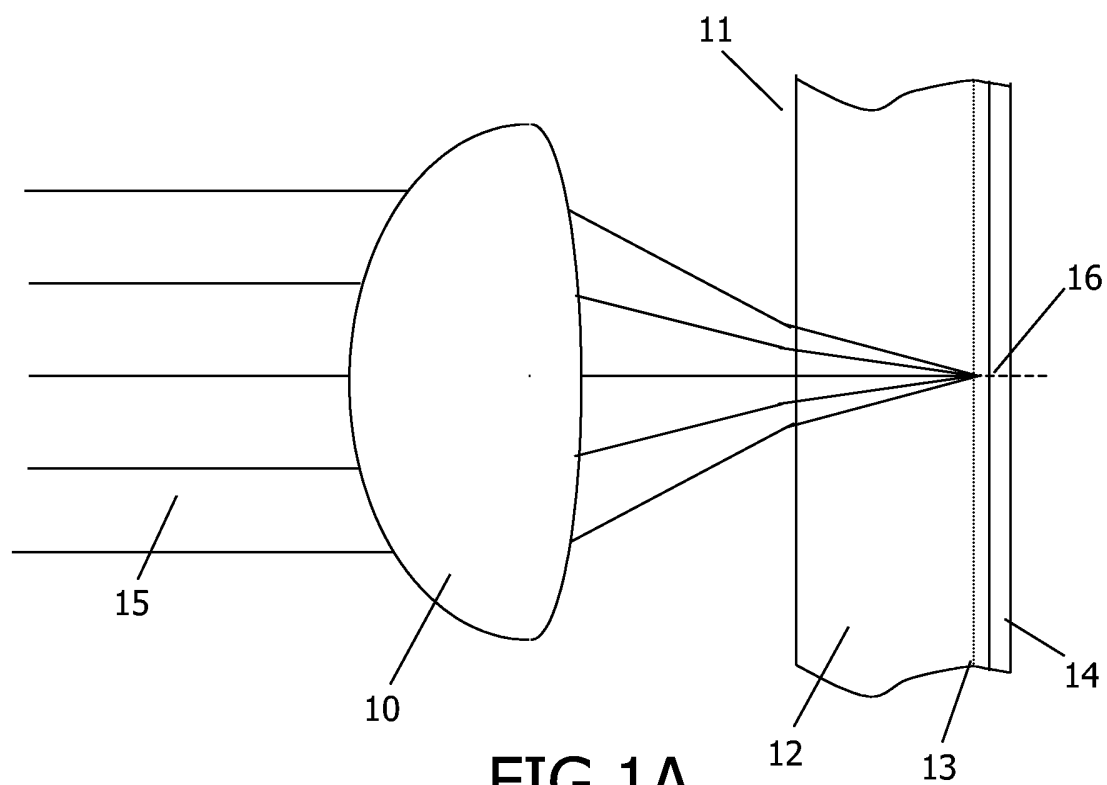


FIG. 1A

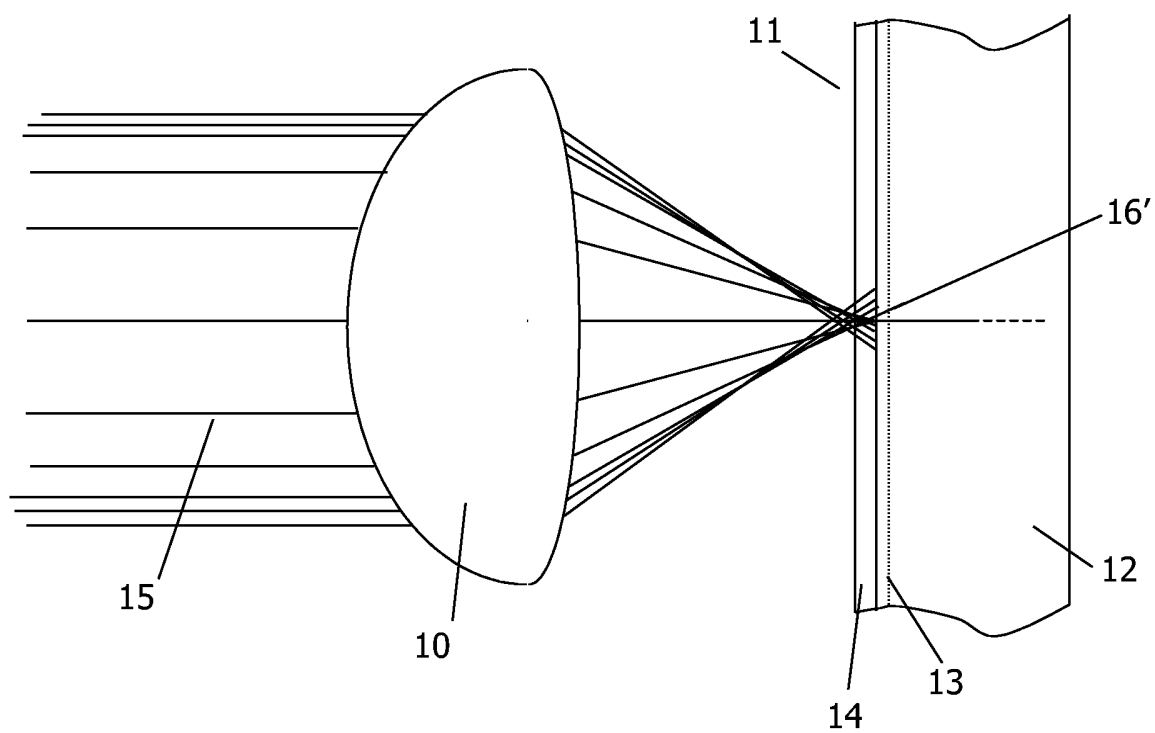
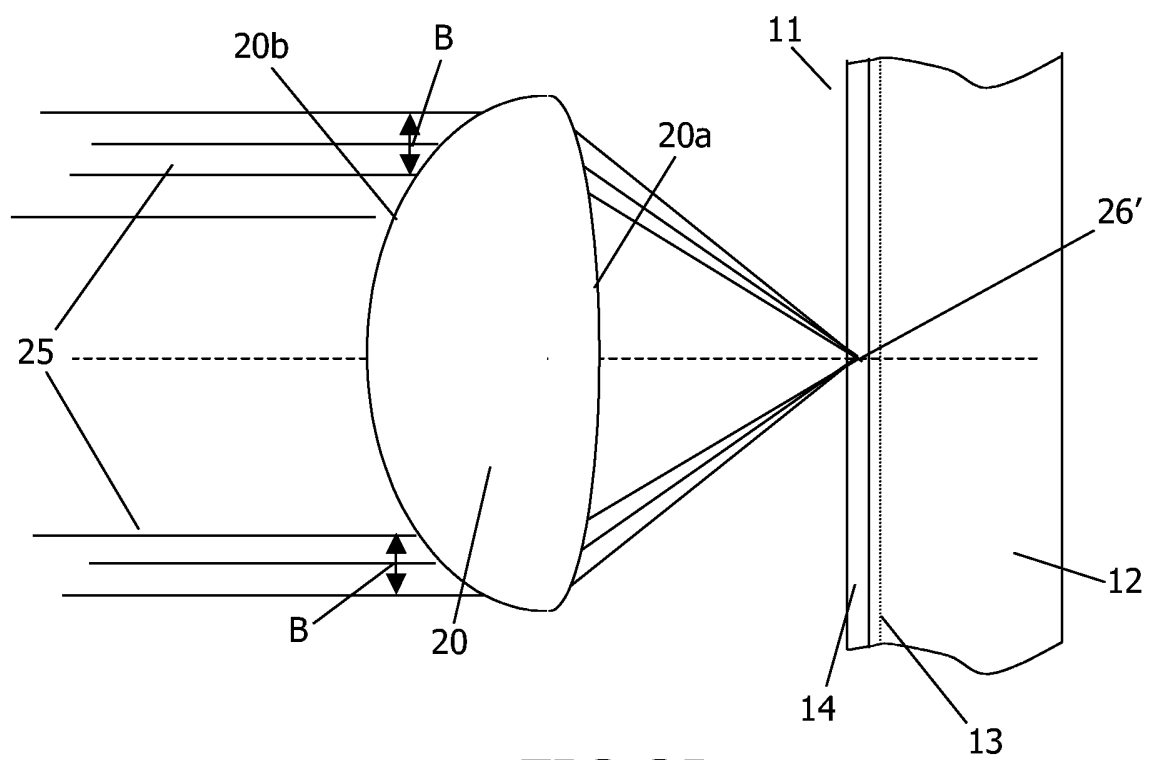
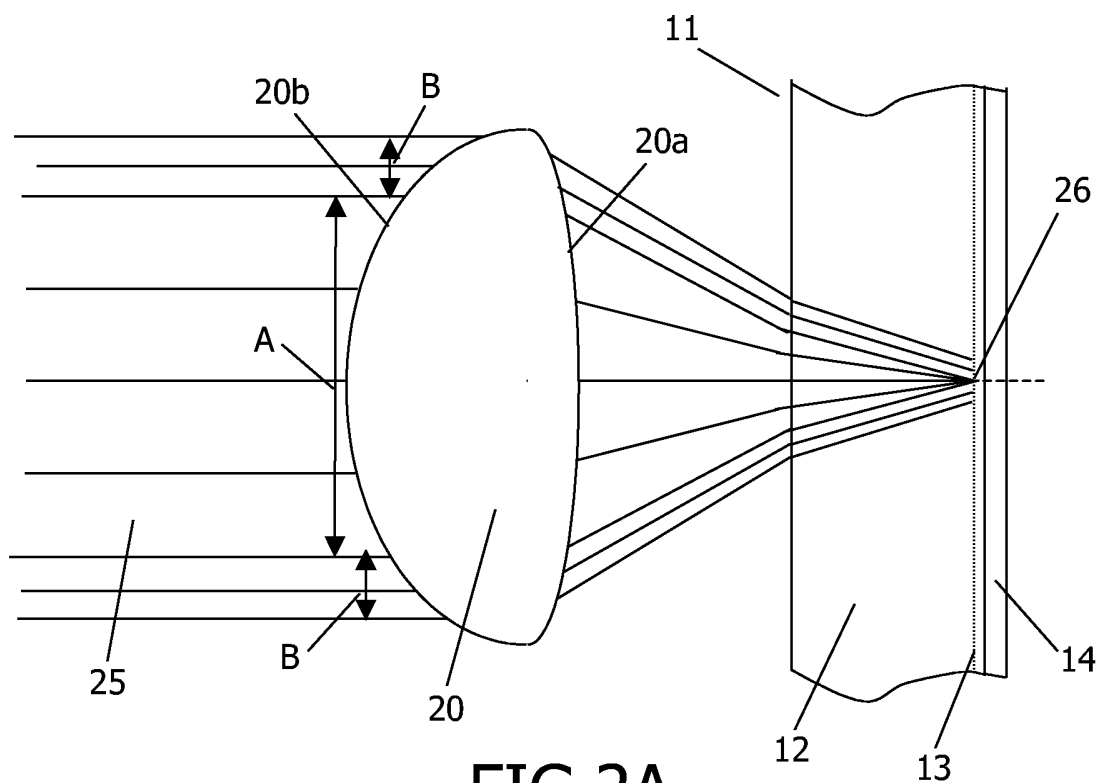


FIG. 1B

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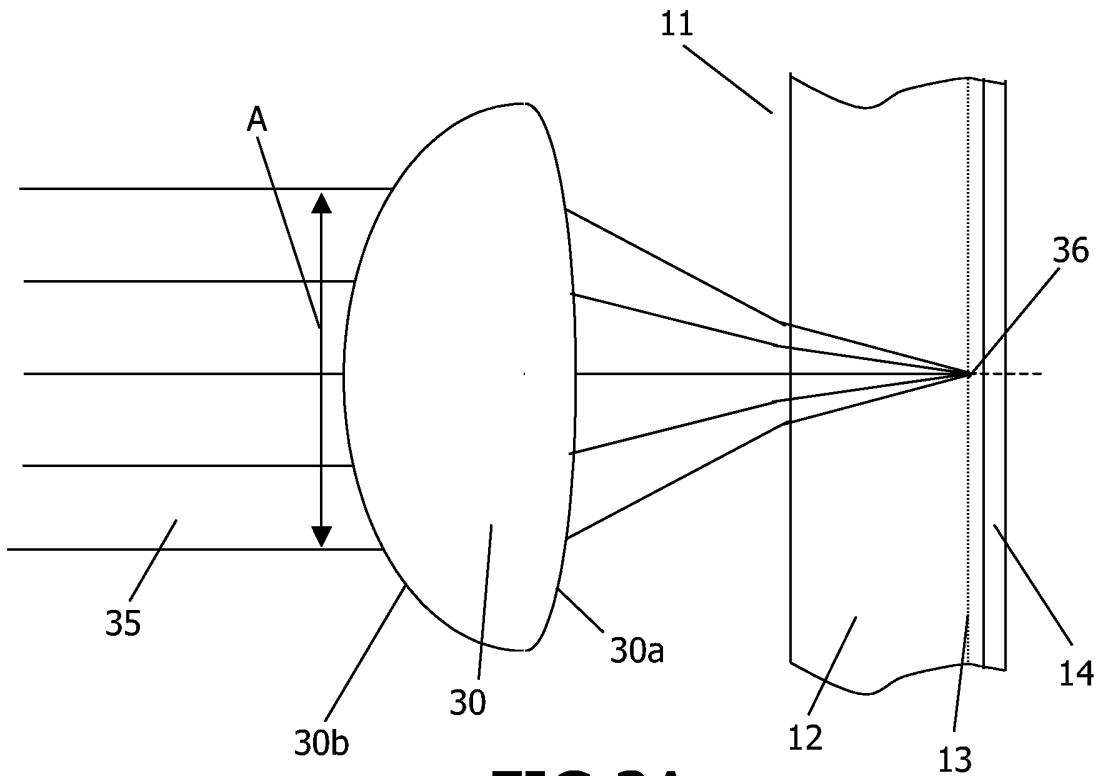


FIG.3A

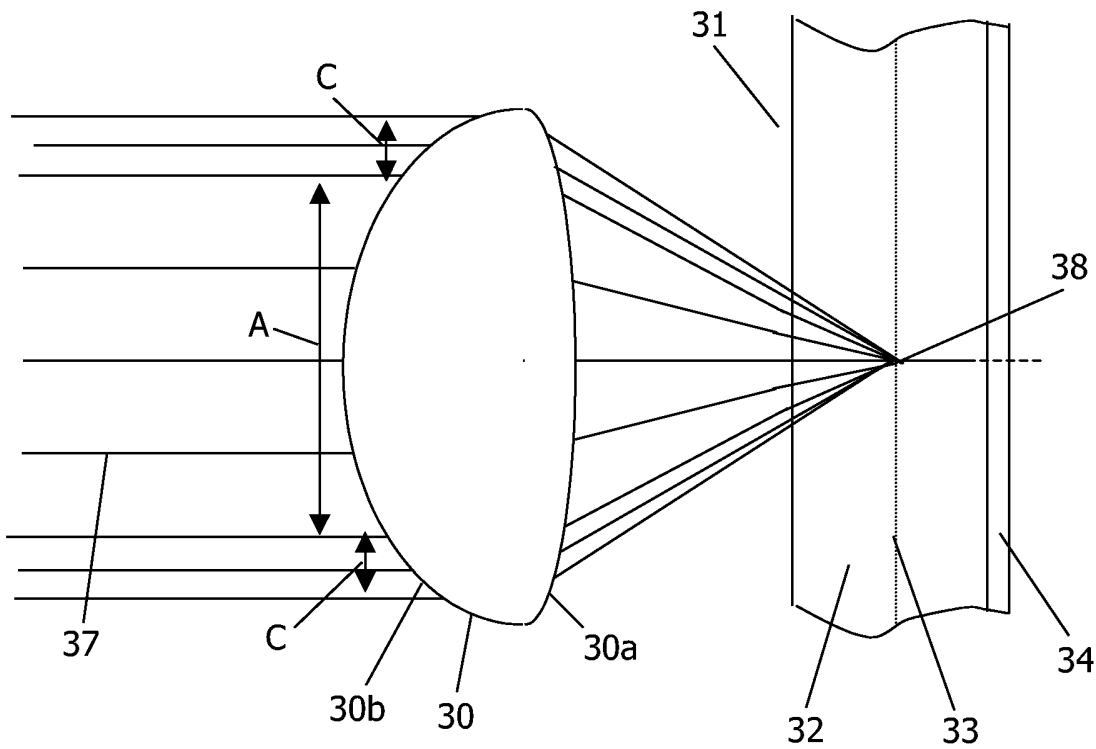


FIG.3B

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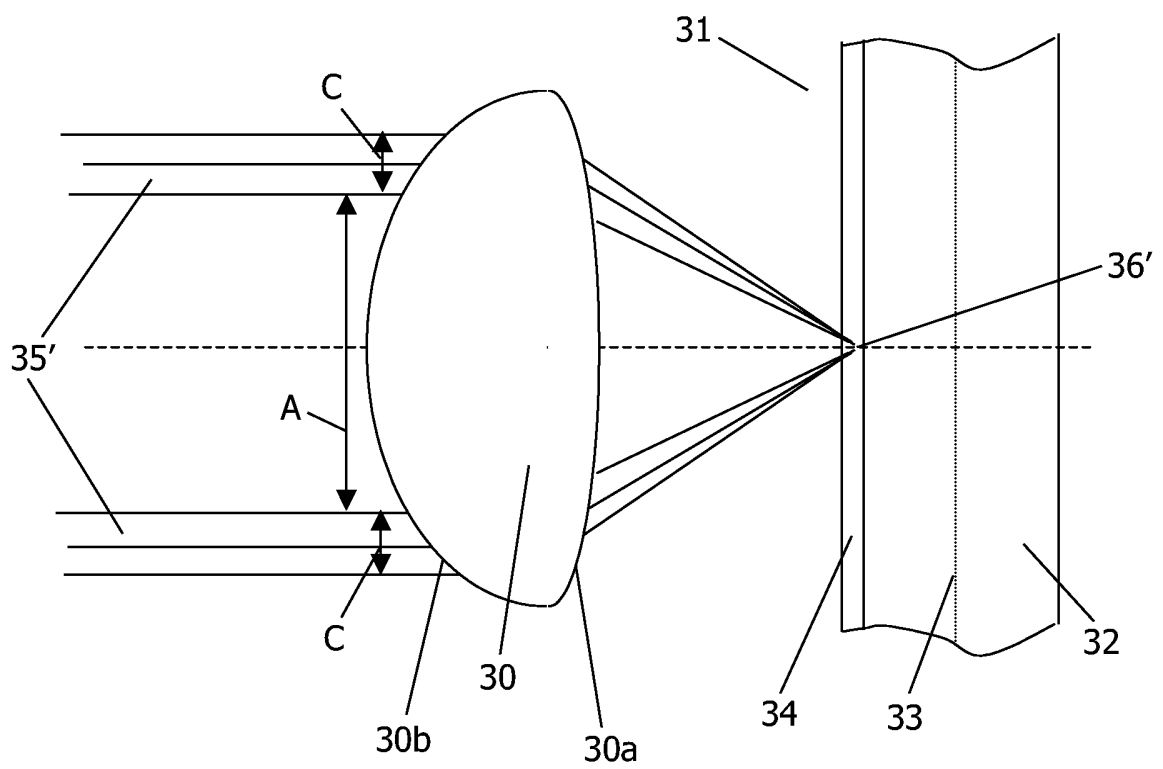


FIG.3C

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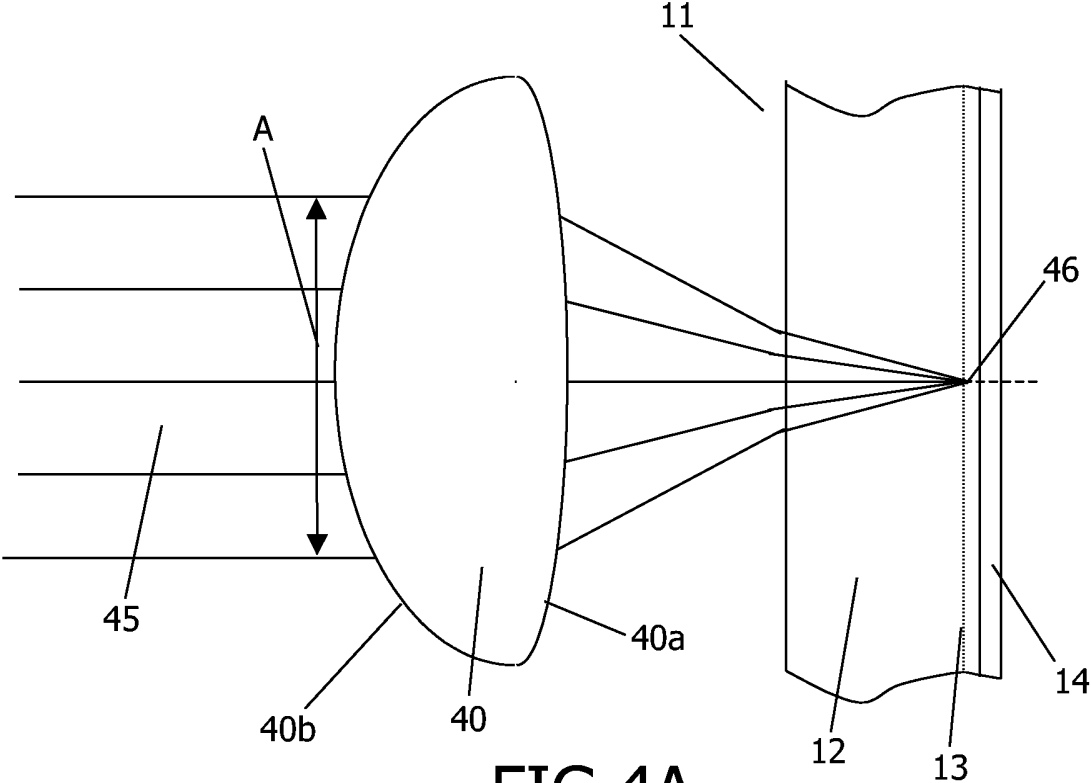


FIG. 4A

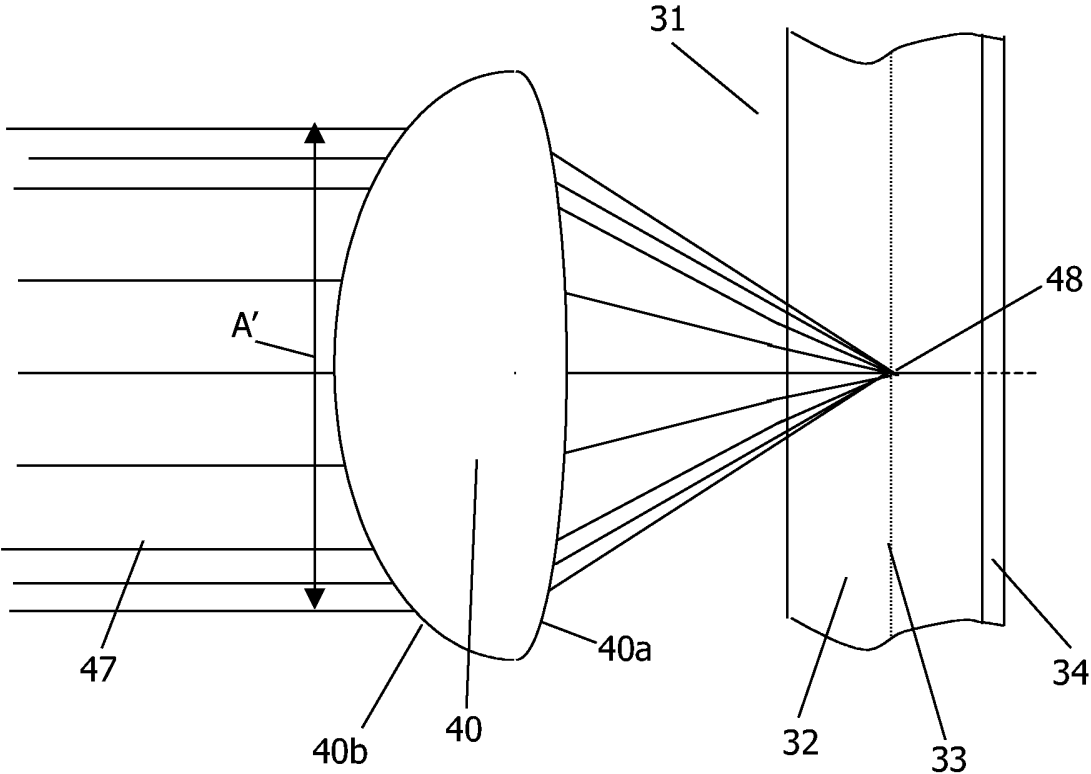


FIG. 4B

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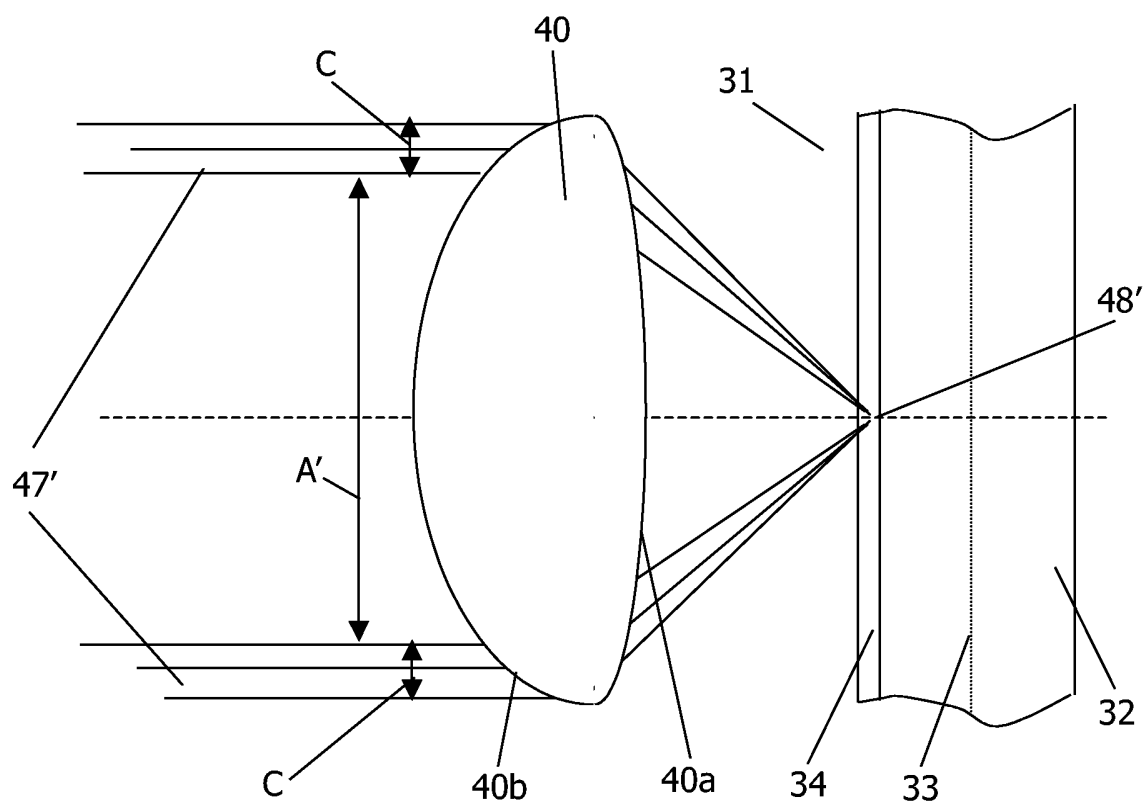


FIG. 4C

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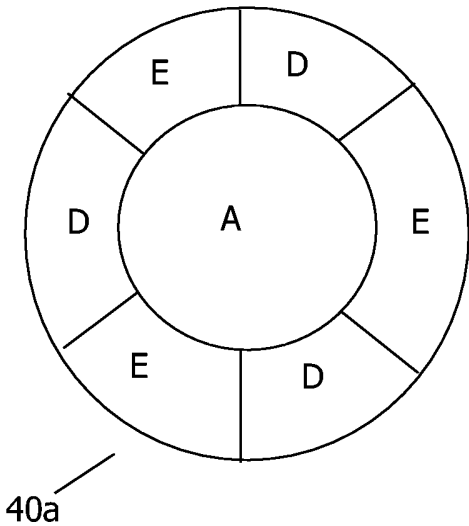


FIG.5A

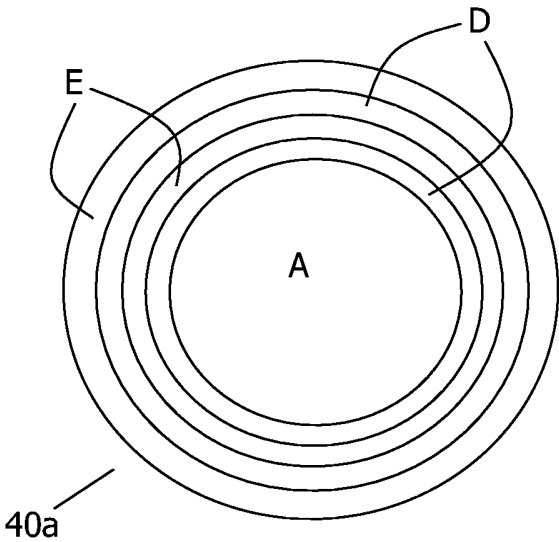


FIG.5B

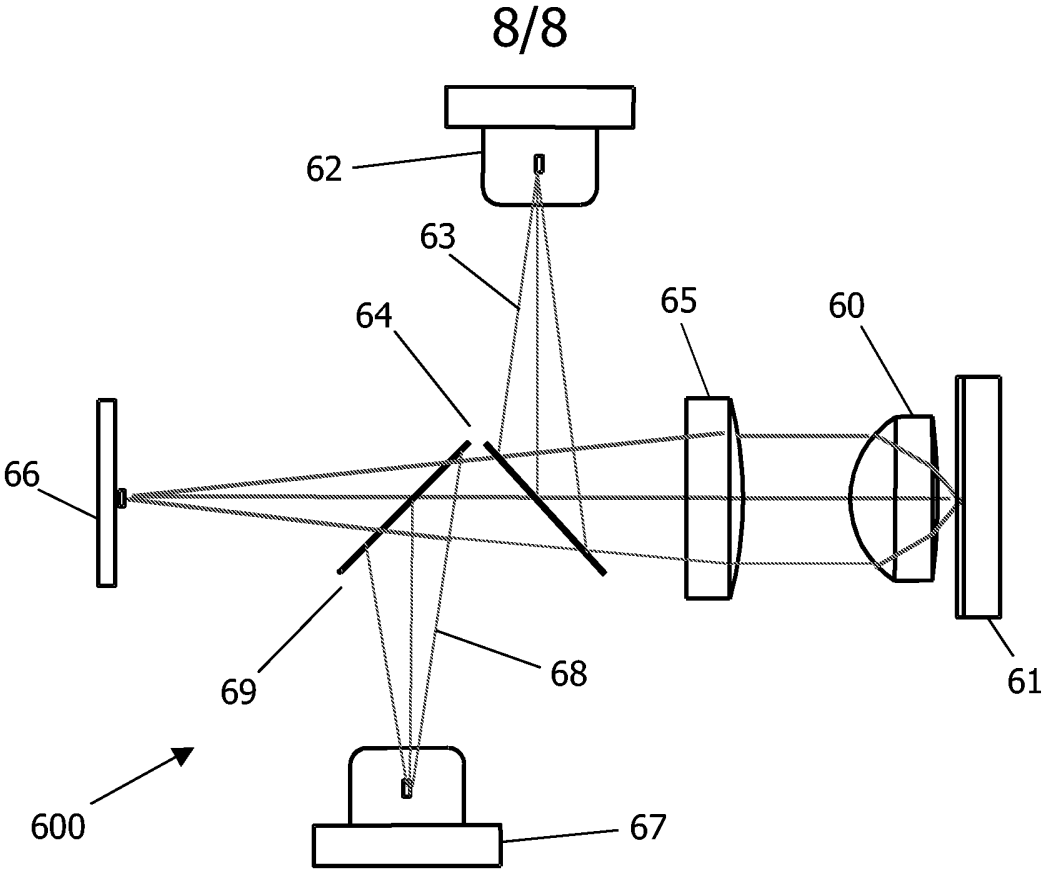


FIG.6

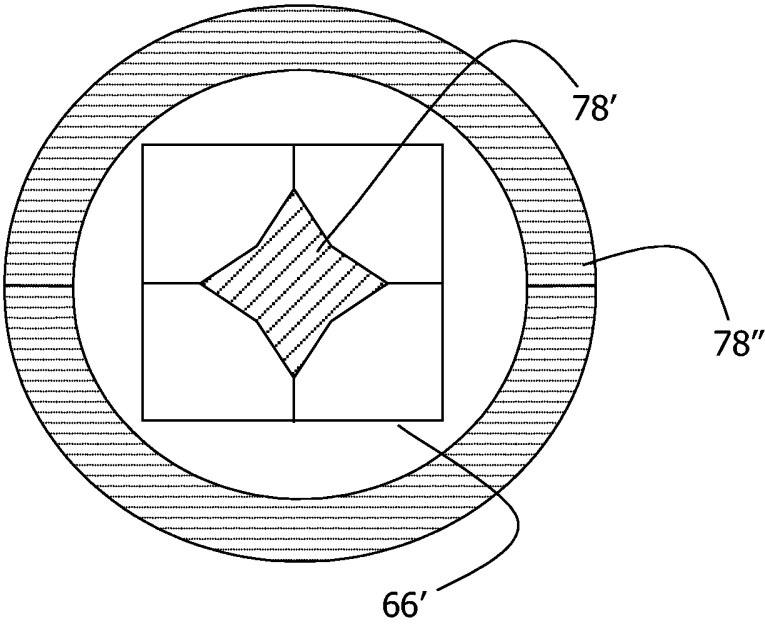


FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/051627

A. CLASSIFICATION OF SUBJECT MATTER

INV. G11B7/135 G02B3/10 G11B23/40 B41J2/47 B41J3/407
G11B7/0037

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G11B G02B B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/136291 A1 (HAYASHI TOYOFUMI) 15 July 2004 (2004-07-15) cited in the application abstract paragraph [0013] figures 2a-2c	3-9,13
X	US 5 930 214 A (KASAHARA ET AL) 27 July 1999 (1999-07-27) abstract	1,2, 10-12
Y	column 48, line 9 - column 51, line 18 column 51, line 51 - column 52, line 23 figures 70,71,74,77	3-9,13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- *Z* document member of the same patent family

Date of the actual completion of the international search

24 August 2006

Date of mailing of the international search report

04/09/2006

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/051627

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004136291 A1	15-07-2004	CN 1479285 A EP 1385154 A2 JP 2004055076 A	03-03-2004 28-01-2004 19-02-2004
US 5930214 A	27-07-1999	NONE	