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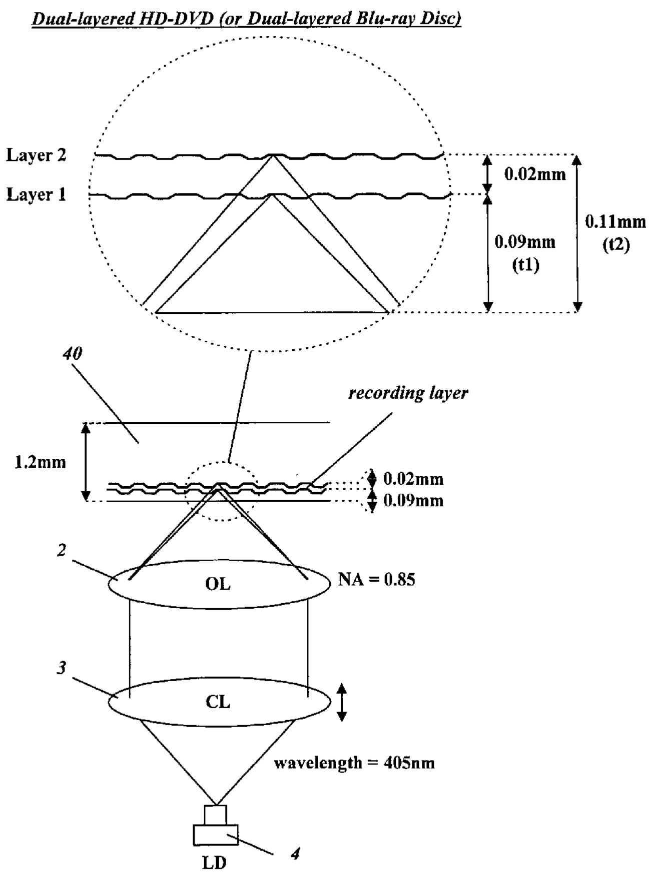

(57) Abstract: A high-density dual-layer optical disc of the present invention is configured so that the first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer is equal to a value obtained by subtracting half the distance between the first and the second recording layers from the substrate thickness from the light incidence surface of a transparent substrate to a recording layer in a general high-density single layer optical disc, and the second substrate thickness from the light incidence surface to the second recording layer is equal to a value obtained by adding half the distance between the two recording layers to the substrate thickness from the light incidence surface to the recording layer in the general high-density single layer optical disc.

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DESCRIPTION

HIGH-DENSITY DUAL-LAYER OPTICAL DISC

1. TECHNICAL FIELD

The present invention relates to a high-density dual-layer optical disc having first and second recording layers, which are both positioned to one side of a central plane bisecting the thickness of the disc, and close to a disc surface.

2. BACKGROUND ART

Fig. 1 shows the structure of a normal DVD(Digital Versatile Disc). As shown in Fig. 1, the DVD, which is denoted by the reference numeral 10, has a diameter of 120 mm and a thickness of 1.2 mm, and is formed with a center hole having a diameter of 15 mm, and a clamping region having a diameter of 44 mm and adapted to be clamped by a turntable and clamper included in an optical disc apparatus.

The DVD 10 has a recording layer, in which data is recorded in a pit pattern. The recording layer of the DVD 10 is positioned at a depth of about 0.6 mm from a disc surface facing an objective lens 1 of an optical pickup device included in the optical disc apparatus. The objective lens 1 of the optical pickup device for the DVD 10 has a numerical aperture NA equal to 0.6.

Fig. 2 shows the structure of a high-density single layer DVD. As shown in Fig. 2, the high-density single layer DVD, which is denoted by the reference numeral 20, has a diameter of 120 mm and a thickness of 1.2 mm, and is formed with a center hole having a diameter of 15 mm, and a clamping region having a diameter of 44 mm and adapted to be clamped by a turntable and clamper included in an optical disc apparatus. The high-density single layer DVD 20 has a data recording layer, which is positioned at a depth of about 0.1 mm from a disc surface facing an objective lens 2 of an optical pickup device included in the optical disc apparatus.

The objective lens 2 of the optical pickup device for the high-density single layer DVD 20 has a numerical aperture NA equal to 0.85, which is a relatively large value in comparison with that of the objective lens 1 for the DVD 10. The objective lens 2 of the optical pickup device adopts a short wave laser beam having a wavelength shorter than that used in the DVD 10 for the reproduction or recording of high-density data.

That is, for the reproduction or recording of high-density data, the DVD 10 uses a laser beam having a wavelength of 650 nm, whereas the high-density single layer DVD 20 uses a laser beam having a wavelength of 405 nm.

By emitting the short wave laser beam and achieving an increase in the numerical aperture of the objective lens, especially in a state of arranging the objective lens 2 of the optical pickup device close to the recording layer of the high-density single layer DVD 20, it is possible to form a small beam spot on a pit of high data density by intensively focusing the laser beam, and to minimize the length of a transparent layer of the short wave laser beam. As a result, the variation of the laser beam's properties and the occurrence of aberration can be minimized.

In recent years many companies have developed high-density dual-layer optical discs, for example, a high-density dual-layer DVD or high-density dual-layer blu-ray disc(hereafter referred to as an "high-density dual-layer BD"), as substitutes for the high-density single layer DVD. The high-density dual-layer optical disc can record and store a large quantity of video and audio data, having about twice the capacity of the high-density single layer DVD, for a long time.

In the case of the high-density dual-layer optical disc as stated above, however, there is no way to effectively restrict a wave front error, which is inevitably generated all over the optical disc due to a spherical aberration produced by a variation in the substrate thickness from the light incidence surface of a transparent substrate to respective first and second recording layers and also due to a coma aberration produced by the tilt of the objective lens included in the optical pickup device. Therefore, a solution to this wave front error is urgently required in the field of the high-density dual-layer optical disc.

3. DISCLOSURE OF INVENTION

It is an object of the present invention to provide a new high-density dual-layer optical disc having a first and a second recording layers, the optical disc being configured to minimize the generation of a wave front error due to the substrate thickness from a light incidence surface of the transparent substrate to the respective first and second recording layers. An Example of the high-density dual-layer optical disc is a high-density dual-layer DVD or high-density dual-layer blu-disc.

It is an object of the present invention to provide a new high-density dual-layer optical disc having first and second recording layers, the optical disc being configured to minimize a wave front error generated all over the optical disc due to a spherical aberration produced by a variation in the substrate thickness from the light incidence surface of a transparent substrate(i.e. a cover layer) to respective first and second recording layers and also due to a coma aberration produced by the tilt of an objective lens included in an optical pickup device.

In accordance with the present invention, the above and other objects can be accomplished by the provision of a high-density dual-layer optical disc having a first and a second recording layers positioned to one side of a central plane bisecting the thickness of the disc, and close to a disc surface, a first substrate thickness from a light incidence surface of a transparent substrate to the first recording layer corresponding to a value obtained by subtracting half a distance between the first and the second recording layers from a substrate thickness from a light incidence surface of a transparent substrate to a recording layer in a high-density single layer optical disc, and a second substrate thickness from the light incidence surface of the transparent substrate to the second recording layer corresponding to a value obtained by adding half the distance between the first and second recording layers to the substrate thickness from the light incidence surface of the transparent substrate to the recording layer in the high-density single layer optical disc.

In accordance with the present invention, the above and other objects can be accomplished by the provision of a high-density dual-layer optical disc having first and second recording layers positioned to one side of a central plane bisecting the thickness of the disc, and close to a light incidence surface, a first substrate thickness from the light incidence surface of the transparent substrate to the first recording layer having a value of more than 70 μm at the minimum, a second substrate thickness from the light incidence surface of the transparent substrate to the second recording layer having a value of less than 108 μm at the maximum, and a distance between the first and second recording layers having a value within a range of 19 μm ±5 μm.

Preferably, the substrate thickness from the light incidence surface of the transparent substrate to the recording layer in the high-density single layer optical disc may be 0.1 mm. The distance between the first and the second recording layers may be 0.02 mm. The first and the second substrate thickness may be 0.09 mm and 0.11 mm, respectively.

Preferably, the first substrate thickness and second substrate thickness may be variably set to an extent that a refractive index n of the transparent substrate is in a range of 1.45 to 1.70. Where the refractive index n of the transparent substrate is equal to 1.60, the first substrate thickness and second substrate thickness may be set at 79.5 μm ±5 μm, and 98.5 μm ±5 μm, respectively.

4. BRIEF DESCRIPTION OF DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows the structure of a normal DVD;

Fig. 2 shows the structure of a general high-density single layer DVD;

Fig. 3 shows the example structure of a high-density dual-layer optical disc to explain the present invention;

Fig. 4 is a graph for comparing a variation in wave front error caused from a spherical aberration with a variation in the substrate thickness from the light incidence surface of a transparent substrate to recording layers in the high-density dual-layer optical disc;

Fig. 5 shows the structure of a high-density dual-layer optical disc in accordance with the present invention;

Figs. 6A to 6C are graphs for comparing a variation in wave front error caused from the tilt of an objective lens with a variation in the substrate thickness from the light incidence surface of a transparent substrate to recording layers in the high-density dual-layer optical disc;

Fig. 7 is a graph showing the range of the substrate thickness from the light incidence surface of a transparent substrate to first and second recording layers applicable to the high-density dual-layer optical disc in accordance with the present invention; and

Fig. 8 shows the structure of a high-density dual-layer optical disc in accordance with an embodiment of the present invention.

5. MODES FOR CARRYING OUT THE INVENTION

Prior to describing a new high-density dual-layer optical disc in accordance with the present invention, a general high-density dual-layer DVD or high-density dual-layer BD will be firstly described.

The general high-density dual-layer DVD, which is denoted by the reference numeral 30, has a diameter of 120 mm and a thickness of 1.2 mm, and is formed with a center hole having a diameter of 15 mm, and a clamping region having a diameter of 44 mm and adapted to be clamped by a turntable and clamper included in an optical disc apparatus. The high-density dual-layer DVD 30 comprises a first recording layer, which is formed on the basis of a recording layer of a general high-density single layer DVD, and a second recording layer spaced apart from the first recording layer by a distance of 0.02 mm. In detail, as shown in Fig. 3, the first recording layer of the high-density dual-layer DVD 30 is positioned at a depth of 0.1 mm from a disc surface facing to an objective lens 2 of an optical pickup device included in the optical disc apparatus, and the second recording layer is positioned at a depth of 0.12 mm from the disc surface.

The objective lens 2 of the optical pickup device for the high-density dual-layer optical disc has a numerical aperture NA equal to 0.85, and adopts a laser beam 4 having a wavelength of 405 nm for the reproduction or recording of high-density data in the first and second recording layers, in the same manner as the high-density single layer DVD 20.

Where the optical pickup device adopting the numerical aperture of 0.85 and the wavelength of 405 nm is used to reproduce or record data in the recording layers, a defocusing margin due to the substrate thickness from the light incidence surface of a transparent substrate to the recording layers is reduced considerably according to the following equation 1.

$$DFM = \frac{\lambda}{(NA)^4 \Delta t} \quad \text{.. Eq. (1)}$$

Where, λ : wavelength, NA : numerical aperture, and Δt: a variation in the substrate thickness from the light incidence surface of a transparent substrate to recording layers.

It should be noted that an increase in the numerical aperture of the objective lens and a decrease in the wavelength result in a significant reduction of the defocusing margin due to a variation in the substrate thickness from the light incidence surface of a transparent substrate to the recording layers, in comparison with that of the general DVD. This significant reduction of the defocusing margin ultimately acts to increase system noise.

Meanwhile, in case that first recording layer is formed in a position of 0.1mm from the substrate and second recording layer is formed in a position of 0.08mm from the substrate, that arrangement has more guarantee DFM(De-Focusing Margin) than the case 0.1mm of the first recording layer and 0.12mm of the second recording layer.

Therefore, it is desirable that the second recording layer has thickness less than the first recording layer in view of the DFM.

That is, the second recording layer is located within the thickness of 0.1mm.

Also, in addition to the DFM, a spherical aberration, comma aberration, and those WFE must be considered when considering the thickness of respective layer.

At first, When it is assumed that the substrate thickness from the light incidence surface of a transparent substrate to a first recording layer is 0.1 mm and the wave front error of a beam spot formed on the recording layer is zero, the wave front error varies with the substrate thickness from the light incidence surface of the transparent substrate to the second recording layer as shown in the graph of Fig. 4. For example, where the substrate thickness from the light incidence surface of the transparent substrate to the second recording layer is 0.08 mm or 0.12 mm, the wave front error has a value of about 0.18 λ rms.

In general, total aberration shall have a value below than 0.07 λ rms in order to not generate an error of large amount in a optical system. In experimental, it is shown that pickup system is no problem if total aberration of pickup has a value below than 0.075 λ rms in an actual system.

Now, hereinafter this invention will be considered as a status which is below 0.075 λ rms.

As shown in Fig. 4, in case that the thickness to second recording layer from substrate is 0.08mm or 0.12mm, this value considerably exceeds a maximum value of 0.075 λ rms acceptable in the actual system.

As stated above, when the substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers are set at 0.1 mm and 0.12 mm, respectively, or set at 0.1mm and 0.08 mm, respectively, the wave front error is about 0.18 λ rms unacceptable in the actual system.

Meanwhile, there are several solutions to compensate for the wave front error as stated above. That is, by finely regulating the position of a collimator lens 3 included in the optical disc apparatus, or by additionally installing a liquid crystal device and the like to the optical disc apparatus, the wave front error is reduced to about 0.045 λ rms when the substrate thickness from the light incidence surface of the transparent substrate to the second recording layer is 0.08 mm or 0.12 mm.

Fig. 5 shows the structure of a high-density dual-layer optical disc in accordance with the present invention. As shown in Fig. 5, the high density dual-layer optical disc, which is denoted by the reference numeral 40, has first and second recording layers. The first substrate thickness 't1' from the light incidence surface of a transparent substrate to the first recording layer corresponds to a value obtained by subtracting half the distance between the first and second recording layers from the substrate thickness from the light incidence surface of a transparent substrate to a recording layer in a general high-density single layer optical disc.

The second substrate thickness 't2' from the light incidence surface of the transparent substrate to the second recording layer corresponds to a value obtained by adding half the distance between the first and second recording layers to the substrate thickness from the light incidence surface of the transparent substrate to the recording layer in the general high-density single layer optical disc.

That is, the high-density dual-layer DVD or high-density dual-layer BD of the present invention has a diameter of 120 mm and a thickness of 1.2 mm, and is formed with a center hole having a diameter of 15 mm, and a clamping region having a diameter of 44 mm and adapted to be clamped by a turntable and clamper included in an optical disc apparatus. The high-density dual-layer DVD 40 of the present invention is provided with the first recording layer positioned at a depth of 0.09 mm from a disc surface facing an objective lens 2 of an optical pickup device included in the optical disc apparatus, and the second recording layer positioned at a depth of 0.11 mm from the disc surface facing the objective lens 2 of the optical pickup device.

Therefore, under the condition as stated above referring to Fig. 4, when the first and second substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers is set at 0.09 mm and 0.11 mm, respectively, the wave front error is only about 0.08 λ rms, close to a maximum value of 0.075 λ rms acceptable in the actual system. Furthermore, by virtue of finely regulating the position of a collimator lens 3 and the installation of the additional compensation liquid crystal device, the wave front error is reduced to about 0.025 λ rms. In this way, the generation of the wave front error due to the substrate thickness from the light incidence surface of the transparent substrate to the recording layers can be effectively restricted.

Figs. 6A to 6C are graphs for comparing a variation in wave front error caused from the tilt of the objective lens with a variation in the substrate thickness from the light incidence surface of the transparent substrate to recording layers in the high-density dual-layer optical disc. Referring to Figs. 6A to 6C, a spherical aberration produced by a variation in the substrate thickness from the light incidence surface of a transparent substrate(i.e. a cover layer) to recording layers, in a no-tilt state of an objective lens included in an optical pickup device, defines a line ① respectively shown in Figs. 6A to 6C.

A coma aberration, produced in a state that the objective lens of the optical pickup device has a tilt angle of less than 0.6°, defines a line ② respectively shown in Figs. 6A to 6C. A wave front error generated all over the optical disc caused from the spherical aberration and coma aberration defines a line ③ respectively shown in Figs. 6A to 6C.

In Figs. 6A to 6C, the line ① is drawn by applying the graph shown in Fig. 4, and ② is obtained from the following equation 2.

$$② = t(n^2-1 / 2n^2)NA^3\alpha \quad \text{.............................. Eq. (2)}$$

where 't' is Thickness, 'n' is Refractive ration, NA is Numerical Aperture of objective lens, 'α' is amount of Tilt.

In general, a general optical system considers a maximum amount of tilt as 0.6, therefore the comma aberration is applied to the equation based on the value.

That is, the value of the wave front error is calculated according to the following equation 3.

$$③=\sqrt{①^2+②^2} \quad \text{.................................... Eq. (3)}$$

Where, ① : spherical aberration produced by a variation in the substrate thickness from the light incidence surface of a transparent substrate to recording layers under a no-tilt state of an objective lens, ② : coma aberration produced under a tilt angle of less than 0.6°at the maximum, and ③ : wave front error generated all over the optical disc due to the spherical aberration and coma aberration.

Therefore, as shown in Fig. 6A, the substrate thickness from the light incidence surface of the transparent substrate to respective first and second recording layers has to be set within a range of about 70 μm to 108 μm, in order to satisfy a maximum wave front error value of 0.075 λ rms acceptable in an actual system.

This result is a value obtained from a consideration of Refractive Index, which means a refractivity of optical disc.

In particular, this result is based on the refractive index of 1.60.

Further, as shown in Fig. 6B, the substrate thickness from the light incidence surface of the transparent substrate to respective first and second recording layers has to be set within a range of about 68.5 μm to 106.5 μm, in order to satisfy a maximum wave front error value of 0.075 λ rms acceptable in an actual system.

Therefore, as shown in Fig. 6C, the substrate thickness from the light incidence surface of the transparent substrate to respective first and second recording layers has to be set within a range of about 71.4 μm to 11.5 μm, in order to satisfy a maximum wave front error value of 0.075 λ rms acceptable in an actual system.

This will be described in detail below.

Fig. 7 is a graph showing the range of the substrate thickness from the light incidence surface of a transparent substrate to first and second recording layers applicable to a high-density dual-layer optical disc in accordance with the present invention. As shown in Figs. 6A to 6C, the substrate thickness from the light incidence surface of the transparent substrate to the recording layers is variably set in accordance with a refractive index of the transparent substrate.

For example, where the refractive index n of the transparent substrate is equal to 1.60, the substrate thickness from the light incidence surface of the transparent substrate to the recording layers has to be in a range of about 70 μm to 108 μm for satisfying the maximum wave front error value of 0.075 λ rms.

In case that the same condition is considered to other refractive index, where the refractive index n of the transparent substrate is equal to 1.45, as shown in Fig. 5B, the substrate thickness from the light incidence surface of the transparent substrate to the recording layers has to be in a range of about 68.5 μm to 106.5 μm for satisfying the maximum wave front error value of 0.075 λ rms.

In addition, where the refractive index n of the transparent substrate is equal to 1.70, as shown in Fig. 5C, the substrate thickness from the light incidence surface of the transparent substrate to the recording layers has to be in a range of about 110.5 μm to 71.4 μm for satisfying the maximum wave front error value of 0.075 λ rms.

In conclusion, the substrate thickness from the light incidence surface of the transparent substrate to the first recording layer is in a range of about 108 μm + 2.5 (or -1.5) μm at the maximum, and the substrate thickness from the light incidence surface of the transparent substrate to the second recording layer is in a range of about 70 μm + 1.4(or -1.5) μm at the minimum.

Therefore, referring to Fig. 8 showing the structure of the high-density dual-layer optical disc in accordance with an embodiment of the present invention, the substrate thickness from the light incidence surface of the transparent substrate to the first recording layer is set at a value of 70 μm at the minimum, the substrate thickness from the light incidence surface of the transparent substrate to the second recording layer is set at a value of 108 μm at the maximum, and also a distance between the first and second recording layers is set in a range of 19 μm ±5 μm.

Now, this will be described in more detail below.

The first and second recording layer can be divided into an average of those values, that is, 89μm (= 70+108/2) as a boundary, for example, when the first recording layer has the minimum value of 70μm, the second recording layer must have 89μm that is a boundary of value, and when the second recording layer has 108μm, the first recording layer must have 89μm that is a boundary of value.

Therefore, the distance between the first recording layer and second recording layer can be set to 19μm. And, if it is considered by manufacturing error margin, it can be set to the value of 19μm±5μm, which is acceptable in current system.

Though the thickness can be considered to a value broader than above value, it desirable that its error margin is ±5μm when the technology for manufacturing the recording substrate is to be considered. Therefore, a average value between respective layers is most stable if a distance between respective layers is searched for a representative as 19μm. That is, the average value is 79.5μm and 98.5μm respectively if we calculate the average of respective ranges of layers. According to this result, the substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers are set at 79.5 μm ±5 μm and 98.5 μm ±5 μm, respectively.

Therefore, as shown in Fig. 8, where the refractive index n of the transparent substrate is equal to 1.60, the substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers are set at 79.5 μm and 98.5 μm, respectively, and the distance between the first and second recording layers is set in a range of 19 μm ±5 μm. In this case, according to the permitted distance limit of ±5 μm, the substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers are set at 79.5 μm ±5 μm and 98.5 μm ±5 μm, respectively.

According to the configuration of the high-density dual-layer optical disc, it is possible to effectively restrict the wave front error generated all over the optical disc due to the spherical aberration produced by a variation in the substrate thickness from the light incidence surface of the transparent substrate to the respective first and second recording layers and also due to the coma aberration produced by the tilt of the objective lens.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

As apparent from the above description, the present invention provides a high-density dual-layer optical disc for minimizing a wave front error generated all over the optical disc due to a spherical aberration produced by a variation in the substrate thickness from a light incidence surface of a transparent substrate to respective first and second recording layers and also due to a coma aberration produced by the tilt of an objective lens, and for enabling the more accurate recording or reproduction of signals onto or from the optical disc.

CLAIMS

1. A high-density dual-layer optical disc, comprising a first recording layer and a second recording layer, the layers being positioned to one side of a central plane bisecting the thickness of the disc, and close to a light incidence surface, wherein:

a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer has a value of more than 70 ㎛ at the minimum; and

a second substrate thickness from the light incidence surface of the transparent substrate to the second recording layer has a value of less than 108 ㎛ at the maximum, respectively in state that the refractive index of the ransparent substrate is *n*.

2. The high-density dual-layer optical disc as set forth in claim 1, wherein the first substrate thickness and second substrate thickness are set to an extent that a refractive index n of the transparent substrate is 1.60.

3. The high-density dual-layer optical disc as set forth in claim 1, a distance between the first and second recording layers is in a range of 19 ㎛ ±5 ㎛.

4. The high-density dual-layer optical disc as set forth in claim 1, wherein the first substrate thickness and second substrate thickness are variably set to an extent that a refractive index n of the transparent substrate is in a range of 1.45 to 1.70.

5. The high-density dual-layer optical disc as set forth in claim 4, wherein the first substrate thickness and second substrate thickness are set at 79.5 ㎛ ±5 ㎛, and 98.5 ㎛ ±5 ㎛,

respectively, where the refractive index n of the transparent substrate is equal to 1.60.

6. An apparatus for recording or reproducing to or from an optical recording medium, comprising:

optical pickup recording or reproducing a data to or from the optical recording medium, said recording medium includes two recording layers which have first recording layer having a thickness value more than 70 ㎛ at the minimum and second recording layer having a thickness value less than 108 ㎛ at the maximum, respectively from the light incidence surface of a transparent substrate, respectively in state that the refractive index of the transparent substrate is *n*; and

controller controlling the pickup to record or reproduce data to or from the first or second recording layer of the optical recording medium.

7. An apparatus of claim 6, wherein a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer has a value of more than 70 ㎛ at the minimum and a second substrate thickness from the light incidence surface of a transparent substrate to the second recording layer has a value of less than 108 ㎛ at the maximum.

8. An apparatus of claim 6, wherein the first substrate thickness and second substrate thickness are set to an extent that a refractive index n of the transparent substrate is 1.60.

9. A high-density dual-layer optical disc, comprising a first recording layer and a second recording layer, the layers being positioned to one side of a central plane bisecting the thickness of the disc, and close to a light incidence surface, wherein:

a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer has a value of more than 68.5 ㎛ at the minimum; and

a second substrate thickness from the light incidence surface of the transparent substrate to the second recording layer has a value of less than 110.5 ㎛ at the maximum,

wherein the range of 68.5 ㎛ to 110.5 ㎛ is based on a Refractive index ratio 1.45 to 1.70.

10. The high-density dual-layer optical disc as set forth in claim 9, wherein a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer having a value of more than 68.5 ㎛ at the minimum is set to an extent that a refractive index n of the transparent substrate is 1.45.

11. The high-density dual-layer optical disc as set forth in claim 9, wherein a second substrate thickness from the light incidence surface of a transparent substrate to the second recording layer having a value of more than 110.5 ㎛ at the maximum is set to an extent that a refractive index n of the transparent substrate is 1.70.

12. The high-density dual-layer optical disc as set forth in claim 9, a distance between the first and second recording layers is in a range of 19 ㎛ ±5 ㎛.

13. The high-density dual-layer optical disc as set forth in claim 12, wherein the first substrate thickness and second substrate thickness are set at 79.5 ㎛ ±5 ㎛, and 98.5 ㎛ ±5 ㎛, respectively, where the refractive index ratio of the transparent substrate is equal to 1.60.

14. An apparatus for recording or reproducing to or from an optical recording medium, comprising:

optical pickup recording or reproducing a data to or from the optical recording medium, said recording medium includes two recording layers which have first recording layer having a value of more than 68.5 μm at the minimum and second recording layer having a value of less than 110.5 μm at the maximum, respectively from the light incidence surface of a transparent substrate, respectively in state that the refractive index of the transparent substrate is *n*; and

controller controlling the pickup to record or reproduce data to or from the first or second recording layer of the optical recording medium.

15. An apparatus of claim 14, wherein the refractive index ratio is 1.45 to 1.70.

16. An apparatus of claim 14, wherein a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer has a value of more than 70 μm at the minimum and a second substrate thickness from the light incidence surface of a transparent substrate to the second recording layer has a value of less than 108 μm at the maximum, respectively in state of the refractive index 1.60 of the transparent substrate.

17. A high-density dual-layer optical disc, comprising a first recording layer and a second recording layer, the layers being positioned to one side of a central plane bisecting the thickness of the disc, and close to a light incidence surface, wherein

said first and second recording layers are located within a range 68.5 μm to 110.5 μm from the light incidence surface of a transparent substrate, in state that a refractive index *n* of the transparent substrate is 1.45 to 1.70.

18. The high-density dual-layer optical disc as set forth in claim 17, wherein a first and second substrate thickness from the light incidence surface of a transparent substrate to the first and second recording layers having a range 68.5 μm to 106.5

are set to an extent that the refractive index n is 1.45.

19. The high-density dual-layer optical disc as set forth in claim 18, wherein a first and second substrate thickness from the light incidence surface of a transparent substrate to the first and second recording layers having a range 70.0 µm to 108.0 are set to an extent that the refractive index n is 1.60.

20. The high-density dual-layer optical disc as set forth in claim 18, wherein a first and second substrate thickness from the light incidence surface of a transparent substrate to the first and second recording layers having a range 71.4 µm to 110.5 are set to an extent that the refractive index n is 1.70.

21. A high-density dual-layer optical disc, comprising a first recording layer and a second recording layer, the layers being positioned to one side of a central plane bisecting the thickness of the disc, and close to a light incidence surface, wherein:

said first and second recording layers are located within a range 70.0 µm to 108.0 µm from the light incidence surface of a transparent substrate, in state that a refractive index *n* of the transparent substrate is 1.60.

22. The high-density dual-layer optical disc as set forth in claim 12, wherein the first substrate thickness and second substrate thickness are set at 79.5 µm ±5 µm, and 98.5 µm ±5 µm.

23. An apparatus for recording or reproducing to or from an optical recording medium, comprising:

optical pickup recording or reproducing a data to or from the optical recording medium, said recording medium includes two recording layers which have first recording layer and second recording layer, said first recording layer and second recording layer are located within range 68.5 µm to 110.5 µm from the light incidence surface of a transparent substrate, in state that a refractive index *n* of the transparent substrate is in range of 1.45 to 1.70; and

controller controlling the pickup to record or reproduce data to or from the first or second recording layer of the optical recording medium.

24. An apparatus of claim 23, wherein a first substrate thickness from the light incidence surface of a transparent substrate to the first recording layer has a value of more than 70 μm at the minimum and a second substrate thickness from the light incidence surface of a transparent substrate to the second recording layer has a value of less than 108 μm at the maximum, respectively in state that the refractive index *n* is 1.60.

25. A high-density dual-layer optical disc, comprising a first recording layer and a second recording layer, the layers being positioned to one side of a central plane bisecting the thickness of the disc, and close to a disc surface, wherein:

a first substrate thickness from a light incidence surface of a transparent substrate to the first recording layer corresponds to a value obtained by subtracting half a distance between the first and second recording layers from a substrate thickness from a light incidence surface of a transparent substrate to a recording layer in a high-density single layer optical disc; and

a second substrate thickness from the light incidence surface of the transparent substrate to the second recording layer corresponds to a value obtained by adding half the distance between the first and second recording layers to the substrate thickness from the light incidence surface of the transparent substrate to the recording layer in the high-density single layer optical disc.

26. The high-density dual-layer optical disc as set forth in claim 25, wherein the substrate thickness from the light

incidence surface of the transparent substrate to the recording layer in the high-density single layer optical disc is 0.1 mm.

27. The high-density dual-layer optical disc as set forth in claim 25, wherein the distance between the first and second recording layers is 0.02 mm.

28. The high-density dual-layer optical disc as set forth in claim 25, wherein the first and second substrate thickness are 0.09 mm and 0.11 mm, respectively.

FIG. 1

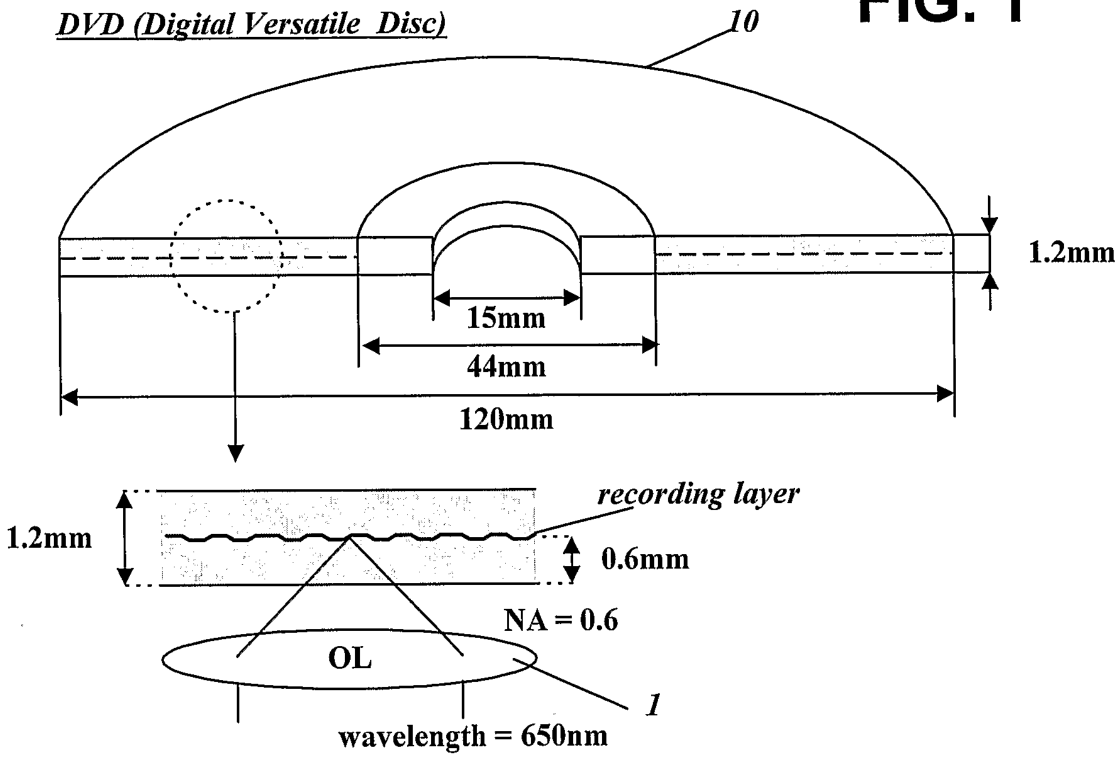
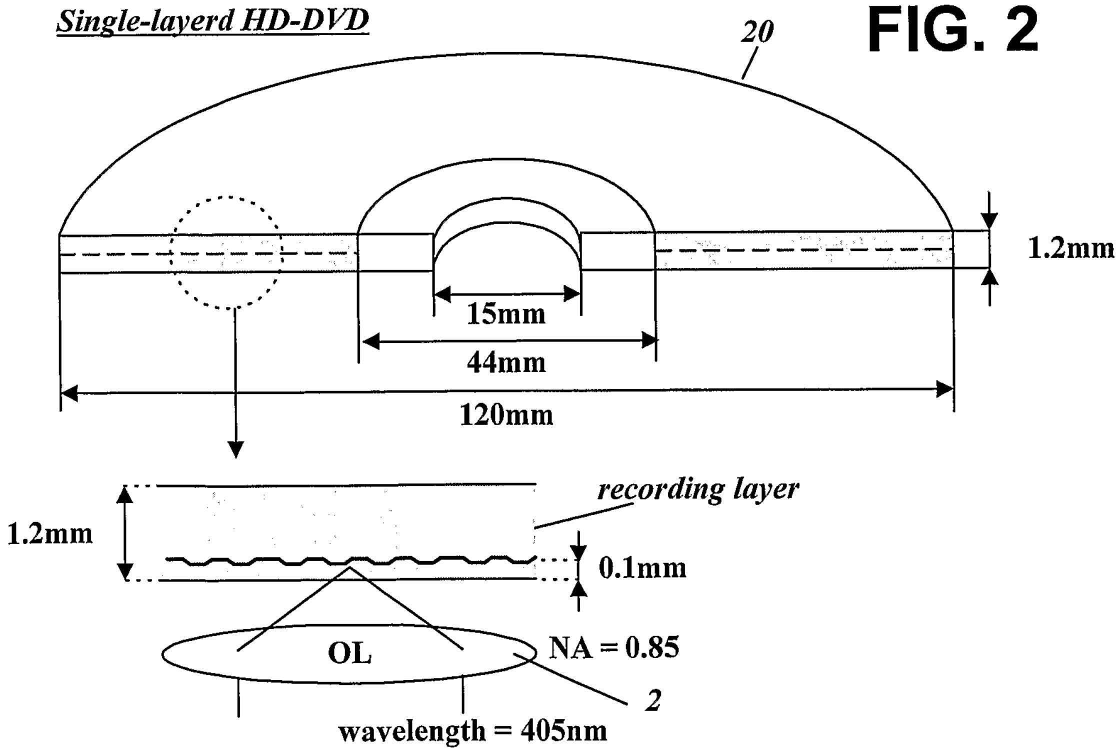

DVD (Digital Versatile Disc)
10
1.2mm
15mm
44mm
120mm
recording layer
1.2mm
0.6mm
NA = 0.6
OL
1
wavelength = 650nm

FIG. 2


Single-layerd HD-DVD
20
1.2mm
15mm
44mm
120mm
recording layer
1.2mm
0.1mm
NA = 0.85
OL
2
wavelength = 405nm

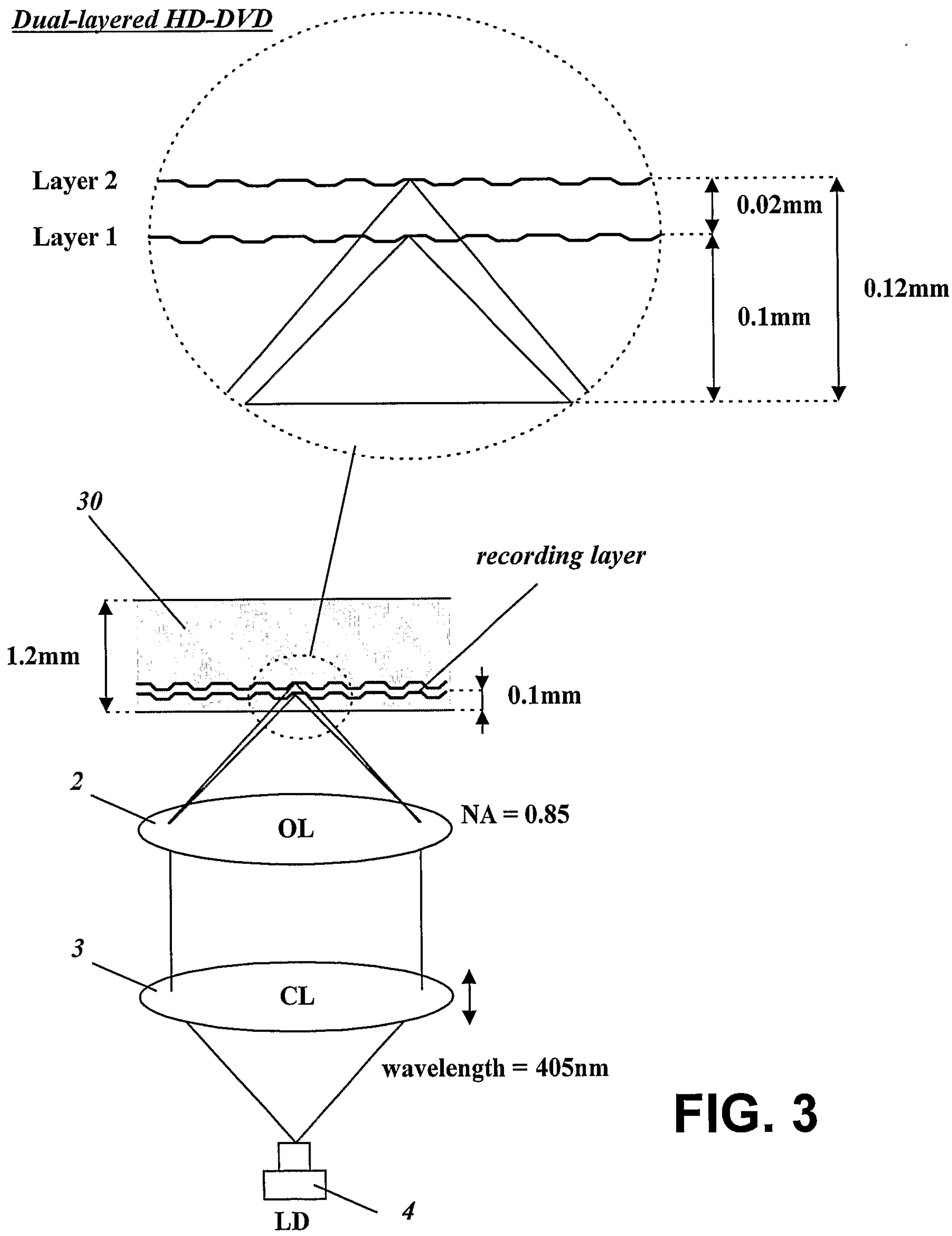
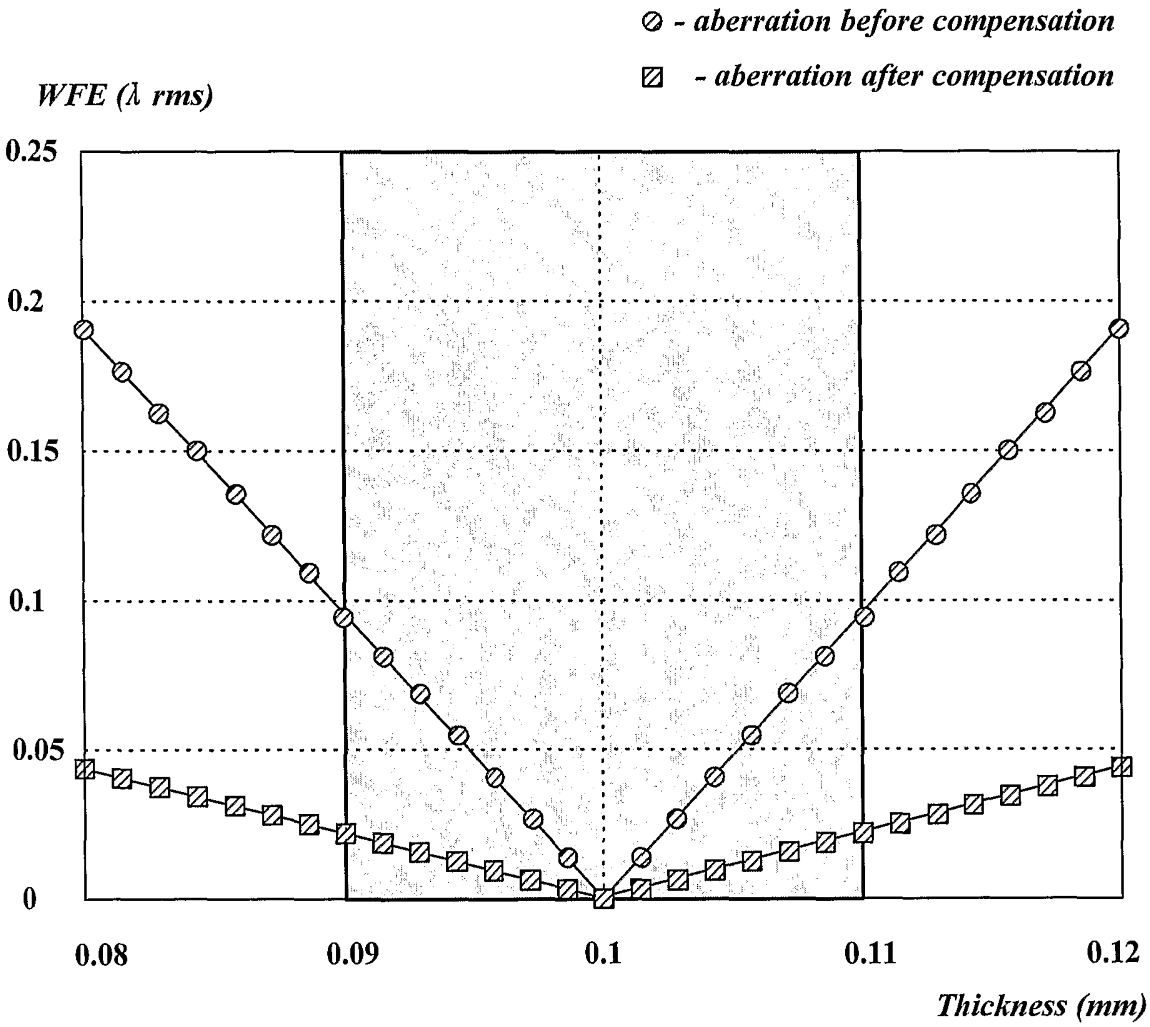

Dual-layered HD-DVD
Layer 2
Layer 1
0.02mm
0.1mm
0.12mm
30
recording layer
1.2mm
0.1mm
2
OL
NA = 0.85
3
CL
wavelength = 405nm
LD
4

FIG. 3

FIG. 4


⊘ - aberration before compensation
▨ - aberration after compensation
WFE (λ rms)
0.25
0.2
0.15
0.1
0.05
0
0.08
0.09
0.1
0.11
0.12
Thickness (mm)

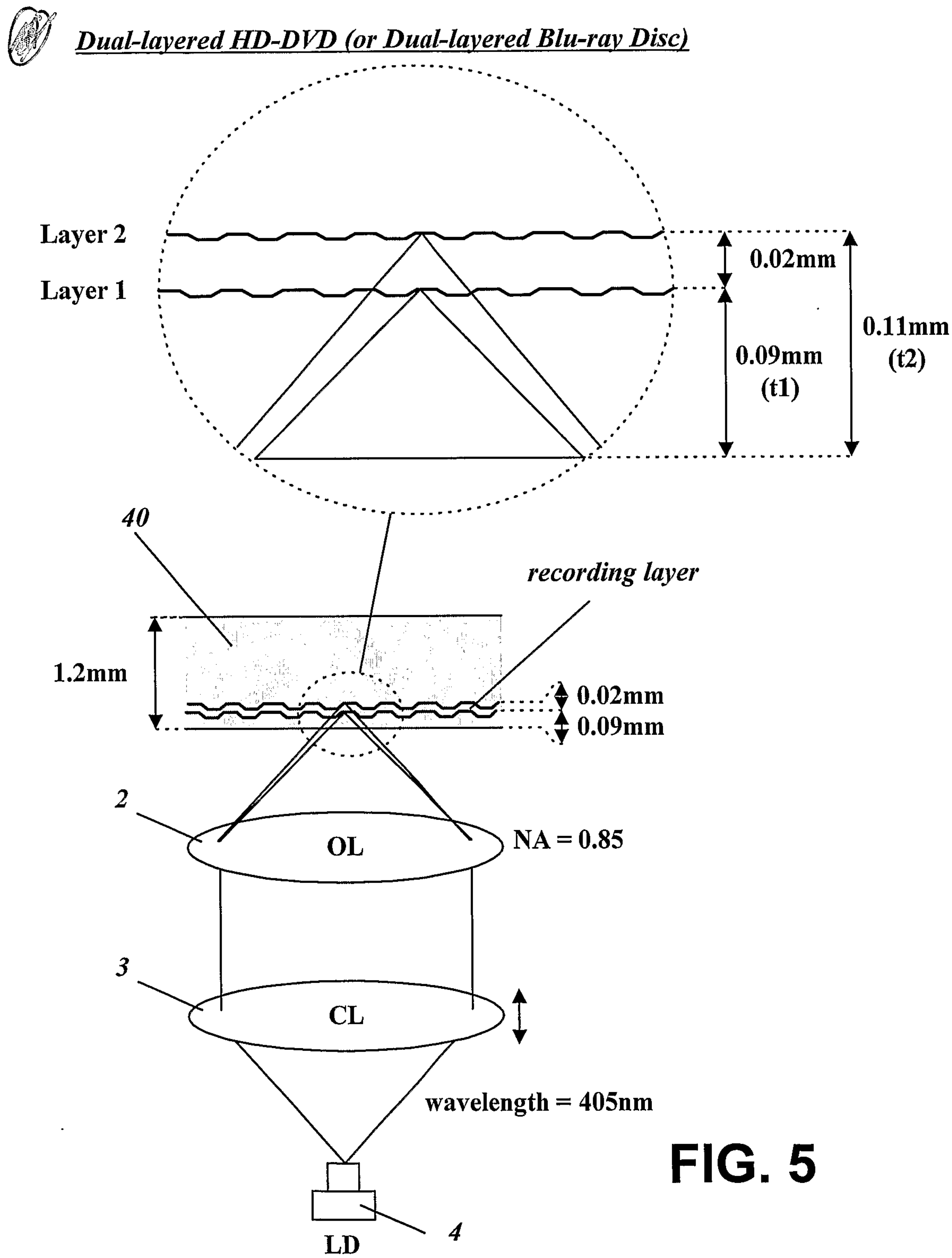

Dual-layered HD-DVD (or Dual-layered Blu-ray Disc)
Layer 2
Layer 1
0.02mm
0.09mm
(t1)
0.11mm
(t2)
40
recording layer
1.2mm
0.02mm
0.09mm
2
OL
NA = 0.85
3
CL
wavelength = 405nm
LD
4

FIG. 5

FIG. 6A

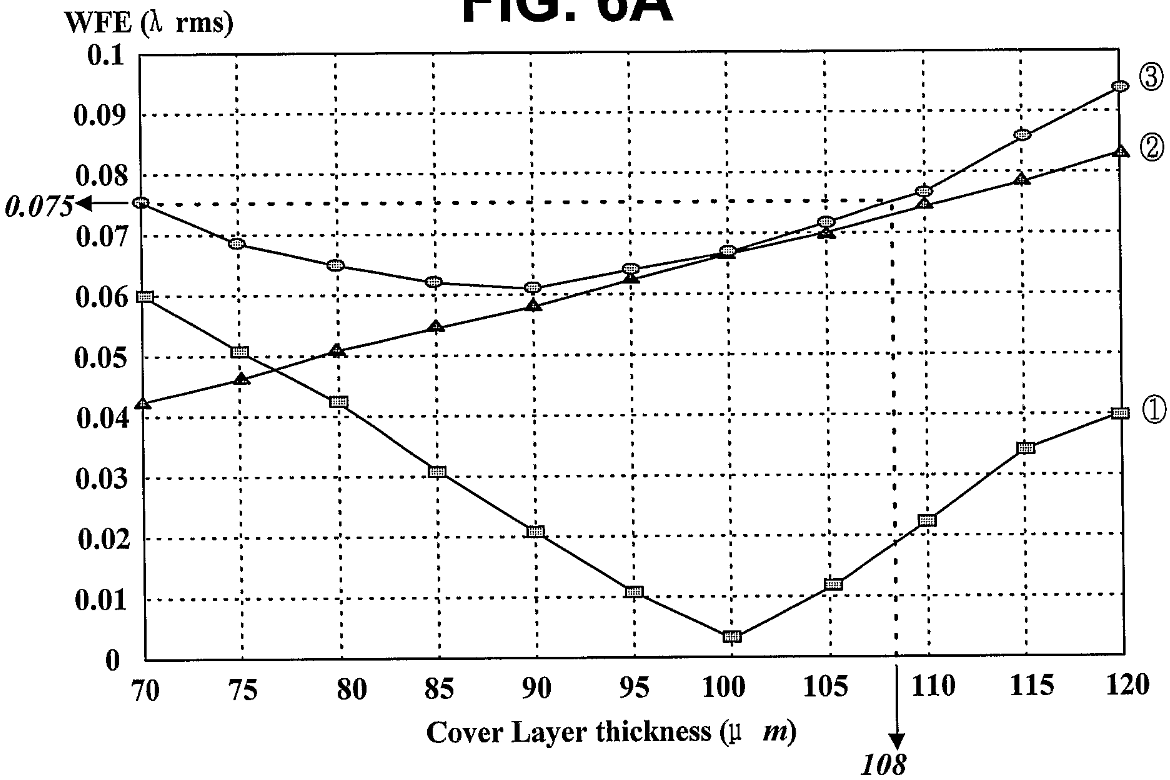

WFE (λ rms)
0.1
0.09
0.08
0.075
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
70
75
80
85
90
95
100
105
110
115
120
Cover Layer thickness (μ m)
108
③
②
①

FIG. 6B

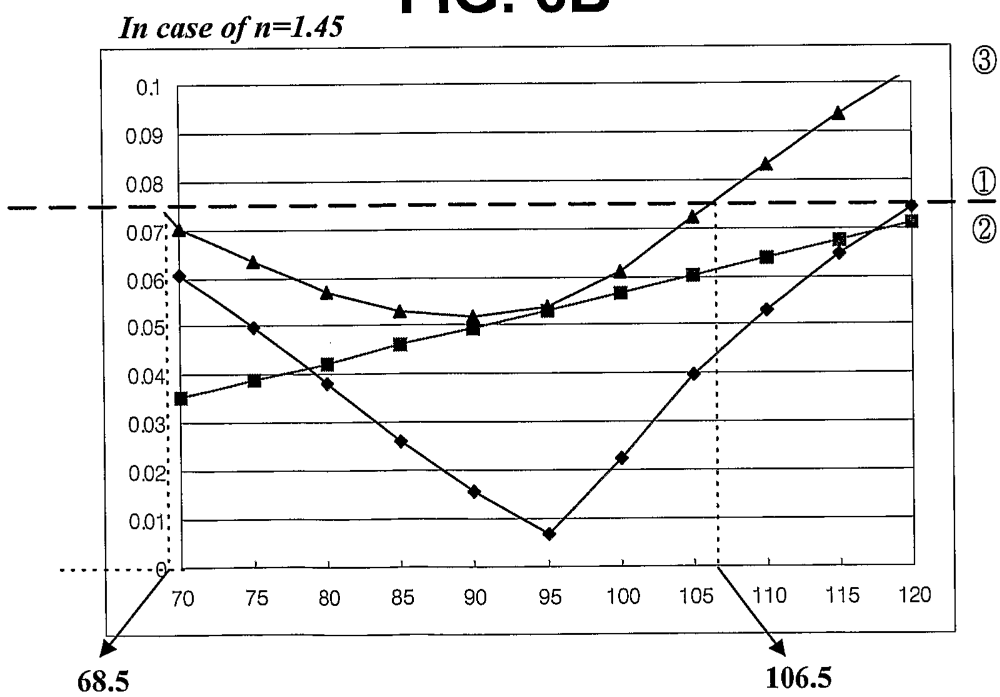

In case of n=1.45
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
70
75
80
85
90
95
100
105
110
115
120
③
①
②
68.5
106.5

FIG. 6C

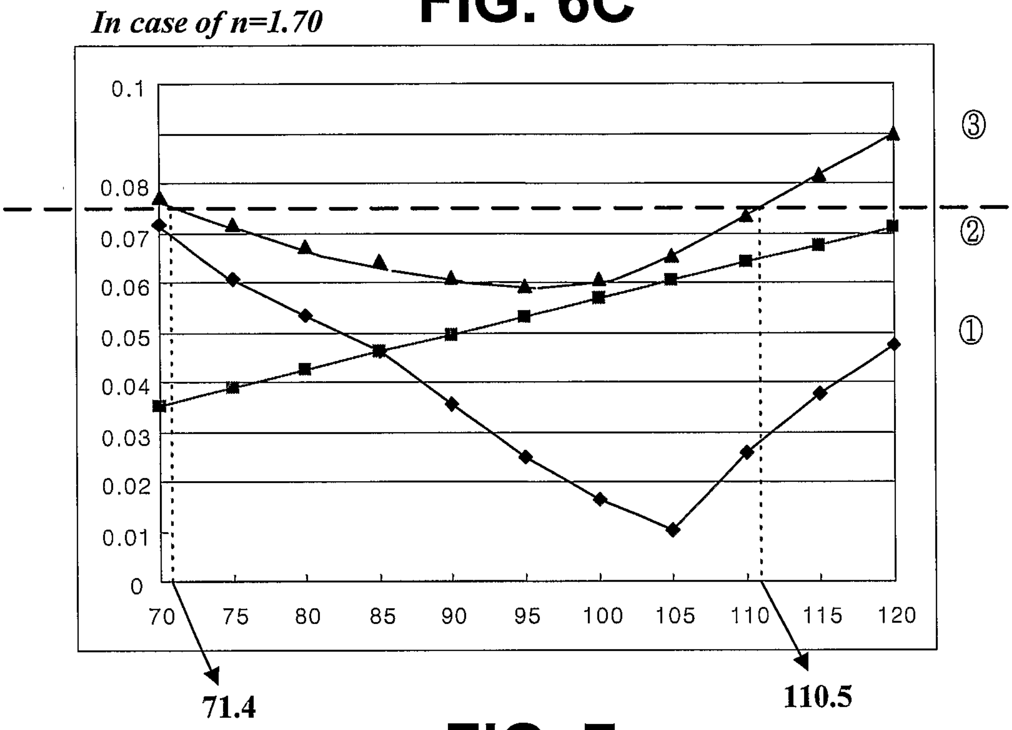
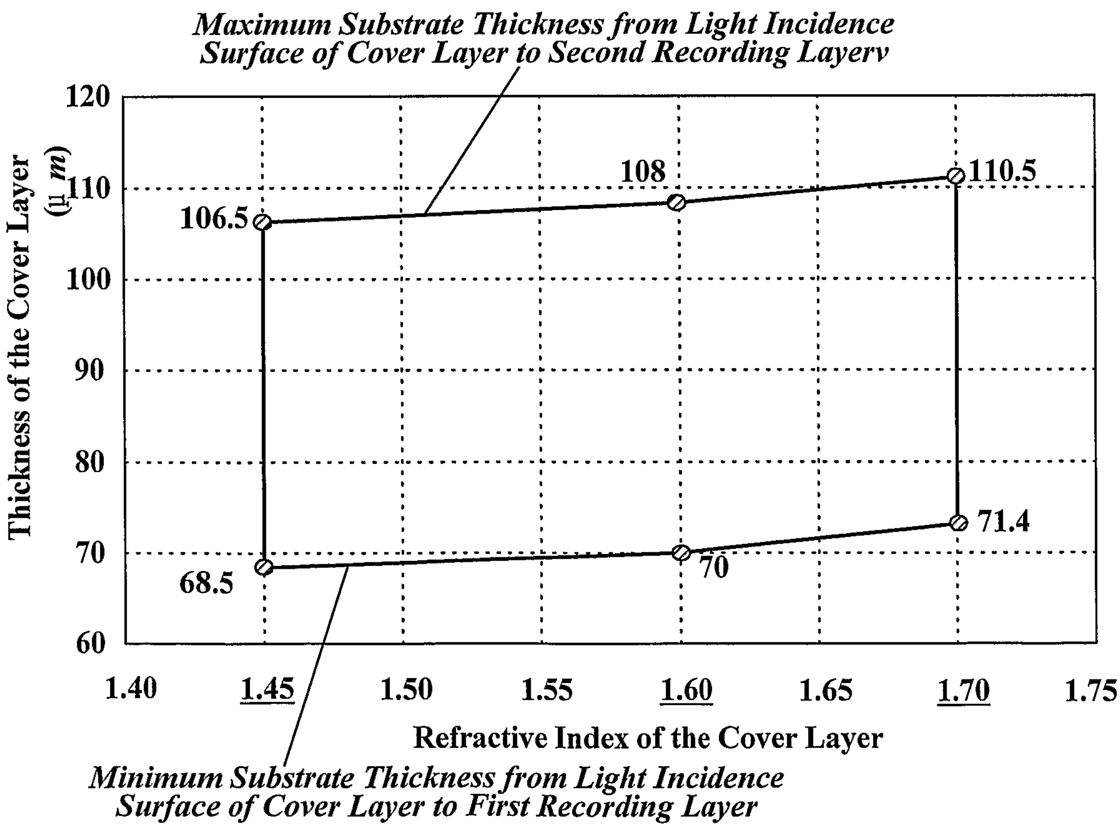

In case of n=1.70
0.1
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
70 75 80 85 90 95 100 105 110 115 120
③
②
①
71.4
110.5

FIG. 7


Maximum Substrate Thickness from Light Incidence Surface of Cover Layer to Second Recording Layerv
Thickness of the Cover Layer (μm)
120
110
100
90
80
70
60
106.5
108
110.5
71.4
70
68.5
1.40 1.45 1.50 1.55 1.60 1.65 1.70 1.75
Refractive Index of the Cover Layer
Minimum Substrate Thickness from Light Incidence Surface of Cover Layer to First Recording Layer

Dual-layered HD-DVD (or Dual-layered Blu-ray Disc)

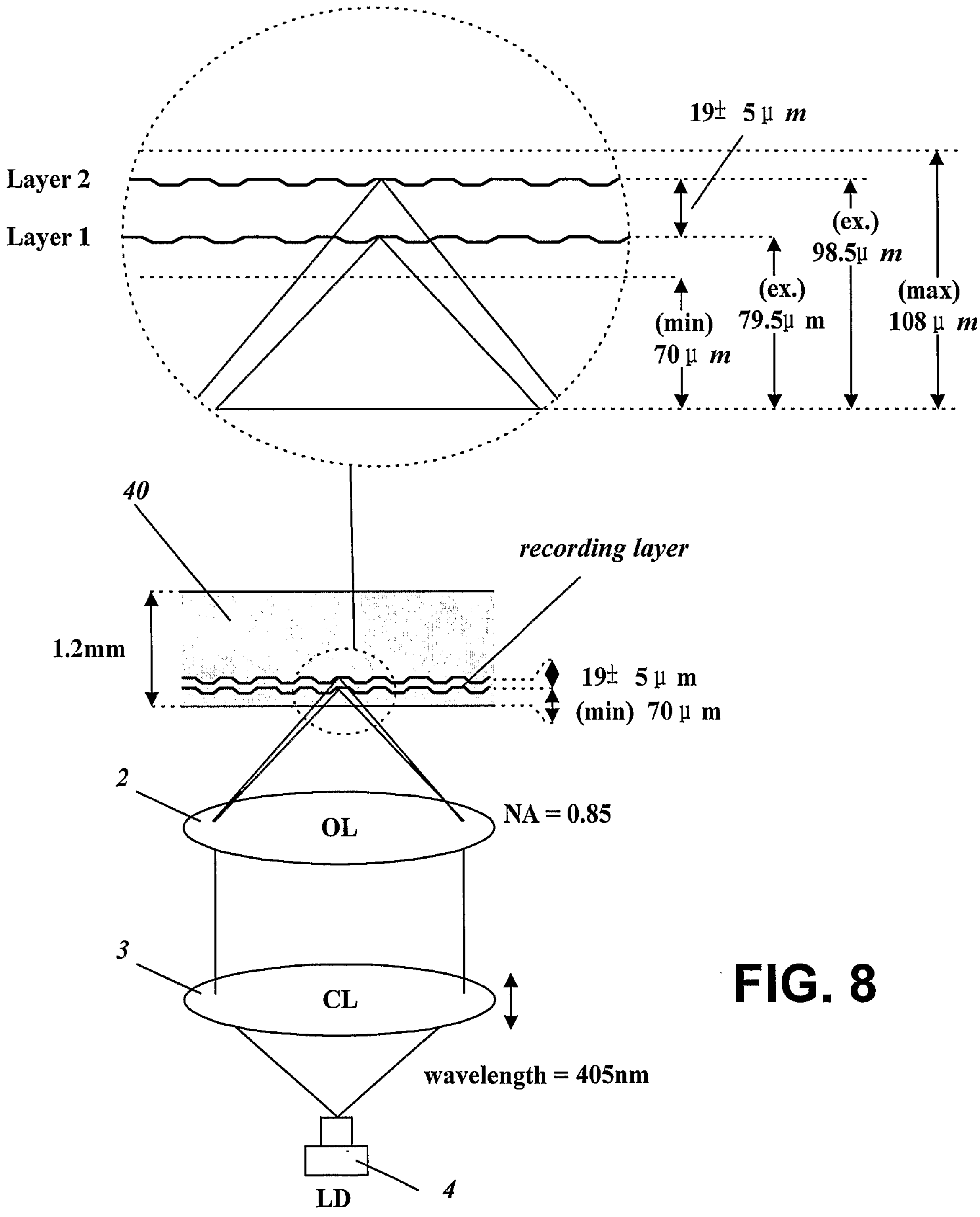


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/01095

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G11B 7/24

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, B23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
KR, JP : IPC above

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
"dual-layer", "DVD", "recording", "substrate", "thickness"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,777,969 A (Matsushita Elec. Ind.Co., Ltd.) 7 July 1998 See the column 3, line 38 - column 6, line 5 ; figures 1, 2	1 ~ 4, 6~8, 21
A		25
A	US 5,679,429 A (Imation Corp.) 21 October 1997 See the whole document	1, 9, 17, 25
A	JP 10-134487 A (Albain Corp.) 22 May 1998 See the whole document	1, 6, 9, 14, 17, 23, 25

☐ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 SEPTEMBER 2003 (16.09.2003)	17 SEPTEMBER 2003 (17.09.2003)

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