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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	**520.47611CX2**
First Inventor	**Koji HIRATA**
Title	**Projection Type Image Display Apparatus**
Express Mail Label No.	

APPLICATION ELEMENTS
SEE MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Commissioner for Patents, P.O. Box 1450, Alexandria VA 22313-1450**

1. ☒ **Fee Transmittal Form** (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)

2. ☐ **Applicant claims small entity status.**
See 37 CFR 1.27.

3. ☒ **Specification** [*Total Pages* 55]
Both the claims and abstract must start on a new page
(For information on the preferred arrangement, see MPEP 608 01(a))

4. ☒ **Drawing(s)** *(35 U.S.C. 113)* [*Total Sheets* 29]

5. **Oath or Declaration** [*Total Sheets* 4]
a. ☐ Newly executed (original or copy)
b. ☒ Copy from a prior application (37 CFR 1.63 (d))
(for continuation/divisional with Box 18 completed)
i. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) Named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b)

6. ☐ **Application Data Sheet.** See 37 CFR 1.76

7. ☐ **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)*
i. ☐ Landscape Table on CD

8. **Nucleotide and/or Amino Acid Sequence Submission**
(if applicable, all necessary)
a. ☐ Computer Readable Form (CRF)
b. Specification Sequence Listing on:
i. ☐ CD-ROM or CD-R (2 copies); or
ii. ☐ Paper
c. ☐ Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. ☐ **Assignment Papers** (cover sheet & documents(s))

10. ☐ **37 CFR 3.73(b) Statement** ☐ **Power of Attorney**
(when there is an assignee)

11. ☐ **English Translation Document** *(if applicable)*

12. ☒ **Information Disclosure Statement** (PTO/SB/08 OR PTO-1449) ☐ Copies of Citations attached

13. ☐ **Preliminary Amendment**

14. ☐ **Return Receipt Postcard** (MPEP 503)
(Should be specifically itemized)

15. ☐ **Certified Copy of Priority Document(s)**
(if foreign priority is claimed)

16. ☐ **Nonpublication Request** under 35 U.S.C. 122 (b)(2)(B)(i).
Applicant must attach form PTO/SB/35 or equivalent.

17. ☒ **Other: Reaffirmation of Claim for Priority**

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: **11/763,465**

Prior application information: *Examiner:* _____ *Art Unit:* _____

19. CORRESPONDENCE ADDRESS : THE ADDRESS ASSOCIATED WITH CUSTOMER NUMBER **020457**

Signature	**/Melvin Kraus/**	*Date*	**JUNE 29, 2010**
Name (Print/Type)	**Melvin Kraus**	*Registration No. (Attorney/Agent)*	22,466

PTO/SB/17 (12-04v2)
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Effective on 12/08/2004
Fee pursuant to the Consolidated Appropriations Act. 2005 (H.R. 4818).

FEE TRANSMITTAL

For FY 2005

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 1,090.00

Complete if Known	
Application Number	
Filing Date	June 29, 2010
First Named Inventor	Koji HIRATA
Examiner Name	
Art Unit	
Attorney Docket No.	520.47611CX2

METHOD OF PAYMENT (check all that apply)

☐ **Check** ☐ **Credit Card** ☐ **Money Order** ☐ **None** ☒ **Other** (please identify): Electronic

☒ **Deposit Account** Deposit Account Number 01-2135 Deposit Account Name Antonelli, Terry, Stout & Kraus, LLP

The Director **is authorized to**: (*check all that apply*)

☐ Charge fee(s) indicated below
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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES	Small Entity	SEARCH FEES	Small Entity	EXAMINATION FEES	Small Entity	
Application Type	**Fee ($)**	**Fee ($)**	**Fee ($)**	**Fee ($)**	**Fee ($)**	**Fee ($)**	**Fees Paid $**
Utility	330	165	540	270	220	110	1090.00
Design	220	110	100	50	140	70	
Plant	220	110	330	165	170	85	
Reissue	330	165	540	270	650	325	
Provisional	220	110	0	0	0	0	

2. EXTRA CLAIM FEES

Fee Description	**Fee ($)**	**Small Entity Fee($)**
Each claim over 20 (including Reissues)	52	26
Each independent claim over 3 (including Reissues)	220	110
Multiple dependent claims	390	195

Total Claims	**Extra Claims**	**Fee ($)**	**Fee Paid ($)**	**Multiple Dependent Claims Fee ($)**	**Multiple Dependent Claims Fee Paid ($)**
6	-20 or HP = 0	x 0	= 0		0

HP= highest number of total claims paid for, if greater than 20.

Indep. Claims	**Extra Claims**	**Fee ($)**	
1	-3 or HP = 0	x 0	= 0

HP=highest number of independent claims paid for, if greater than 3.

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41 (a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	**Extra Sheets**	**Number of each additional 50 or fraction thereof**	**Fee($)**	**Fee Paid ($)**
-100	0	/50= (round up to a whole number) x	270.00	= 0

4. OTHER FEE (S)

	Fee Paid ($)
Non-English Specification, $130 fee (no small entity discount)	0
Other (e.g., late filing surcharge):	0

SUBMITTED BY				**Complete (*if applicable*)**	
Signature	/Melvin Kraus/	*Registration No. (Attorney/Agent)*	22,466	*Telephone*	(703) 312-6600
Name (Print/Type)	Melvin Kraus			*Date*	June 29, 2010

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time your require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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SPECIFICATION

TITLE OF THE INVENTION

PROJECTION TYPE IMAGE DISPLAY APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. Application Serial No. 11/763,465, filed June 15, 2007, the contents of which are incorporated herein by reference. This application also relates to US Application Serial No. _____, and US Application Serial No. _____, both filed the same date as the filing of this application.

BACKGROUND OF THE INVENTION

The present invention relates to a projection-type image displaying apparatus, for conducting image display by projecting an image on a image display element(s), enlargedly, upon a tracing or surface, such as a translucent screen, and it relates to a projection display apparatus, in particular, being suitable for a front-projection type image display apparatus, and further a projection optic unit for the same.

For a color image display apparatus for projecting an image on an image display element(s) onto a screen (a tracing picture) through a projection optic unit, being made up with a plural number of lenses, it is requested to obtain an enlarged image having sufficient size or magnitude on a screen, without generating distortion therein. For achieving this, as is disclosed in Japanese Patent Laying-Open No. Hei 5-134213 (1993) or Japanese Patent Laying-Open No. 2000-162544 (2000), for example, there is already known a projection apparatus or an optic system for projecting an image, enlargedly, into the direction

perpendicular to an optical axis of a projection system and also with using an additional optic system, being disposed by inclining by a predetermined angle with respect to that optical axis of the projection system. Herein, the additional optic system (i.e., afocal converter) is an optical system having a function of converting the sizes of projection image, and it is provided for obtaining a rectangular projection image with compensation/reduction upon the distortion of projection image, which is generated accompanying with the projection thereof from the inclined direction onto the screen.

Also, for example, in Japanese Patent Laying-Open No. 2004-157560 (2004), there is already known a reflection-type image forming optical system, for projecting an image on the image display element(s) onto the screen (i.e., the tracing surface), enlargedly, but with using a plural number of reflection mirrors in the place of the lenses mentioned above (i.e., the optic elements within a transmitting system).

BRIEF SUMMARY OF THE INVENTION

When projecting an image onto the screen from direction inclined thereto, then so-called trapezoidal distortion is generated on the projected image. For dissolving this, within structures of the projection optic unit, described in the Japanese Patent Laying-Open No. Hei 5-134213 (1993), the trapezoidal distortion is suppressed with bringing the additional optic system (i.e., the afocal converter) to be eccentric, which is disposed on a screen side. However, for lenses for building up such the eccentric additional optic system, it is difficult to widen the lens angle thereof since the magnification thereof is low, and for that reason, it is necessary to make the distance large from the projection apparatus up to the screen, for obtaining a projection image to have a necessary magnification. And, also the distance is large between the projection screen and the projection system. For this reason, there is a problem that the entire of the apparatus comes to be large (in particular, the length in direction of an optical axis of the optic unit). In addition to the above, it is necessary to provide an additional optic system having a large aperture, as a lens for building up the additional optic eccentric additional

optic system mentioned above, but accompanying this, it also results into a reason of rising up the costs of the projection optic unit.

Also, within the projection optic unit described in the Japanese Patent Laying-Open No. 2000-162544 (2000), similar to that shown in the Japanese Patent Laying-Open No. Hei 5-134213 (1993), it is difficult to widen the lens angle due to low magnification thereof, and fit is also difficult to manufacture it, because of the necessity of making the lenses applied eccentric with, separately, and further, in addition thereto, it also necessitates the additional optic system having the large aperture; thereby resulting into a reason of increasing of costs of the projection optic unit.

On the other hand, with the reflection-type image forming optic system described in the Japanese Patent Laying-Open No. 2004-157560 (2004), it aims to obtain a wide angle of view while suppressing large-sizing of the image forming optic system, with applying the reflection-type image forming optic system (i.e., reflection mirrors) in the place of the conventional image forming optic system of transmission type. However, because an amount of eccentricity (or deflection) is large upon the reflection mirror, it is difficult to dispose a plural number of reflection mirrors at correct positions, including inclining angles thereof, and also the inclining angles of the reflection mirrors can be changed, easily, due to vibration, within an apparatus, and therefore it has a problem that it is very difficult to manufacture the apparatus.

Then, according to the present invention, by taking the problems of the conventional arts mentioned above into the consideration thereof, it is an object to provide a projection-type image display apparatus, for enabling the wide angle of view, without enlarging the apparatus, and also relatively easy manufacturability thereof, as well as, a projection optic unit to be applied with such the optic unit therein. Thus, there is provided a technology being suitable for obtaining the projection-type image display apparatus, being more compact by itself, in particular, in external sizes thereof, not only the depth thereof, without necessity of an additional optic system having large aperture, but not generating the

trapezoidal distortion.

For accomplishing the object mentioned above, according to the present invention, there is provided a 1. A projection-type image display apparatus for projecting an image, enlargedly, onto a projection surface, comprising: an image display element; a lens group, being disposed behind said image display element, comprising therein, a front lens group made up with a plural number of lenses, including, at least, a refractive lens, having a positive power and being rotationally symmetric in a surface configuration thereof, and a rear lens group made up with a plural number of lenses, including, at least, a lens having a free curved surface configuration and being rotationally asymmetric, thereby emitting the image displayed on said image display element; a reflection mirror for reflecting the light from said lens group, thereby projection onto said projection surface, obliquely; and a movement member for moving the plural number of lenses of said rear lens group.

BRIEF DESCRIPTION OF THE DRAWINGS

Those and other objects, features and advantages of the present invention will become more readily apparent from the following detailed description when taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a perspective view for showing the entire of a projection-type image display apparatus, according to an embodiment of the present invention;

Fig. 2 is a cress-section view of a projection optic unit of the projection-type image display apparatus mentioned above;

Fig. 3 is a perspective view for showing an example of an arrangement of lenses of the optic unit;

Figs. 4(a) and 4(b) are cross-section views in the vertical direction and the horizontal direction, for explaining the lens surfaces of the optic unit;

Fig. 5 is a perspective view for showing the entire of a projection-type image display apparatus, according to other embodiment of the present invention;

Fig. 6 is a perspective view for showing an example of an arrangement of lenses of the optic unit, within the projection-type image display apparatus, according to other embodiment of the present invention mentioned above;

Fig. 7 is a cross-section view in the vertical direction, for explaining the lens surfaces of the optic unit;

Fig. 8 is a Y-Z cross-section view for showing the optical path within the projection-type image display apparatus, according to the present invention;

Fig. 9 is a X-Z cross-section view for showing the optical path within the projection-type image display apparatus, according to the present invention;

Fig. 10 is a view for showing the distortion power of the optic unit, according to an embodiment 1;

Fig. 11 is a view for showing the spot power of the optic unit, according to the embodiment 1;

Fig. 12 is a view for showing the distortion power of the optic unit, according to an embodiment 2;

Fig. 13 is a view for showing the spot power of the optic unit, according to the embodiment 2;

Fig. 14 is a view for showing the distortion power of the optic unit, according to an embodiment 3;

Fig. 15 is a view for showing the spot power of the optic unit, according to the embodiment 3;

Fig. 16 is a view for showing the distortion power of the optic unit, according to an embodiment 4;

Fig. 17 is a view for showing the spot power of the optic unit, according to the embodiment 4;

Fig. 18 is a view for showing the condition of projecting an image on a screen, enlargedly, with applying the projection optic unit into the projection-type image display apparatus;

Fig. 19 is a view for showing the condition of changing a projection distance, within the projection-type image display apparatus applying the projection optic unit therein;

Figs. 20(a) and 20 (b) are views for showing the distortion power and the spot power in case when changing the projection distance, within the projection-type image display apparatus applying the projection optic unit therein;

Figs. 21(a) and 21 (b) are views for showing the distortion power and the spot power in case when changing the projection distance, within the projection-type image display apparatus applying the projection optic unit therein;

Figs. 22(a) to 22(c) are views for showing the condition of shifting a rear lens group within the projection optic unit mentioned above;

Figs. 23(a) and 23(b) are perspective views, including a cross-section view in a part thereof, for showing the structures of moving the rear lens group within the projection optic unit, in the projection-type image display apparatus mentioned above;

Fig. 24 is a cross-section view in the horizontal direction, for explaining the lens surfaces within the projection optic unit mentioned above;

Figs. 25(a) to 25(c) are views for showing the distortion power in case

when shifting a rear lens group within the projection optic unit mentioned above;

Fig. 26 is a view for showing the spot power in case when shifting a rear lens group within the projection optic unit mentioned above;

Fig. 27 is a perspective view for showing an example of an arrangement of lenses of the optic unit, within the projection-type image display apparatus, according to further other embodiment of the present invention mentioned above;

Fig. 28 is a cress-section view of the projection optic unit of the projection-type image display apparatus, according to the further other embodiment mentioned above; and

Fig. 29(a) to 29(c) are views for explaining the structures of a positioning mechanism, which is attached in a part of the projection-type image display apparatus, according to present invention, as well as the way of using thereof.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Hereinafter, embodiments according to the present invention will be fully explained by referring to the attached drawings.

First of all, Fig. 1 attached herewith is a perspective view for showing the entire structures of a projection-type image display apparatus, according to an embodiment of the present invention. Thus, in this figure, within an inside of an about box-like housing 110 for building up the projection-type image display apparatus are provided an image display element 1 for displaying a picture or an image, which is inputted from an external personal computer, for example, and a light source 8, such as, a lamp, etc., for irradiating white light of high intensity, and wherein, although the structures thereof will be explained in more details later, but there is further mounted a projection optic unit for projecting and irradiating the lights, which are irradiated from the said light source 8 and modulated through the image display element 1, enlargedly. And, in case when using this projection-type image display apparatus within a room, as is shown by an arrow in the figure, the

lights emitting from the said projection optic unit are projected onto a wall surface of the room or a sheet-like screen, being positioned opposing thereto, in one direction of that housing 110 (e.g., the longitudinal direction thereof in the figure), i.e., a screen 5.

Next, by referring to the cross-section view of Fig. 2 attached herewith, explanation will be made on the fundamental or basic optical structures of the projection optic unit building up the projection-type image display apparatus mentioned above. However, this cross-section view of Fig. 2 shows the cross-section, seeing into the lower right direction in Fig. 1 mentioned above (see an outlined arrow in the figure), and this corresponds to Y-Z cross-section within a XYZ coordinates system (shown by arrows in the figure).

As is shown in this Fig. 2, a projection optic unit according to the present invention comprises an image display element 1 and a prism 10, for receiving a light from a light source 8 and emitting a desired image or picture therefrom, a transmission (lens) optic system, being constructed with two (2) lens groups, including a front lens group 2 and a rear lens group 3, and a reflection optic system, including a reflection mirror (herein after, being called a “free curved (or sculptured) surface mirror”) 4 having a reflection surface of a free curved surface, i.e., not rotationally symmetric (rotationally asymmetric).

Herein, although there is shown an example of applying a transmission type, such as, a liquid crystal panel, representatively, for example, as the image display element 1 mentioned above, however the present invention should not be restricted only to this, and it may be a self-emission type, such as, a CRT, for example. Also, in case when applying the transmission type, such as, the above-mentioned liquid crystal panel or the like, for example, it is necessary to provide a lamp, to be a light source 8 for irradiating the liquid crystal panel. Also, as such the liquid crystal panel, it may be a so-called three (3) plates type, forming images of R, G and B, and in that case, it is necessary to provide a prism or the like, for use of synthesizing an image. However, an illustration is omitted herein, in particular, about the details of those liquid crystal panels and the light source 8 for

irradiating them, which will be explained later, since they do not relate directly. On the other hand, with the self-emission type, such as, the CRT, it is apparent that there is no need of such the light source 8 as was mentioned above.

Within the projection optic unit having such the structures as was mentioned above, according to the present invention, the light emitted from the image display element 1 mentioned above through the prism 10 is firstly incident upon the front lens group 2 building up the lens optic system. Though the details thereof will be explained later, but this front lens group 2 is constructed with a plural number of dioptric lenses, each having a rotationally symmetric surface configuration of a positive or a negative power. Thereafter, the light emitted from this front lens group 2 passes through the rear lens group 3, which is constructed with a plural number of lenses, including a plural number (two (2) pieces in this example) of lenses, each having the sculptured or free curved surface at least on one surface thereof, i.e., not rotationally symmetric (rotationally asymmetric). And, the light emitted from this rear lens group 3, further after being reflected enlargedly, upon a reflection optic system, including the reflection mirror (hereinafter, being called “free curved (or sculptured) surface mirror”) 4, having the reflection surface of the free curved surface, not rotationally symmetric, it is projected onto a predetermined screen 5 (for example, a wall surface of a room or a sheet-like screen, etc.).

However, within the present embodiment, as is apparent from this Fig. 1, differing from the optic system shifting the projection screen (i.e., the display element) into the direction perpendicular to the optical axis of the projection system, and further disposing the additional optic system inclined by a predetermined angle with respect to the optical axis of the projection system, as disclosed in the conventional art (in particular, the Japanese Patent Laying-Open No. Hei 5-134213 (1993) and the Japanese Patent Laying-Open No. 2000-162544 (2000)), the image display element 1 is so arranged that a center of the display screen thereof is approximately positioned on the optical axis of the optic system (i.e., defining a coaxial optic system). Accordingly, the light beam 11 directing to a center of the image on the screen 5, emitting from a center of the display screen

of the image display element 1 and passing through a center of an entrance pupil of the lens optic system, propagates along the optical axis of the lens optic system (including the front lens group 2 and the rear lens group 3 mentioned above), approximately, (hereinafter, those will be called a "picture center light"). Thereafter, this screen center light 11, after being reflected on a point P2 upon the reflection surface 4 having the free curved surface of the reflection optic system (including the sculptured surface mirror), is incident upon a point 5 at a center of the image on the screen 5, obliquely, from a lower side with respect to a normal line 7 of the screen. Hereinafter, this angle is called an "oblique incident angle" and is presented by "θs". This means that, the light passing along the optical axis of the lens optic system is incident upon the screen, inclining to the screen, and it is substantially equal to provide the optical axis of the lens system inclining to the screen (i.e., an oblique incidence system).

However, as was mentioned above, an oblique incidence of the light upon the screen produces various kinds of aberrations, including so-called a trapezoidal distortion, i.e., an oblong configuration of projection from the image display element 1 becomes a trapezoid, and also other than that, due to the rotational asymmetry to the optical axis, etc., but according to the present invention, those are compensated upon the reflection surfaces of the rear lens group 3, which builds up the lens optic system mentioned above, and also those of the reflection optic system.

In particular, with the oblique incidence of the light projected from the image display element 1 mentioned above upon the screen 5, after being reflected upon the reflection surface of the reflection mirror 4 building up the reflection optic system mentioned above, since it enables to obtain an eccentricity (i.e., the deflection angle) much larger, being much larger comparing to that obtained through the lenses building up the lens optic system, and also it hardly produces the aberrations, therefore it is possible to suppress large-sizing of the apparatus, as well as, to obtain the wide angle of view. Thus, it is possible to build up the lens optic system, including the front lens group 2 and the rear lens group 3 mentioned above, as an optic system to be much smaller in the aperture thereof, comparing

to that of the structures offsetting the additional optic system (i.e., an afocal converter) of the conventional technology mentioned above, thereby suppressing the trapezoidal distortion.

Also, since the light incident upon the reflections surface of the reflection mirror 4, which builds up the reflection optic system mentioned above, is projected while being enlarged up to a predetermined size or magnitude thereof through the lens optic system mentioned above, as was mentioned above, therefore it is easy to be manufactured, comparing to the conventional structures, building up an enlarging projection system with only the reflection mirror. Thus, the lens optic system is manufactured, separately from the reflection optic system, and thereafter it is fixed within a housing of the apparatus with adjusting the positions of both of those; i.e., obtaining the structures being suitable, in particular, for mass production thereof. Also, with such the structures of disposing the rear lens group 3 for compensating the trapezoidal distortion, etc., in front of the above-mentioned front lens group 2, as was mentioned above, since the rear lens group 3 and the front lens group 2 can be disposed while reducing the distance between them, it is possible to achieve the apparatus, being compact, as a whole thereof, mounting the said projection optic unit therein, and also to obtain a preferable effect of enabling to reduce the height, in particular, below the screen.

In this manner, combining the transmission type lens optic unit having the free curved surface and the reflection optic system having the free curved surface, in particular, in case when applying it into an image display apparatus of a front projection type, it is possible to obtain an optic system being compact, small-sizing the apparatus as a whole, while achieving the wide angle of view, which is strongly required for that front projection type, with certainty and relatively easily.

Next, Figs 3 and 4(a) and 4(b) shows the lens surfaces of optical elements within the projection optic unit, including the reflection optic system therein. Thus, Fig. 3 is a perspective view of the projection optic system mentioned above, and Fig. 4(a) shows a cross-section in the vertical direction thereof, while Fig. 4(b) a cross-section in the horizontal direction thereof, respectively.

As is shown in those figures, within the lens optic system, an image emitted from the image display element 1 through the prism 10 is firstly incident upon the front lens group 2, including a plural number of lenses therein, which has the rotationally symmetric configuration. As was mentioned above, the front lens group 2 includes a spherical lens, being rotationally symmetric, and also an aspheric lens therein. Or, as will be mentioned later by referring to Fig. 5 and/or Fig. 6, a bending mirror may be disposed on the way between the front lens group 2 and the rear lens group 3, so as to bend the light at a right angle.

Also, the rear lens group 3 is constructed with at least two (2) pieces of free curved or sculptured surface lenses. As is shown in those figures, a free curved surface lens 31, nearest to the reflection surface S22 of the reflection mirror 4, directs a concave into the direction of light emission, and a curvature of a portion, where the light passes through to be incident upon a low end of that screen, is determined to be larger than that of a portion, where the light passes through to be incident upon an upper end of that screen. Thus, it is assumed that, the free curved or sculptured surface lens has such a configuration, i.e., being curved directing the concave into the direction of emission of that light, and having the curvature in the portion where the light passes through to be incident upon the low end of that screen, being larger than that in a portion where the light passes through to be incident upon the upper end of that screen.

Also, according to the present embodiment, it is constructed to fulfill the following condition. Thus, within the cross-section shown in Fig. 2 mentioned above, it is assumed that the light incident upon a point P6 at an upper end of picture on the screen 5, being emitted from a lower end of screen on the image display element 1 and passing through a center of the entrance pupil of the front lens group 2, is a light 12. It is assumed that an optical path length is “L1” for this light 12 to reach the point P6 from a point P3 where this light 12 passes through the free curved surface mirror 4. Also, it is assumed that the light incident upon a point P4 at the lower end of picture on the screen 5 is a light 13, being emitted from the upper end of screen of the image display element 1 and passing through the center of the entrance pupil of the front lens group 2. It is assumed that the

optical pass length is “L2” for this light 13 to reach the point P4 from the point P1 where this light 13 passes through the free curved surface mirror 4. And, the projection optic unit mentioned above is so constructed that the “L1” and the “L2” satisfy the following equation (Eq. 1):

$$| L1 - L2 | < 1.2 * \sin\theta s * Dv$$

However, where “Dv” is a size of the picture on the screen, within the cross-section shown in Fig. 2, and in other words, it is a distance from the point P6 at the upper end of picture to the point P4 at the lower end thereof on the screen. Also, “θs” is the oblique incident angle mentioned above.

On the other hand, although the image display element 1 mentioned above is disposed in such a manner that the center of the display screen thereof is located on the optical axis of the lens optic system mentioned above, or alternatively, it is preferable to dispose it in such a manner that the normal line on the said display screen is inclined a little bit to the optical axis of the lens optic system mentioned above, as is shown in Fig. 7 attached herewith.

Further, judging from seeing Fig. 2, as was mentioned previously, the optical path length reaching from the point P3 to the point P6 is longer than the optical path length reaching from the point P1 to the point P4. This means that the image point P6 is farther from than the image point P4. Then, if an object point (i.e., a point in the display screen) corresponding to the image point P6 on the screen is located at a point nearer to the lens optic system and also if an object point corresponding to the image point P4 is located at a position farther from the lens optic system, it is possible to compensate the inclination of an image surface. For that purpose, as will be shown in Fig. 7, it is preferable to incline a normal line vector at a center on the display screen of the image display element 1, a little bit, with respect to the optical axis of the lens optic system, within a plane defined to include the normal line of the screen 5 and the light at the center of the screen therein. And, it is preferable that the direction of that inclination is opposite to the direction into which the screen 5 is positioned.

Further, a method for inclining an abject surface for the purpose of obtaining an image surface inclined to the optical axis, however within a practical region of the angle of view, deformations asymmetric to the optical axis are produced upon the image surface, which is obtained through the inclination of the object surface, and therefore it is difficult to make compensation by means of a projection lens, which is rotationally symmetric. According to the present embodiment, because of applying the free curved surface lens 31 and further also the free curved surface lens 32, which are rotationally asymmetric, within the rear lens group 3 mentioned above, it is possible to treat with the deformations upon the asymmetric image surface. For this reason, inclination of the object surface, i.e., the display surface of the image display element, enables to reduce the distortions of low dimensions on the image surface, greatly, and therefore it is effective for assisting the compensation of aberrations due to the free curved surface.

Next, with the function of each of the optical elements mentioned above, in particular, within the lens optic system mentioned above, the front lens group 2 (i.e., lenses 21 to 25), they build up a main lens for projecting the display screen of the image display element 1 onto the screen 5, and also compensate the basic aberrations within the optic system that is rotationally symmetric. And, the rear lens group 3 (i.e., lenses 31 to 34) within the lens optic system mentioned above, they are made up with lenses, each having the free curved surface, being not rotationally symmetric (i.e., rotationally asymmetric). Further, since the reflection optic system 4 mentioned above is built up with the reflection surfaces, each having the free curved surface configuration that is not rotationally symmetric, then it mainly compensates the aberration, which is produced due to the oblique incidence of the light. Thus, within such the structures as was mentioned above, the mirror 4 building up the reflection optic system mentioned above mainly compensates the trapezoidal distortion, while the rear lens group 3 of the lens optic system mainly compensate the asymmetric aberrations, such as, the distortion on the image surface, etc.

As was mentioned above, according to the present embodiment, the

reflection optic system mentioned above is built up with one (1) piece of the reflection surface (i.e., mirror) 4 having the free curved surface configuration that is not rotationally symmetric, while the rear lens group 3 of the lens optic system mentioned above includes two (2) pieces of the transmission-type lenses (i.e., the lenses 31 and 32 on the side of reflection mirror 4), in the structures thereof. Herein, the free curved surface mirror 4 is curved directing a convex into the direction of reflection. And, a curvature on a portion of the free curved surface mirror 4, reflecting the light to be incident upon a lower end of the screen, is determined to be larger than the curvature of a portion thereof, reflecting the light to be incident upon an upper end of the screen. Or, a portion reflecting the light to be incident upon the lower end of the screen may be defined into a configuration convex to the reflecting direction of the light, on the other hand, a portion reflecting the light to be incident upon the upper end of the screen into a configuration concave to the reflecting direction thereof.

The distance between an origin of coordinates on the reflection surface (i.e., the mirror) 4 of the reflection optic system and the lens surface nearest to the reflection surface (i.e., the mirror) 4 among the front lens group 2, in the direction of the optical axis, it is preferable to be set as five (5) times large as the focus distance of the front lens group 2 or more than that. With this, it is possible to compensate the trapezoidal distortion by the reflection surface of the reflection optic system, having the free curved surface configuration, more effectively, and thereby obtaining a preferable performance.

Hereinafter, explanation will be made on the numerical values of the embodiment, according to the present embodiment.

<Embodiment 1>

Firstly, explanation will be made on the details of the projection optic unit, according to the present embodiment explained in the above, by referring to Figs. 8 and 9 attached herewith and further tables 1 to 4 below, while showing the detailed numerical values of the optical elements, including the lens optic system and the reflection optic system therein. However, Figs. 8 and 9 attached herewith

are diagrams for showing light beams in the optic system according to the present invention, upon basis of an example of first numerical values. Thus, within XYZ rectangular coordinates system shown in Fig. 2 mentioned above, Fig. 8 shows the Y-Z cross-section, i.e., extending the optic system into the Z-axis direction. Also, Fig. 9 shows the structures on X-Z cross-section. Further, this Fig. 9 shows an example of disposing the bending mirror 35 on the way between the front lens group 2 and the rear lens group 3 building up the lens optic system, as is shown in the details thereof in Figs. 5 and 6, and thereby bending the light path into the X-axis direction, once.

In the present embodiment, the light emitted from the image display element 1, which is below in Fig. 4, firstly passes through the front lens group 2 built up with only lenses, each having only surfaces that are rotationally symmetric, among the lens optic system including the plural number of lenses therein. Then, it passes through the rear lens group 3 including the free curved surface lens that is rotationally asymmetric, and is reflected upon the reflection surface of the free curved surface mirror 4 within the reflection optic system. Thereafter, the reflecting light thereupon is incident upon the screen 5.

Herein, the front lens group 2 of the lens optic system is built up with the plural number of lenses, all of which have a refracting interface of rotationally symmetric configuration, and four (4) of the refracting interfaces of those lenses have aspheric surfaces, each being rotationally symmetric, and others have the spherical surfaces. The aspheric surface being rotationally symmetric, which is used therein, can be expressed by the following equation (Eq. 2), with using a local cylindrical coordinates system for each surface:

$$Z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + A\cdot r^4 + B\cdot r^6 + C\cdot r^8 + D\cdot r^{10} + E\cdot r^{12} + F\cdot r^{14} + G\cdot r^{16} + H\cdot r^{18} + J\cdot r^{20}$$

Where, “r” is the distance from an optic axis, and “Z” represents an amount of sag. Also, “c” is the curvature at an apex, “k” a conical constant, “A” to “J” coefficients of a term of power of “r”.

On the other hand, the free curved surfaces building up the rear lens group 3 of the lens optic system mentioned above can be expressed by the following equation (Eq. 3), including polynomials of X and Y, with applying the local coordinates system (x, y, z) assuming the apex on each surface to be the origin.

$$Z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + \sum_m \cdot \sum_n (C(m,n) \cdot x^m \cdot y^n)$$

Where, "Z" represents an amount of sag of the free curved surface configuration, in particular, into the direction perpendicular to X- and Y-axes, "c" the curvature at the apex, "r" the distance from the origin within a plane of X- and Y-axes, "k" the conical constant, and C(m,n) the coefficients of the polynomials.

Next, the following table 1 shows the numerical data of the optic system, according to the present embodiment. In this table 1, S0 to S23 correspond to the marks S0 to S23 shown in Fig. 3 mentioned above, respectively. Herein, the mark S0 shows the display surface of the image display element 11, i.e., the object surface, and S23 the reflection surface of the free curved surface mirror 5. Also, though not shown in those figures, but a mark S24 shows an incident surface of the screen 5 shown in Fig. 2 mentioned above, i.e., the image surface.

Table 1

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	7.06		
S3	246.358	4.65	1.85306	17.2
S4	-84.858	18.00		
S5*	-83.708	9.00	1.49245	42.9
S6*	-75.314	0.10		
S7	41.651	9.32	1.49811	60.9
S8	-42.282	2.50	1.76014	20.0
S9	29.550	0.10		
S10	29.476	9.00	1.49811	60.9
S11	-79.153	25.90		
S12	Infinity	9.10		
S13	-265.353	6.00	1.85306	17.2

S14	-53.869	65.00		
S15	-24.898	4.19	1.74702	33.2
S16	-58.225	9.00		
S17*	-27.332	10.00	1.49245	42.9
S18*	-32.424	2.50		
S19#	Infinity	8.00	1.49245	42.9
S20#	Infinity	20.51		
S21#	Infinity	8.00	1.49245	42.9
S22#	Infinity	160.99		
S23#	Infinity	-705.00	REFL	

Also, in the table 1 mentioned above, "Rd" is the radius of curvature for each surface, and it is presented by a positive value in case when having a center of curvature on the left-hand side of the surface in Fig. 3 mentioned above, while by a negative value in case when having it on the right-hand side, contrary to the above. Also, "TH" is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface. The distance between the surfaces is presented by a positive value in case when the next lens surface is at the left-hand side, while by a negative value in case when it is at the right-hand side, with respect to that lens surface.

Further, in the table 1 mentioned above, S5, S6, S17 and S18 are aspheric surfaces, being rotationally symmetric, and also in this table 1, they are attached with "*" beside the surface numbers for easy understanding thereof, wherein coefficients of the aspheric surface of those four (4) surfaces are shown in the table 2 below.

Table 2

Surface	Aspheric Surface Coefficients							
S5	K	-11.7678542	C	-1.159E-11	F	2.298642E-20	J	-1.255E-26
	A	-2.7881E-06	D	-3.2834E-14	G	1.05201E-21		
	B	9.67791E-09	E	1.09359E-16	H	1.96001E-24		
S6	K	-5.4064901	C	2.0324E-12	F	3.0211E-19	J	-1.4982E-26
	A	6.14967E-07	D	-2.2078E-14	G	4.30049E-22		
	B	4.60362E-09	E	-8.0538E-17	H	4.79618E-24		
S17	K	1.106429122	C	-9.0262E-11	F	-1.0521E-18	J	-6.0837E-26
	A	-1.1068E-05	D	-1.3984E-13	G	-8.1239E-23		
	B	7.21301E-08	E	3.1153E-16	H	3.86174E-23		
S18	K	0.742867686	C	-2.2719E-11	F	1.09398E-19	J	9.02232E-29
	A	1.51788E-07	D	-4.6853E-14	G	1.62146E-22		
	B	2.10472E-08	E	2.9666E-17	H	-3.0801E-25		

Also, S19 to S22 in the table 1 mentioned above are the refraction surfaces, each having the free curved surface configuration, which builds up the rear lens group of the lens optic system mentioned above, and S23 is the reflection surface having the free curved surface configuration S23 of the reflection optic system, wherein they are shown by attaching "#" beside the surface numbers thereof. Values of the coefficients for presenting the configurations of those five (5) free curved surfaces are shown in the table 3 below.

Table 3

Surface	Aspheric Surface Coefficients							
			C17	5.38933E-07	C34	-1.2381E-09	C51	-7.4126E-14
	K	0	C19	8.33432E-07	C36	1.13944E-09	C53	2.05074E-12
S19	C4	0.013500584	C21	-4.6367E-08	C37	3.87771E-12	C55	-9.2166E-13
	C6	0.003493312	C22	-6.2643E-09	C39	1.04779E-11	C56	-2.5867E-15
	C8	-0.00083921	C24	-2.2449E-08	C41	1.80038E-11	C58	-8.7122E-15
	C10	-0.00032098	C26	-5.6706E-08	C43	5.23019E-11	C60	2.85321E-14
	C11	8.59459E-06	C28	9.69952E-10	C45	1.69253E-11	C62	-8.5084E-14
	C13	2.14814E-06	C30	-1.1968E-10	C47	-2.7E-14	C64	1.25198E-13
	C15	7.54355E-06	C32	-1.3638E-09	C49	7.30978E-13	C66	-5.6277E-14
			C17	7.49262E-07	C34	-5.7462E-10	C51	-3.6141E-13
	K	0	C19	1.19039E-06	C36	1.27396E-09	C53	8.54188E-14
S20	C4	0.015488689	C21	-1.2953E-07	C37	-4.7746E-12	C55	-5.3469E-13
	C6	0.006553414	C22	5.115E-10	C39	7.32855E-12	C56	8.92545E-17
	C8	-0.00116756	C24	-2.1936E-08	C41	5.30157E-11	C58	-5.3434E-15
	C10	-0.00033579	C26	-5.9543E-08	C43	5.05014E-11	C60	1.96533E-14
	C11	7.5015E-06	C28	2.03972E-08	C45	-2.1894E-11	C62	-1.3923E-13
	C13	-2.5728E-06	C30	1.16701E-11	C47	-1.2515E-13	C64	1.06322E-13
	C15	-1.3543E-06	C32	-1.6198E-09	C49	7.64489E-13	C66	-4.6602E-15
			C17	-1.0379E-07	C34	2.81743E-10	C51	-8.1775E-15
	K	0	C19	3.0082E-08	C36	6.05663E-10	C53	3.06022E-14
S21	C4	0.015096874	C21	7.95521E-08	C37	8.39381E-13	C55	-9.1775E-13
	C6	0.009982808	C22	-1.3911E-09	C39	1.98531E-12	C56	-7.8543E-17
	C8	0.000358347	C24	9.33292E-10	C41	1.37477E-11	C58	-8.9588E-16
	C10	0.000209267	C26	3.54468E-09	C43	-1.0671E-11	C60	-6.0768E-15
	C11	-3.8593E-07	C28	4.1615E-09	C45	9.04109E-12	C62	-1.9528E-14
	C13	-6.8336E-06	C30	-1.2331E-11	C47	2.48401E-14	C64	2.6781E-14
	C15	-2.2455E-05	C32	-2.3367E-10	C49	6.92603E-14	C66	-1.4324E-14
			C17	-3.6973E-07	C34	4.8045E-10	C51	-2.9795E-13
	K	0	C19	-3.0682E-07	C36	1.43328E-10	C53	-2.5306E-14
S22	C4	0.022813527	C21	4.12093E-08	C37	-2.0707E-12	C55	-3.9401E-13
	C6	0.012060543	C22	4.07969E-09	C39	-4.9221E-12	C56	6.88651E-16
	C8	0.000638931	C24	8.5986E-09	C41	-2.3681E-12	C58	1.55006E-15
	C10	0.000196027	C26	2.1713E-08	C43	-2.1567E-11	C60	-1.4674E-15
	C11	-7.1204E-06	C28	1.63499E-08	C45	-2.3679E-12	C62	-9.9822E-15
	C13	-1.269E-05	C30	1.38704E-10	C47	-5.7167E-15	C64	2.72925E-14
	C15	-2.5184E-05	C32	2.02372E-10	C49	-9.0337E-14	C66	-1.1966E-14
			C17	-1.1083E-09	C34	-4.9118E-14	C51	-5.4918E-19
	K	0	C19	-5.7768E-10	C36	8.12546E-14	C53	-2.2569E-18
S23	C4	0.001597194	C21	1.60076E-10	C37	-7.486E-17	C55	-3.5657E-18

	C6	0.001324181	C22	1.91534E-12	C39	6.80626E-16	C56	1.09883E-21
	C8	1.37885E-05	C24	-1.0665E-11	C41	-5.1295E-17	C58	-2.1535E-20
	C10	1.34349E-05	C26	-8.6063E-12	C43	-3.6526E-16	C60	2.01763E-20
	C11	-4.8064E-08	C28	-1.1125E-12	C45	1.46399E-15	C62	-1.2016E-20
	C13	5.24071E-08	C30	6.24714E-14	C47	-2.1563E-18	C64	3.21408E-21
	C15	9.53861E-08	C32	-3.4381E-14	C49	2.86073E-18	C66	-1.4922E-19

Also, according to the present invention, as is shown in Fig. 7, the object surface, i.e., the display screen of the image display element 1 is inclined by –1.163 degrees to the optical axis of the lens optic system mentioned above. However, with the direction of inclination, it is assumed that a positive value presents the direction, in which the normal line on the object surface rotates into the clockwise direction within the cross-section shown this Fig. 7. Accordingly, according to the present embodiment, it means that, within the cross-section shown in Fig. 7, the object surface is inclined into the anti-clockwise direction by 1.163 degrees from the position perpendicular to the optical axis of the lens optic system mentioned above.

Also, the free curved surface mirror 4 shown by the mark S23 in Figs. 3 and 7 mentioned above is so disposed that, the normal line at the origin of the local coordinates thereof, i.e., the Z-axis is inclined by around +29 degree from the position in parallel with the optical axis of the lens optic system mentioned above while positioning that origin of the local coordinates on the optical axis of the lens optic system mentioned above. However, the direction of this inclination is assumed to be positive in the anti-clockwise rotating direction, within the cross-sections shown in Figs. 3 and 7, similar to that of the object surface mentioned above, and therefore, it is inclined into the anti-clockwise rotation. With this, the light at the center of the screen, emitting from the center on the screen of the image display element 1 and propagating almost along the optical axis of the lens optic system mentioned above, after reflection upon S23, it propagates into a direction inclined by 58 degrees, i.e., 2 times large as the inclination angle with respect to the optical axis of the lens optic system mentioned above (see an arrow in the figure).

Further, in the present embodiment, the conditions of the inclination and an offset of the local coordinates are shown in the table 4 below, on each of the

surfaces. In this table 4, values of the inclination angle and the offset are shown on the columns on the right-hand sides of the surface number, wherein "ADE" is a magnitude of the inclination within the surface in parallel with the cross-section of Fig. 4, and a rule of display thereof is as mentioned above. Also, "YDE" is a magnitude of the offset, and the offset is set up into the direction perpendicular to the optical axis within the surface in parallel with the cross-section of Fig. 4, and the offset below on the cross-section of Fig. 4 is assumed to be positive. However, also in the embodiments that will be explained hereinafter, the inclination and the offset of an optical element are setup to be the direction within the cross-section in parallel with the cross-section shown therein.

Table 4

Surface	ADE(°)	YDE(mm)
S0	-1.163	0.0
S23	29.000	0.0

However, as be seen from the tables 1 and 3 mentioned above, according to the present embodiment, it is apparent that the curvature "c" and the conic coefficients "k" are "0". Thus, the trapezoidal distortion, being generated due to the oblique incidence, is extremely large in the direction of the oblique incidence, but the amount thereof is small in the direction perpendicular to this. Accordingly, between the direction of the oblique incidence and the direction perpendicular to this, there must be provided functions greatly different from each other, and it is possible to compensate or correct the asymmetric aberration, preferably, without using the curvature "c" nor the conic coefficient "k", being rotationally symmetric and functioning in all directions.

Also, in the table 4 mentioned above, "ADE" of the surface S23 is same to "θm" shown in Fig. 2, and "ADE" on the surface of the screen 5 is "θs", as is shown in Fig. 2 mentioned above. From the values of both of those, the condition mentioned above is satisfied or fulfilled, and therefore, there can be achieved an optic system, being compact, i.e., reducing the height below the screen.

Also, since the value of the difference |L1-L2| of the optical pat, which is

shown by the equation (Eq. 1) mentioned above, is 0.42 times large as the height of picture on the screen, and "θs" is 30 degrees, then the condition of the (Eq. 1) mentioned above is satisfied. The numerical values in the tables 1 to 4 are of the case when projecting the image of the region (12.16 × 0.84 mm) on the object surface (on a liquid crystal panel of a ration 16:9), enlargedly, upon a screen (60" + over-scan: 1452.8 × 817.2 mm). The distortion of that instance is shown in Fig. 10. The vertical direction in this Fig. 10 corresponds to the vertical direction shown in Fig. 8 mentioned above, and also corresponds to the direction of Y-axis in Fig. 2 mentioned above. And, the horizontal direction in this Fig. 8 corresponds to the direction perpendicular to the Y-axis on the screen, and a central portion of the oblong in the figure corresponds to the center of the screen. Further, this Fig. 10 shows the condition of curvature of each of straight lines, in particular, when displaying the screen while dividing it into four (4) in the vertical direction and eight (8) in the horizontal direction, and thereby showing the state or condition of graphic distortion.

Further, spot diagrams are shown in Fig. 11 attached herewith. In this Fig. 11 are shown the spot diagram of the light flux emitting from eight (8) points on the display screen of the image display element 5; i.e., (8, 4.5), (0, 4.5), (4.8, 2.7), (8, 0), (0, 0), (4.8, -2.7), (8, -4.5) and (0, -4.5) with the values of the X and Y coordinates, in the sequential order from the top (i.e., (1) to (8)). However, the unit thereof is "mm". The horizontal direction of each spot diagram corresponds to the X direction on the screen, while the vertical direction the Y direction on the screen. Both show that they maintain preferable performances.

In addition thereto, in case when assuming that the size is "Lo" of the projection image, which is obtained by the above-mentioned (for example, the screen 5 shown in Fig. 1), in the diagonal direction thereof, and that the distance is "Lp" from the center of the free curved surface mirror 4 up to the projection image (see Fig. 1 mentioned above), since Lo=1,524 mm, Lp=700 × cos 45°□495 mm, then the ratio between them comes to be greater than two (L0/Lp>2), therefore it can be seen that an object surface can be projected, enlargedly, onto the screen, being sufficiently large, even with a relatively near distance; i.e., being

superior in the ratio of enlarged projection.

<Embodiment 2>

Next, explanation will be made of a second embodiment by referring to Figs. 12 and 13 and tables 5 to 8. Herein, the front lens group 2 of the lens optic system is built up with the plural number of lenses, all of which have a refracting interface of rotationally symmetric configuration, and four (4) of the refracting interfaces of those lenses have aspheric surfaces, each being rotationally symmetric, and others have the spherical surfaces. The aspheric surface being rotationally symmetric, which is used therein, can be expressed by the equation (Eq. 2) mentioned above, with using a local cylindrical coordinates system for each surface.

Also, the free curved surfaces building up the rear lens group 3 of the lens optic system mentioned above can be expressed by the equation (Eq. 3) mentioned above, including polynomials of X and Y, with applying the local coordinates system (x, y, z) assuming the apex on each surface to be the origin.

The following table 5 shows lends data of the present embodiment including numerical values thereof, wherein the surface numbers starting from S0, presenting the object surfaces, sequentially, further from S1 to S23. In this table 1, "Rd" is also the radius of curvature for each surface, and "TH" is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface.

Table 5

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	7.65		
S3	210.000	4.65	1.85306	17.2
S4	-92.276	18.00		
S5*	-119.154	9.00	1.49245	42.9
S6*	-99.255	0.10		
S7	41.651	9.32	1.49811	60.9

S8	-43.298	2.50	1.76014	20.0
S9	29.535	0.10		
S10	29.472	9.00	1.49811	60.9
S11	-81.846	25.90		
S12	Infinity	9.10		
S13	-259.960	6.00	1.85306	17.2
S14	-54.061	65.00		
S15	-24.878	4.19	1.74702	33.2
S16	-64.884	9.00		
S17*	-20.009	10.00	1.49245	42.9
S18*	-28.982	2.50		
S19#	Infinity	8.00	1.49245	42.9
S20#	Infinity	20.51		
S21#	Infinity	8.00	1.49245	42.9
S22#	Infinity	159.95		
S23#	Infinity	-852.00	REFL	

In the table 5 mentioned above, S5, S6, S17 and S18 are aspheric surfaces, being rotationally symmetric, and also in this table 5, they are attached with "*" beside the surface numbers for easy understanding thereof, wherein coefficients of the aspheric surface of those four (4) surfaces are shown in the table 6 below.

Table 6

Surface	Aspheric Surface Coefficients							
S5	K	-23.3033479	C	-9.6351E-12	F	6.40059E-20	J	5.14145E-27
	A	-2.4809E-06	D	-3.1244E-14	G	-2.06E-22		
	B	6.68597E-09	E	1.70809E-16	H	-1.9587E-24		
S6	K	-7.9521673	C	-2.8461E-12	F	1.68916E-19	J	-4.2604E-27
	A	8.81129E-07	D	-4.2436E-16	G	-4.7764E-22		
	B	3.27597E-09	E	-2.4174E-17	H	3.1265E-24		
S17	K	1.294916014	C	-9.1246E-11	F	-8.1666E-19	J	-9.4083E-26
	A	-1.7719E-05	D	-1.8651E-13	G	-7.81036E-22		
	B	5.73314E-08	E	2.9427E-16	H	3.77766E-23		
S18	K	0.463935076	C	-1.1724E-11	F	1.23091E-19	J	-2.0819E-28
	A	-3.417E-06	D	-5.4303E-14	G	1.99428E-22		
	B	1.57331E-08	E	1.37371E-17	H	-3.49141E-25		

Also, S19 to S22 in the table 5 mentioned above are the refraction surfaces, each having the free curved surface configuration, which builds up the rear lens group of the lens optic system mentioned above, and S23 is the reflection surface having the free curved surface configuration S23 of the reflection optic system, wherein they are shown by attaching "#" beside the

surface numbers thereof. Values of the coefficients for presenting the configurations of those five (5) free curved surfaces are shown in the table 7 below.

Table 7

Surface	Free curved Surface Coefficients							
S19			C17	5.06259E-07	C34	-1.4837E-09	C51	-1.0027E-12
	K	0	C19	4.85077E-07	C36	1.31263E-09	C53	6.99745E-13
	C4	0.017559144	C21	-1.5853E-07	C37	1.83299E-12	C55	-1.6619E-12
	C6	0.001733207	C22	-5.42E-09	C39	-4.3583E-13	C56	-1.9766E-15
	C8	-0.00066382	C24	-1.5702E-08	C41	2.72981E-11	C58	1.40369E-15
	C10	-0.00013226	C26	-5.9063E-08	C43	3.0878E-11	C60	1.05828E-14
	C11	8.28618E-06	C28	-7.7982E-09	C45	2.26152E-11	C62	-8.9296E-14
	C13	1.03545E-06	C30	-1.0233E-10	C47	2.99348E-14	C64	7.84407E-14
	C15	8.99822E-06	C32	-8.8036E-07	C49	4.57827E-13	C66	-9.1078E-14
S20			C17	7.92636E-07	C34	-1.6758E-09	C51	-3.5813E-13
	K	0	C19	8.89146E-06	C36	1.45469E-09	C53	6.84539E-13
	C4	0.021458089	C21	-1.4324E-07	C37	-7.7649E-12	C55	-1.511E-12
	C6	0.004154169	C22	-1.0382E-09	C39	-2.0012E-12	C56	1.77674E-15
	C8	-0.00099953	C24	-1.4146E-08	C41	5.28532E-11	C58	5.96659E-15
	C10	-0.00011911	C26	-5.677E-08	C43	2.30872E-11	C60	-2.0891E-15
	C11	8.42605E-06	C28	6.05026E-09	C45	1.03045E-11	C62	-9.4541E-14
	C13	-6.6069E-06	C30	2.65443E-11	C47	-1.2622E-13	C64	1.01913E-13
	C15	-3.2455E-07	C32	-1.5185E-09	C49	7.4513E-13	C66	-8.0588E-15
S21			C17	-1.0996E-07	C34	6.726E-11	C51	-1.0707E-13
	K	0	C19	1.27907E-07	C36	7.7809E-10	C53	-6.8789E-14
	C4	0.016481821	C21	1.59073E-07	C37	1.78369E-12	C55	-1.3595E-12
	C6	0.009814027	C22	-2.3156E-09	C39	5.1641E-12	C56	-4.5963E-16
	C8	0.000360473	C24	-1.533E-10	C41	1.45879E-11	C58	-1.5431E-16
	C10	0.000256882	C26	6.12508E-09	C43	4.21499E-12	C60	-9.4112E-15
	C11	-1.2641E-06	C28	4.69033E-09	C45	2.24112E-11	C62	-1.7181E-14
	C13	-7.1071E-06	C30	-3.0818E-11	C47	5.4765E-14	C64	1.14179E-14
	C15	-2.6709E-05	C32	-3.7474E-10	C49	3.77477E-14	C66	-1.4481E-14
S22			C17	-4.2509E-07	C34	6.03428E-10	C51	-4.5666E-13
	K	0	C19	-2.8996E-07	C36	2.79273E-10	C53	-1.1058E-13
	C4	0.024865431	C21	1.2041E-08	C37	-1.9296E-12	C55	-5.1945E-13
	C6	0.013574823	C22	4.59025E-09	C39	-4.3532E-12	C56	5.15206E-16
	C8	0.000656946	C24	9.31761E-09	C41	-1.0393E-11	C58	1.80646E-15
	C10	0.00023588	C26	3.01345E-08	C43	-1.737E-11	C60	-1.4435E-16
	C11	-9.5439E-06	C28	2.56904E-08	C45	-6.9004E-13	C62	-1.1182E-14
	C13	-1.3485E-05	C30	1.87694E-10	C47	-2.2366E-16	C64	1.55635E-14
	C15	-3.0664E-05	C32	1.26944E-10	C49	-1.2748E-13	C66	-1.4201E-14
S23			C17	-9.3593E-10	C34	-4.9686E-14	C51	1.8026E-18
	K	0	C19	-6.409E-10	C36	-5.1319E-14	C53	-8.6197E-18
	C4	0.001494744	C21	3.91751E-10	C37	-8.103E-17	C55	1.1354E-17
	C6	0.001287983	C22	1.80884E-12	C39	5.19251E-16	C56	1.89778E-21
	C8	1.19776E-05	C24	-8.191E-12	C41	1.38639E-16	C58	-1.6083E-20
	C10	1.18228E-05	C26	-7.7154E-12	C43	-9.0016E-16	C60	9.98054E-21
	C11	-4.3922E-08	C28	9.92084E-14	C45	2.67935E-16	C62	4.42337E-21
	C13	3.28597E-08	C30	4.90899E-14	C47	-1.5465E-18	C64	-1.4286E-20
	C15	8.20779E-08	C32	-1.3332E-14	C49	1.58291E-18	C66	6.04404E-21

Further, in the following table 8 are shown the inclination of each surface

and magnitude of eccentricity according to the second embodiment. In this table 8, the definitions for showing the values of "ADE" and "YDE" are as was mentioned above. The inclination of each surface according to the present embodiment is almost same to that of the previous embodiment 1.

Table 8

Surface	ADE(°)	YDE(mm)
S0	-1.289	0.0
S15	0.0	-0.193
S17	0.0	0.193
S23	28.814	0.0

Further, in the table 8 mentioned above, from the "ADE(=θm)" of S23 and the "ADE(=θs)" of the screen surface 5, it is apparent that a compact optic system can be achieved, being small in the height below the screen, while fulfilling the condition mentioned above. Also, since the value of the difference |L1-L2| of the optical pat, which is shown by the equation (Eq. 1) mentioned above, is 0.43 times large as the height of picture on the screen, and "θs" is 30 degrees, then the condition of the (Eq. 1) mentioned above is satisfied.

On the other hand, in this second embodiment, as is shown in the table 8 mentioned above, S15 is shifted or offset by –0.193 mm, on the contrary thereto, the surface S17 is shifted or offset by 0.193 mm. In case when offsetting a certain surface, the optical axis is shifted by an amount of offsetting on the surfaces thereafter. Accordingly, the offsetting on this S15 and S17 means that one (1) piece of lens, which is made up with the surfaces S15 and S16, is offset by –0.193 mm from the optical axis. This amount of offsetting is very small, and it does not cause ill influence, such as, enlarging the size of the lens, for example. This eccentricity enables to achieve a fine adjustment on asymmetric chromatic aberration (or chromatism).

Also, as can be seen from the tables 4 and 6 mentioned above, according to the present embodiment, it is apparent that the curvature "c" and the conic coefficients "k" are "0". Thus, the trapezoidal distortion, being generated due to the oblique incidence, is extremely large in the direction of the oblique incidence, but

the amount thereof is small in the direction perpendicular to this. Accordingly, between the direction of the oblique incidence and the direction perpendicular to this, there must be provided functions greatly different from each other, and it is possible to compensate or correct the asymmetric aberration, preferably, without using the curvature “c” nor the conic coefficient “k”, being rotationally symmetric and functioning in all directions.

As an effective region of the second embodiment with such the numerical values mentioned above, the region on the object surface (ratio=16:9) is projected, enlargedly, upon the image surface (70” + over-scan:1694.9 × 953.4 mm), and the graphic distortion of that is shown in Fig. 12. The vertical direction in this Fig. 12 corresponds to the vertical direction shown in Fig. 2, and the Y-axis. The horizontal direction in this Fig. 12 corresponds to the direction perpendicular to the Y axis on the screen, and a central portion of the oblong in the figure corresponds to the center of the screen. Further, this shows the condition of curvature of each of straight lines, in particular, when displaying the screen while dividing it into four (4) in the vertical direction and eight (8) in the horizontal direction, and thereby showing the state or condition of graphic distortion.

Further, Fig. 13 shows spot diagrams according to the second embodiment. In this Fig. 13 are shown the spot diagram of the light flux emitting from eight (8) points on the display screen of the image display element 61; i.e., (8, 4.5), (0, 4.5), (4.8, 2.7), (8, 0), (0, 0), (4.8, -2.7), (8, -4.5) and (0, -4.5) with the values of the X and Y coordinates, in the sequential order from the top (i.e., (1) to (8)). The unit thereof is “mm”. The horizontal direction of each spot diagram corresponds to the X direction on the screen, while the vertical direction the Y direction on the screen. Thus, it is apparent that both of those maintain preferable performances.

Also, in this example, assuming that the size is “Lo” of the projection image obtained through the mentioned above, in the diagonal direction thereof and the distance is “Lp” from the center of the free curved surface mirror 4 up to the projection image, since Lo=1,524 mm, Lp=700 × cos 45°□495 mm, then the

ratio between them comes to be greater than two (L0/Lp>2), therefore it can be seen that an object surface can be projected, enlargedly, onto the screen, being sufficiently large, even with a relatively near distance; i.e., being superior in the ratio of enlarged projection.

<Embodiment 3>

Next, explanation will be made of a third embodiment, according to the present invention, by referring to Figs. 14 and 15 and tables 9 to 12. Herein, also the front lens group 2 of the lens optic system is built up with the plural number of lenses, all of which have a refracting interface of rotationally symmetric configuration, and four (4) of the refracting interfaces of those lenses have aspheric surfaces, each being rotationally symmetric, and others have the spherical surfaces. The aspheric surface being rotationally symmetric, which is used therein, can be expressed by the equation (Eq. 2) mentioned above, with using a local cylindrical coordinates system for each surface.

The free curved surfaces building up the rear lens group 3 of the lens optic system mentioned above can be expressed by the equation (Eq. 3) mentioned above, including polynomials of X and Y, with applying the local coordinates system (x, y, z) assuming the apex on each surface to be the origin.

The following table 9 shows lends data of the present embodiment including numerical values thereof, wherein the surface numbers starting from S0, presenting the object surfaces, sequentially, further from S1 to S23. In this table 1, “Rd” is also the radius of curvature for each surface, and “TH” is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface.

Table 9

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	5.00		
S3	69.501	4.65	1.85306	17.2

S4	-477.064	18.00		
S5*	-54.329	9.00	1.49245	42.9
S6*	-53.208	0.10		
S7	48.857	9.32	1.49811	60.9
S8	-29.376	2.50	1.76014	20.0
S9	40.402	0.10		
S10	40.607	9.00	1.49811	60.9
S11	-54.359	25.90		
S12	Infinity	9.10		
S13	2090.112	6.00	1.85306	17.2
S14	-66.019	65.00		
S15	-45.540	4.19	1.74702	33.2
S16	108.965	9.00		
S17*	-37.449	10.00	1.49245	42.9
S18*	-75.474	2.50		
S19#	Infinity	8.00	1.49245	42.9
S20#	Infinity	19.35		
S21#	Infinity	8.00	1.49245	42.9
S22#	Infinity	122.15		
S23#	Infinity	-605.00	REFL	

In this table 9, also the surfaces S5, S6, S17 and S18 are aspheric surfaces, being rotationally symmetric, and also in this table 9, they are attached with "*" beside the surface numbers for easy understanding thereof, wherein coefficients of the aspheric surface of those four (4) surfaces are shown in the table 10 below.

Table 10

Surface	Aspheric Surface Coefficients							
S5	K	-13.108806	C	1.46508E-11	F	-2.0555E-19	J	8.25281E-27
	A	-2.4809E-06	D	-3.1244E-14	G	-2.06E-22		
	B	1.95435E-08	E	-1.5302E-16	H	-7.5179E-25		
S6	K	-8.59084843	C	1.51155E-11	F	-1.6279E-19	J	1.22719E-20
	A	7.67114E-07	D	-4.743E-15	G	-1.8394E-21		
	B	9.20816E-09	E	-9.3745E-17	H	3.4992E-24		
S17	K	3.170476396	C	-4.2843E-12	F	1.18119E-18	J	2.06192E-26
	A	-8.7308E-06	D	1.96465E-13	G	-4.5716E-21		
	B	-3.8136E-08	E	7.89179E-16	H	-1.5681E-23		
S18	K	9.315246698	C	2.51005E-11	F	-5.9791E-20	J	3.13406E-28
	A	-4.2604E-06	D	3.09426E-14	G	-6.6563E-23		
	B	-1,5518E-08	E	-8.892E-18	H	7.14735E-26		

Also, S19 to S22 in the table 9 mentioned above are the refraction surfaces, each having the free curved surface configuration, which builds up the rear lens group of the lens optic system mentioned above, and S23 is the

reflection surface having the free curved surface configuration S23 of the reflection optic system, wherein they are shown by attaching "#" beside the surface numbers thereof. Values of the coefficients for presenting the configurations of those five (5) free curved surfaces are shown in the table 11 below.

Table 11

Surface	Free Curved Surface Coefficients							
S19			C17	3.43096E-07	C34	-2.7065E-10	C51	1.990777E-13
	K	0	C19	2.13857E-06	C36	1.31926E-09	C53	-5.2135E-12
	C4	0.00503963	C21	9.15856E-08	C37	2.1077E-12	C55	-2.1831E-12
	C6	0.020700865	C22	-1.9441E-09	C39	-6.1349E-11	C56	-3.3204E-15
	C8	-0.0007276	C24	-9.6181E-09	C41	-6.9182E-11	C58	1.52276E-14
	C10	-0.00062901	C26	2.71279E-09	C43	-1.1634E-10	C60	4.722E-14
	C11	4.83792E-06	C28	1.5813E-08	C45	1.55247E-11	C62	3.79581E-14
	C13	1.58097E-05	C30	-4.1204E-10	C47	1.79452E-14	C64	3.11821E-14
	C15	-1.9636E-05	C32	-2.3107E-09	C49	-6.0452E-13	C66	-1.876E-13
S20			C17	6.40078E-08	C34	-1.0668E-09	C51	-4.5767E-13
	K	0	C19	2.35312E-06	C36	-3.2106E-10	C53	-3.1387E-12
	C4	-0.00417899	C21	9.31605E-07	C37	1.82824E-12	C55	1.09346E-12
	C6	0.031326266	C22	-5.0811E-10	C39	-2.9101E-11	C56	-1.6513E-15
	C8	-0.00077771	C24	-3.1548E-08	C41	1.04208E-10	C58	8.47256E-15
	C10	-0.00097819	C26	-8.825E-08	C43	7.01421E-11	C60	-1.694E-15
	C11	2.05947E-06	C28	3.84368E-08	C45	-1.0493E-10	C62	-1.7011E-13
	C13	2.31241E-05	C30	-9.4717E-11	C47	2.95795E-14	C64	6.71828E-14
	C15	-3.0456E-05	C32	-8.4146E-10	C49	-7.9902E-13	C66	1.92712E-14
S21			C17	-1.4263E-07	C34	-1.7091E-10	C51	-4.2269E-14
	K	0	C19	-3.1384E-08	C36	-2.9029E-10	C53	2.21959E-14
	C4	0.016712489	C21	3.78605E-07	C37	2.14998E-13	C55	-9.5144E-15
	C6	0.024854646	C22	7.83561E-10	C39	1.12281E-12	C56	-1.3876E-16
	C8	0.000280556	C24	-1.1076E-09	C41	3.49849E-12	C58	-2.0224E-16
	C10	-5.99E-05	C26	-5.1644E-09	C43	2.81764E-12	C60	4.00029E-17
	C11	-4.5381E-06	C28	-1.9091E-09	C45	-1.5444E-12	C62	-4.1764E-15
	C13	-7.3701E-06	C30	2.60008E-11	C47	-3.3945E-15	C64	1.05212E-15
	C15	-1.0002E-05	C32	2.73923E-11	C49	2.75972E-14	C66	-3.6542E-15
S22			C17	-1.7327E-07	C34	-3.122E-10	C51	-3.8555E-14
	K	0	C19	-1.5061E-07	C36	-6.1374E-10	C53	2.368E-13
	C4	0.016645995	C21	5.38912E-07	C37	9.78887E-14	C55	1.87115E-13
	C6	0.021101685	C22	8.11263E-10	C39	1.08112E-12	C56	-9.9798E-17
	C8	0.00032094	C24	-1.1477E-10	C41	3.69407E-12	C58	-2.3837E-16
	C10	-5.1172E-05	C26	-4.8707E-09	C43	-5.8299E-13	C60	-2.2734E-16
	C11	-4.3183-06	C28	-1.1809E-09	C45	-3.7079E-12	C62	-3.0547E-15
	C13	-8.5909E-06	C30	3.39643E-11	C47	-2.9359E-15	C64	5.55175E-15
	C15	-1.0155E-05	C32	1.47622E-10	C49	-5.9302E-15	C66	-1.0145E-15
S23			C17	-2.203E-09	C34	8.2099E-14	C51	-1.2799E-17
	K	0	C19	2.39237E-09	C36	-4.3614E-14	C53	4.0335E-18
	C4	0.002149003	C21	1.39506E-09	C37	-1.7915E-16	C55	-3.2746E-18
	C6	0.000317113	C22	4.22192E-12	C39	1.80308E-15	C56	3.626098E-21
	C8	2.85992E-05	C24	-3.3322E-11	C41	-2.7999E-15	C58	-3.5037E-20
	C10	9.52914E-06	C26	1.45814E-11	C43	7.24461E-16	C60	6.79833E-20
	C11	-8.2644E-08	C28	1.00262E-11	C45	-1.0528E-15	C62	-3.7507E-20
	C13	2.89938E-07	C30	1.34005E-13	C47	-4.0973E-18	C64	5.06597E-21

	C15	1.20082E-07	C32	-3.6767E-13	C49	1.4053E-17	C66	5.93238E-21

Further, in the following table 12 are shown the inclination of each surface and magnitude of eccentricity according to the third embodiment. In this table 12, the definitions for showing the values of "ADE" and "YDE" are as was mentioned above.

Table 12

Surface	ADE(°)	YDE(mm)
S0	-2.000	0.0
S15	0.0	0.304
S17	0.0	-0.304
S23	35.000	0.0

From this table 12, it can be seen that this does not fulfill the condition mentioned above. However, with this third embodiment, it has the structures, being small in the depth thereof, i.e., having priority of the depth.

Also, as is shown in the table 12, similar to the embodiment 2 mentioned above, one (1) piece of lens, which is made up with the surfaces S15 and S16, is offset by –0.304 mm from the optical axis. This amount of offsetting is very small, and it does not cause ill influence, such as, enlarging the size of the lens, for example. This eccentricity enables to achieve a fine adjustment on asymmetric chromatic aberration (or chromatism).

Further, since the value of the difference |L1-L2| of the optical pat, which is shown by the equation (Eq. 1) mentioned above, is 0.62 times large as the height of picture on the screen, and "θs" is 45 degrees, then this satisfies the condition mentioned above.

Also, from the tables 9 and 11 mentioned above, according to this third embodiment, it is apparent that the curvature "c" and the conic coefficients "k" are "0". Thus, the trapezoidal distortion, being generated due to the oblique incidence, is extremely large in the direction of the oblique incidence, but the amount thereof is small in the direction perpendicular to this. Accordingly, between the direction of the oblique incidence and the direction perpendicular to this, there must be

provided functions greatly different from each other, and it is possible to compensate or correct the asymmetric aberration, preferably, without using the curvature “c” nor the conic coefficient “k”, being rotationally symmetric and functioning in all directions.

As an effective region of the second embodiment with such the numerical values mentioned above, the region on the object surface (ratio= 16 : 9) is projected, enlargedly, upon the image surface (50” + over-scan: 1210.7 × 681.0 mm), and the graphic distortion of that is shown in Fig. 14. The vertical direction in this Fig. 14 corresponds to the vertical direction shown in Fig. 2, and the Y-axis. The horizontal direction in this Fig. 14 corresponds to the direction perpendicular to the Y axis on the screen, and a central portion of the oblong in the figure corresponds to the center of the screen. Further, this shows the condition of curvature of each of straight lines, in particular, when displaying the screen while dividing it into four (4) in the vertical direction and eight (8) in the horizontal direction, and thereby showing the state or condition of graphic distortion.

Further, Fig. 15 shows spots diagrams according to the present embodiment of numerical values. In this Fig. 15 are shown the spot diagram of the light flux emitting from eight (8) points on the display screen of the image display element 61; i.e., (8, 4.5), (0, 4.5), (4.8, 2.7), (8, 0), (0, 0), (4.8, -2.7), (8, -4.5) and (0, -4.5) with the values of the X and Y coordinates, in the sequential order from the top (i.e., (1) to (8)). The unit thereof is “mm”. The horizontal direction of each spot diagram corresponds to the X direction on the screen, while the vertical direction the Y direction on the screen. Thus, it is apparent that both of those maintain preferable performances.

Also, in this example, assuming that the size is “Lo” of the projection image obtained through the mentioned above, in the diagonal direction thereof and the distance is “Lp” from the center of the free curved surface mirror 4 up to the projection image, since Lo=1,524 mm, Lp=700 × cos 45°□495 mm, then the ratio between them comes to be greater than two (L0/Lp>2), therefore it can be seen that an object surface can be projected, enlargedly, onto the screen, being

sufficiently large, even with a relatively near distance; i.e., being superior in the ratio of enlarged projection.

<Embodiment 4>

Explanation will be made of a fourth embodiment, according to the present invention, by referring to Figs. 16 and 17 and tables 13 to 16.

Herein. also the light emitting from the image display element 1 is reflected upon the reflection surface 4 of the reflection optic system, which has the free curved surface configuration, thereby to be incident upon the screen 5, after passing through in the order, i.e., the front lens group 2 of the lens optic system, which is built up with the transmission-type lenses having the rotationally symmetric surface configuration and the rear lens group of the lens optic system, which is built up with the transmission-type lenses having the free curved surface configuration.

Thus, herein, also the front lens group 2 of the lens optic system is built up with the plural number of lenses, all of which have a refracting interface of rotationally symmetric configuration, and four (4) of the refracting interfaces of those lenses have aspheric surfaces, each being rotationally symmetric, and others have the spherical surfaces. The aspheric surface being rotationally symmetric, which is used therein, can be expressed by the equation (Eq. 2) mentioned above, with using a local cylindrical coordinates system for each surface.

The free curved surfaces building up the rear lens group 3 of the lens optic system mentioned above can be expressed by the equation (Eq. 3) mentioned above, including polynomials of X and Y, with applying the local coordinates system (x, y, z) assuming the apex on each surface to be the origin.

The following table 13 shows lends data of the fourth embodiment including numerical values thereof, wherein the surface numbers starting from S0, presenting the object surfaces, sequentially, further from S1 to S23. In this table 1,

"Rd" is also the radius of curvature for each surface, and "TH" is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface.

Table 13

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	4.97		
S3	49.017	4.65	1.85306	17.2
S4	201.672	18.00		
S5*	-60.233	9.00	1.49245	42.9
S6*	-55.360	0.10		
S7	56.669	9.32	1.49811	60.9
S8	-27.651	2.50	1.76014	20.0
S9	46.949	0.10		
S10	47.407	9.00	1.49811	60.9
S11	-46.359	25.90		
S12	Infinity	9.10		
S13	-9457.081	6.00	1.85306	17.2
S14	-64.870	65.00		
S15	-42.429	4.19	1.74702	33.2
S16	137.716	9.00		
S17*	-34.874	10.00	1.49245	42.9
S18*	-63.364	2.50		
S19#	Infinity	8.00	1.49245	42.9
S20#	Infinity	19.55		
S21#	Infinity	8.00	1.49245	42.9
S22#	Infinity	121.95		
S23#	Infinity	-742.00	REFL	

In this table 13, "TH" is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface. The distance between the surfaces is presented by a positive value in case when the next lens surface is at the left-hand side (see Fig. 3), while by a negative value in case when it is at the right-hand side, with respect to that lens surface.

In this table 13, S5, S6, S17 and S18 are aspheric surfaces, being rotationally symmetric, and also in this table 13, they are attached with "*" beside the surface numbers for easy understanding thereof, wherein coefficients of the aspheric surface of those four (4) surfaces are shown in the table 14 below.

Table 14

Surface	Aspheric Surface Coefficients							
S5	K	-7.49933947	C	8.20794E-12	F	1.67212E-19	J	2.75191E-26
	A	-4.2871E-06	D	-3.3905E-14	G	1.22978E-22		
	B	1.47929E-08	E	5.30418E-18	H	-9.2584E-24		
S6	K	-5.10683146	C	2.31215E-12	F	1.4876E-19	J	1.4023E-26
	A	-4.215E-08	D	-8.8141E-15	G	-2.1285E-21		
	B	9.97857E-09	E	2.96852E-17	H	3.39217E-25		
S17	K	2.729972673	C	-6.3329E-11	F	-5.5239E-19	J	2.95633E-25
	A	-6.7402E-06	D	3.24143E-13	G	-2.1415E-20		
	B	-1.1095E-08	E	1.38117E-15	H	-4.6503E-23		
S18	K	5.628556104	C	2.5008E-11	F	-6.694E-20	J	4.08388E-28
	A	-1.8686E-06	D	1.72887E-14	G	-5.6024E-23		
	B	-1,1602E-08	E	-2.9081E-17	H	5.15556E-26		

Also, S19 to S22 in the table 13 mentioned above are the refraction surfaces, each having the free curved surface configuration, which builds up the rear lens group of the lens optic system mentioned above, and S23 is the reflection surface having the free curved surface configuration S23 of the reflection optic system, wherein they are shown by attaching "#" beside the surface numbers thereof. Values of the coefficients for presenting the configurations of those five (5) free curved surfaces are shown in the table 15 below.

Table 15

Surface	Free Curved Surface Coefficients							
S19			C17	3.06092E-07	C34	-1.504E-09	C51	1.89916E-12
	K	0	C19	2.13689E-06	C36	9.24213E-10	C53	-2.6408E-12
	C4	-0.00523704	C21	3.17855E-07	C37	2.73895E-12	C55	-2.2305E-12
	C6	0.022327058	C22	-2.18E-09	C39	-5.7332E-11	C56	-2.3991E-15
	C8	-0.00076156	C24	-1.35E-08	C41	-6.5197E-11	C58	2.74339E-14
	C10	-0.00059005	C26	-4.4124E-09	C43	-1.4335E-10	C60	9.09554E-14
	C11	4.88728E-06	C28	2.72086E-08	C45	-2.1121E-11	C62	2.42098E-14
	C13	1.92499E-05	C30	-4.0242E-10	C47	4.94771E-14	C64	1.85581E-13
	C15	-1.9167E-05	C32	-2.6688E-09	C49	5.78829E-13	C66	-1.2907E-13
S20			C17	4.41515E-08	C34	-2.1067E-09	C51	1.36481E-13
	K	0	C19	2.59357E-06	C36	-1.3645E-09	C53	-1.7814E-12
	C4	-0.00380713	C21	1.34672E-06	C37	2.5542E-12	C55	1.48598E-12
	C6	0.034310744	C22	-6.3335E-10	C39	-3.0724E-11	C56	-1.1411E-15
	C8	-0.00082075	C24	-3.2842E-08	C41	9.742992E-11	C58	1.71485E-14
	C10	-0.00096306	C26	-9.4354E-08	C43	5.80355E-11	C60	1.60064E-14
	C11	1.46478E-06	C28	5.63114E-08	C45	-1.3903E-10	C62	-1.6566E-13
	C13	2.57064E-05	C30	-1.5828E-10	C47	7.97383E-14	C64	1.4173E-13
	C15	-3.3719E-05	C32	-9.3186E-10	C49	-2.2316E-13	C66	5.3295E-14
S21			C17	-1.4847E-07	C34	-1.578E-10	C51	-3.1391E-14
	K	0	C19	-4.1463E-08	C36	-3.154E-10	C53	4.92021E-14
	C4	0.01628158	C21	3.75928E-07	C37	1.44753E-13	C55	-1.2229E-14
	C6	0.024536292	C22	8.73333E-10	C39	1.02001E-12	C56	-1.1929E-16

	C8	0.000287791	C24	-1.3318E-09	C41	4.04083E-12	C58	-1.9881E-16
	C10	-5.6467E-05	C26	-5.0191E-09	C43	2.15125E-12	C60	-1.1661E-16
	C11	-4.4889E-06	C28	-1.338E-09	C45	1.05501E-13	C62	-3.9789E-15
	C13	-7.4216E-06	C30	2.11331E-11	C47	-1.2171E-15	C64	1.92077E-15
	C15	-9.5063E-06	C32	3.73498E-11	C49	1.57629E-14	C66	-5.4374E-15
S22			C17	-1.7539E-07	C34	-2.5651E-10	C51	-3.1411E-14
	K	0	C19	-1.5271E-07	C36	-6.0608E-10	C53	2.14522E-13
	C4	0.016419443	C21	5.09788E-07	C37	1.26957E-13	C55	1.76045E-13
	C6	0.021115451	C22	7.02901E-10	C39	1.00917E-12	C56	-9.5762E-17
	C8	0.000323178	C24	-1.3689E-10	C41	3.91234E-12	C58	-2.6471E-16
	C10	-4.5525E-05	C26	-4.0137E-09	C43	-1.1163E-12	C60	-2.2728E-16
	C11	-4.138-06	C28	1.70813E-10	C45	-4.4694E-12	C62	-3.086E-15
	C13	-9.223E-06	C30	2.82551E-11	C47	-7.7346E-16	C64	5.99803E-15
	C15	-9.9105E-06	C32	1.42902E-10	C49	-1.20512E-14	C66	-1.1247E-15
S23			C17	-2.5231E-09	C34	7.66238E-14	C51	-2.3328E-17
	K	0	C19	2.58369E-09	C36	3.37658E-15	C53	1.85177E-17
	C4	0.002289792	C21	1.24861E-09	C37	-1.5632E-16	C55	-4.0416E-18
	C6	0.000330451	C22	4.81491E-12	C39	2.15761E-15	C56	1.15938E-21
	C8	3.09058E-05	C24	-3.7371E-11	C41	-3.7026E-15	C58	-3.3248E-20
	C10	1.02245E-05	C26	1.56104E-11	C43	1.35291E-15	C60	7.75597E-20
	C11	-9.5057E-08	C28	7.8498E-12	C45	-3.329E-16	C62	-8.1537E-20
	C13	3.1048E-07	C30	1.56487E-13	C47	-4.2776E-18	C64	8.41917E-20
	C15	1.27367E-07	C32	-4.1734E-13	C49	1.73654E-17	C66	-2.3609E-20

Further, in the following table 16 are shown the inclination of each surface and magnitude of eccentricity according to the second embodiment. In this table 16, the definitions for showing the values of “ADE” and “YDE” are as was mentioned above. The inclination of each surface according to the present embodiment is almost same to that of the previous embodiment 1.

Table 16

Surface	ADE(°)	YDE(mm)
S0	-2.000	0.0
S15	0.0	0.230
S17	0.0	-0.230
S23	35.000	0.0

Thus, from this table 16, it can be seen that this does not fulfill the condition mentioned above. However, with this third embodiment, it has the structures, being small in the depth thereof, i.e., having priority of the depth.

On the other hand, in this fourth embodiment, as is shown in the table 16, the surface S15 is offset by 0.23 mm, while offsetting the surface S17 by 0.23 mm contrarily. In case when offsetting a certain surface, the optical axis is shifted by an amount of offsetting on the surfaces thereafter. Accordingly, the offsetting on

this S15 and S17 means that one (1) piece of lens, which is made up with the surfaces S15 and S16, is offset by –0.193 mm from the optical axis. This amount of offsetting is very small, and it does not cause ill influence, such as, enlarging the size of the lens, for example. This eccentricity enables to achieve a fine adjustment on asymmetric chromatic aberration (or chromatism).

Further, since the value of the difference |L1-L2| of the optical pat, which is shown by the equation (Eq. 1) mentioned above, is 0.62 times large as the height of picture on the screen, and "θs" is 45 degrees, then this satisfies the condition of [Eq. 1] mentioned above.

Also, seeing from the tables 13 and 15 mentioned above, according to this fourth embodiment, it is apparent that the curvature "c" and the conic coefficients "k" are "0". Thus, the trapezoidal distortion, being generated due to the oblique incidence, is extremely large in the direction of the oblique incidence, but the amount thereof is small in the direction perpendicular to this. Accordingly, between the direction of the oblique incidence and the direction perpendicular to this, there must be provided functions greatly different from each other, and it is possible to compensate or correct the asymmetric aberration, preferably, without using the curvature "c" nor the conic coefficient "k", being rotationally symmetric and functioning in all directions.

As an effective region of the present embodiment, the region on the object surface (ratio= 16 : 9) is projected, enlargedly, upon the image surface (60" + over-scan: 1452.8 × 817.2 mm), and the graphic distortion of that is shown in Fig. 16. The vertical direction in this Fig. 16 corresponds to the vertical direction shown in Fig. 2, and the Y-axis. The horizontal direction in this Fig. 16 corresponds to the direction perpendicular to the Y axis on the screen, and a central portion of the oblong in the figure corresponds to the center of the screen. Further, this shows the condition of curvature of each of straight lines, in particular, when displaying the screen while dividing it into four (4) in the vertical direction and eight (8) in the horizontal direction, and thereby showing the state or condition of graphic distortion.

Further, Fig. 17 shows spots diagrams according to the present embodiment of numerical values. In this Fig. 17 are shown the spot diagram of the light flux emitting from eight (8) points on the display screen of the image display element 61; i.e., (8, 4.5), (0, 4.5), (4.8, 2.7), (8, 0), (0, 0), (4.8, -2.7), (8, -4.5) and (0, -4.5) with the values of the X and Y coordinates, in the sequential order from the top (i.e., (1) to (8)). The unit thereof is "mm". The horizontal direction of each spot diagram corresponds to the X direction on the screen, while the vertical direction the Y direction on the screen. Thus, it is apparent that both of those maintain preferable performances.

Also, in this example, assuming that the size is "Lo" of the projection image obtained through the mentioned above, in the diagonal direction thereof and the distance is "Lp" from the center of the free curved surface mirror 4 up to the projection image, since Lo=1,524 mm, Lp=700 $\times$ cos 45°$\fallingdotseq$495 mm, then the ratio between them comes to be greater than two (L0/Lp>2), therefore it can be seen that an object surface can be projected, enlargedly, onto the screen, being sufficiently large, even with a relatively near distance; i.e., being superior in the ratio of enlarged projection.

Next, Fig. 18 attached herewith shows the condition of projecting an image, enlargedly, upon a wall surface of a room or a sheet-like screen, etc., for example, by applying the projection optic unit, the details of which was mentioned above, into a projection-type image display apparatus, and further Fig. 19 attached herewith shows the problem in case when changing a projection distance, i.e., from the projection optic unit up to the screen. Thus, as is apparent from Fig. 19, in a manner of projecting an image, while inclining the optical axis to the screen with using the free curved surface, the graphic distortion becomes large when changing the projection distance largely from the distance designed, and also the spot size becomes large; i.e., the performance of resolution is deteriorated.

Figs. 20(a) and 20(b) attached herewith show the spot configuration and the condition of distortions, in particular, when the screen 5 is disposed at a

position 66 for reducing the projection screen (for example, corresponding to the 60" screen size), shifting from the designed position 65 (the screen size designed, for example, corresponding to 80" screen), as shown in Fig. 19. On the other hand, Figs. 21(a) and 21(b) attached herewith show those when it is disposed at a position 67 for enlarging the projection screen (for example, corresponding to the 100" screen size). As apparent from those Figs. 20(a) through 21(b), the magnitude of distortion increases up to about 2% of or more of the vertical width of the screen, and the stop configuration is enlarged, three (3) times large or more as when it is at the designed position; thus, deteriorating the performance of resolution.

However, with the increase of spots, it is impossible to bring them into preferable spot configuration thereof, in particular, all over the screen, even if shifting the position of the panel into front and back to fit the focus thereon. The reason of this lies in that, because the optic system is not rotationally symmetric, therefore when shifting the panel or the rotationally symmetric lens(es), to bring a portion on the screen into the focus, it rather destroys the focusing of the other portion, largely. Also, even if moving only the lenses 31 and 32 of the rear lens group, i.e., the free curved surface lenses, it is still impossible to compensate or correct that spot configuration. This is because there is necessity of a power of a lens, which is rotationally symmetric, for compensating the distortion accompanying movement of the screen.

Then, upon basis of the embodiment mentioned above, as a result of searching on lenses to have an effect for improvement of the distortion of the spot configuration and/or the resolution performance, with moving the lens corresponding to the movement of the screen position, then it is found that, in particular, it is effective to move the lenses 33 and 34 (see Figs. 2 and 6 mentioned above), both having a negative power and building up the rear lens group mentioned above, into the direction of the optical axis thereof, respectively and independently, by a predetermined distance. Further, it is also effective to move the mirror 4 having the free curved surface mentioned above. However, because of a large number of difficulties for moving the mirror 4 having the free

curved surface, which is relatively large in the size, judging from the structures of the apparatus, it is most effective, in particular, to move the lenses 31-34, building up the rear lens group 3 mentioned above.

Figs. 22(a) to 22(c) attached herewith show the conditions when moving the lens building up the rear lens group 3, i.e., the transmission lens 31 having the free curves surface, and the other transmission lens 32 having the free curved surface, and further the rotationally symmetric lenses 33 and 34, each having a negative power, to the predetermined positions thereof. In more details, Fig. 22(a) shows the condition when disposing the screen at the position 66 in the direction for reducing the projection screen (for example, corresponding to the 60" screen size), Fig. 22(b) the condition when disposing the screen at the designed position 65 (for example, corresponding to the 80" screen size), and Fig. 22(c) the condition when disposing the screen at the position 67 in the direction for enlarging the projection screen, respectively, in Fig. 19 mentioned above. Thus, within this embodiment, an adjustment is made for the movement of the screen position, by moving those lens groups, into the direction of the optical axis thereof, i.e., including a lens group unifying the negative power lens building up the rear lens group mentioned above and the lenses in the vicinity thereof, which are rotationally symmetric, as a unit, and also those two (2) pieces of the transmission lens having the free curved surface, each building up one lens group, respectively.

Further, as was mentioned above, the structures for moving the lenses 31 to 34 for building up the rear lens group 3 mentioned above comprises, for example, as shown in Fig. 23(a) attached herewith, on two (2) sets of mounting bases 210 and 220 are mounted the above-mentioned front lens group 2 (the rotationally symmetric lenses 21-25) and the above-mentioned rear lens group 3 (lenses 31-34), respectively. However, upon one of the mounting bases (for example, the mounting base 210) are fixed the above-mentioned front lens group 2 (the rotationally symmetric lenses 21-25) at the predetermined positions thereof, and that mounting base 210 is installed within the apparatus. And, on the other mounting base (for example, the mounting base 220) are formed grooves 221, 222 and 223, in advance, and also that mounting base 220 is installed within the

apparatus to be movable with respect to the mounting base 210 mentioned above (in this example, being movable in the direction perpendicular to that of the optical axis of the lens groups, as is shown by an arrow in the figure).

However, with the lenses 31-34 building up the rear lens group 3 mentioned above, as is shown in Figs. 23(b), the lenses 33 and 34 are unified as a body, in other words, they are divided into three (3), i.e., the lens 31, the lens 32 and the lenses 33 and 34, and the respective positions thereof are moved or shifted, corresponding to the sizes of the screen, which can be obtained through projection onto the screen (i.e., 60", 80", and 100"). Thus, those grooves 221, 222 and 223 are formed at a desired inclining angle for each of the lens groups. With such the structures as was mentioned above, by moving a rod member 231, projecting from the movable mounting base 220 into an outside of the housing, to the positions, at which marks, such as, 60", 80" and 100", or the like, are attached or formed on a surface of the housing 110 in advance, the three (3) groups of lenses, i.e., the lens 31, the lens 32 and the lenses 33 and 34 move, respectively, along with the grooves 221, 222 and 223, and thereby being disposed at the desired positions thereof. Thus, with such the structures, it is possible to change the sizes of the projection image, without deteriorations in distortion of the spot configuration or resolution power or performance, from an outside of the projection-type image display apparatus, by shifting a tip of the rod-like member 321 mentioned above into the direction of an arrow in the figure.

Alternatively, in the place of such the structures as was mentioned above, it is also possible to achieve the effect similar to that mentioned above, with using a cylinder, on an outer periphery of which are formed such the grooves as mentioned above, for example. However, in such the case, in particular, it is not necessary for the two (2) pieces of transmission lenses 31 and 32, each having the free curved surface within the rear lens group 3, to be accompanied with rotation thereof, irrespective of the change of relative positions thereof in the direction of the optical aids. For this reason, it is preferable, for example, the cylindrical member is divided into a top end side and a rear end side, i.e., each being rotatable independently, but the top end side cannot rotate, within the

structures thereof. Further, with using a driving means including an electric motor therein, for example, it is also possible to adopt the structures, so that the rear lens group 3 (i.e., the lenses 31-34) can be move, respectively. Thus, with this, it is possible to obtain an effect of achieving an improvement in the distortion of spot configuration and/or the resolution power or performance, corresponding to changes of position of the screen, on which the image is projected (i.e., the distance from the apparatus to the screen).

Following to the above, lens data of the embodiment mentioned above will be shown hereinafter, by referring to the following tables 17-21 and Figs. 24 to 26.

Herein also, the equation for the free curved surface is same to the [Eq. 2] mentioned above. And, the numerical values in the following tables 17-20 are those for showing an example of projecting the image within a region on the object surface (ratio=16:9) onto the image surface (60" + over-scan: 1841.9 × 1036.1 mm), enlargedly. Also, the lens surfaces of the optical elements within the projection optic unit in this case will be shown in Fig. 24. However, differing from those embodiments mentioned above, the lens surfaces indicated by S9 and S10 in Fig. 4 mentioned above, according to the present embodiment, are unified as one body, in this Fig. 21, and therefore they are built up with the surfaces S0 to S22.

In the table 17, "Rd" is the radius of curvature for each surface, and it is presented by a positive value in case when having a center of curvature on the left-hand side of the surface in the figure, while by a negative value in case when having it on the right-hand side, contrary to the above. Also, "TH" is the distance between the surfaces, i.e., presenting the distance from the apex of the lens surface to the apex of the next lens surface. The distance between the surfaces is presented by a positive value in case when the next lens surface is at the left-hand side, while by a negative value in case when it is at the right-hand side, with respect to that lens surface. Further, in this table 17 mentioned above, S5, S6, S16 and S17 (see Fig. 4 mentioned above) are aspheric surfaces, being rotationally symmetric, and also in the table 17, they are attached with "*" beside

the surface numbers for easy understanding thereof. Further, coefficients of the aspheric surface of those four (4) surfaces are shown in the table 18 below.

Table 17

Surface	Rd	TH	nd	νd
S0	Infinity	7.600		
S1	Infinity	22.200	1.51827	48.0
S2	Infinity	7.343		
S3	62.278	4.500	1.85306	17.2
S4	-266.980	19.016		
S5*	-51.942	5.000	1.49245	42.9
S6*	-47.349	0.100		
S7	32.165	11.700	1.48876	52.8
S8	-32.506	2.246	1.85306	17.2
S9	33.772	10.500	1.48876	52.8
S10	-42.116	18.784		
S11	Infinity	6.916		
S12	198.090	5.500	1.85306	17.2
S13	-59.931	41.959		
S14	-20.939	3.200	1.74702	33.2
S15	134.847	4.782		
S16*	-27.918	6.000	1.49245	42.9
S17*	-31.695	6.437		
S18#	Infinity	6.000	1.49245	42.9
S19#	Infinity	11.138		
S20#	Infinity	6.000	1.49245	42.9
S21#	Infinity	91.557		
S22#	Infinity	-996.000	REFL	

Table 18

Surface	Aspheric Surface Coefficients							
5	K	-19.19	C	1.6E-10	F	1.19E-17	J	1.28E-24
	A	-1.3E-05	D&	-8.9E-13	G	1.59E-19		
	B	7.24E-08	E	-3.5E-15	H&	-8.8E-22		
6	K	-14.7411	C	1.79E-10	F	2.48E-17	J	3.16E-25
	A	-6.9E-06	D&	-1.1E-12	G	-3.2E-20		
	B	6.14E-08	E	-1.8E-15	H&	-1.4E-22		
16	K	-2.80795	C	-3.6E-10	F	-6.5E-17	J	4.91E-24
	A	-1.18E-05	D&	2.15E-13	G	-8.8E-19		
	B	-2.2E-07	E	2.24E-14	H&	6.62E-22		
17	K	-3.04559	C	-1.3E-11	F	-6.7E-18	J	1.47E-25
	A	7.14E-06	D&	8.97E-13	G	-2.7E-20		
	B	-1.5E-07	E	8.7E-17	H&	-3.1E-23		

Also, S18 to S21 in the table 17 mentioned above are the refraction surfaces, each having the free curved surface configuration, which builds up the rear lens group of the lens optic system mentioned above, and S22 is the reflection surface having the free curved surface mirror, wherein they are shown by attaching "#" beside the surface numbers thereof. Values of the coefficients for presenting the configurations of those five (5) free curved surfaces are shown in the table 19 below.

Next, in the table 19 below, the name and the value of each coefficient are shown in a combination of frames alighting left and right, wherein the right-hand side is the value of the coefficient and the left-hand side the name, wherein a set of the numerical values divided by a comma within parenthesis presents the values "m" and "n" shown in the [Eq. 2] mentioned above.

Table 19

Surface	Free c Curved Surface Coefficients							
18			C(4,1)	1.66E-06	C(2,5)	-6.4E-09	C(4,5)	2.8E-12
	K	0	C(2,3)	2.53E-06	C(0,7)	7.43E-09	C(2,7)	5.2E-11
	C(2,0)	-0.01616	C(0,5)	1.98E-06	C(8,0)	-4.6E-11	C(0,9)	-2E-11
	C(0,2)	-0.1788	C(6,0)	4.65E-08	C(6,2)	-2.1E-10	C(10,0)	-1.7E-13
	C(2,1)	-0.00075	C(4,2)	-5.3E-09	C(4,4)	-9.1E-10	C(8,2)	4.71E-13
	C(0,3)	-0.00079	C(2,4)	2.61E-08	C(2,6)	-3E-10	C(6,4)	2.11E-12
	C(4,0)	9.37E-06	C(0,6)	-4.1E-08	C(0,8)	1.55E-10	C(4,6)	2.48E-12
	C(2,2)	2.32E-05	C(6,1)	-5.2E-09	C(8,1)	1.38E-12	C(2,8)	1.11E-12
	C(0,4)	3.49E-05	C(4,3)	-1.6E-08	C(6,3)	5.41E-11	C(0,10)	-3.6E-13
19			C(4,1)	3.72E-07	C(2,5)	1.86E-09	C(4,5)	-8.4 E-12
	K	0	C(2,3)	7.05E-07	C(0,7)	6.3E-09	C(2,7)	1.61E-11
	C(2,0)	-0.1514	C(0,5)	5.2E-07	C(8,0)	2.16E-12	C(0,9)	-6.2E-12
	C(0,2)	-0.01501	C(6,0)	3.39E-12	C(6,2)	-2.8E-12	C(10,0)	-1.2E-13
	C(2,1)	-0.00072	C(4,2)	-1E-08	C(4,4)	-2.8E-10	C(8,2)	5.85E-14
	C(0,3)	-0.00078	C(2,4)	-5.5E-08	C(2,6)	1.8E-10	C(6,4)	7.4E-13
	C(4,0)	4.19E-06	C(0,6)	-1.1E-07	C(0,8)	2.33E-10	C(4,6)	4.42E-13
	C(2,2)	2.77E-05	C(6,1)	-9.1E-10	C(8,1)	-1.6E-12	C(2,8)	7.55E-15
	C(0,4)	3.81E-05	C(4,3)	-5.8E-09	C(6,3)	2.17E-11	C(0,10)	2.57E-13
20			C(4,1)	-8.8E-07	C(2,5)	2.22E-09	C(4,5)	-2.3E-12
	K	0	C(2,3)	-6.1E-07	C(0,7)	-1.9E-09	C(2,7)	1.21E-12
	C(2,0)	0.027017	C(0,5)	-2E-07	C(8,0)	1.23E-12	C(0,9)	1.01E-13
	C(0,2)	0.013975	C(6,0)	7.2E-10	C(6,2)	2.59E-11	C(10,0)	-1.4E-16
	C(2,1)	0.00078	C(4,2)	-2E-08	C(4,4)	6.17E-11	C(8,2)	-2.1E-14
	C(0,3)	0.000502	C(2,4)	-8.2E-09	C(2,6)	1.19E-10	C(6,4)	-1.7E-14
	C(4,0)	-6.8E-06	C(0,6)	-3.4E-08	C(0,8)	7.66E-12	C(4,6)	-1.1E-13
	C(2,2)	-1.9E-06	C(6,1)	4.75E-10	C(8,1)	4.11E-14	C(2,8)	-5.5E-14
	C(0,4)	-2.1E-05	C(4,3)	1.45E-09	C(6,3)	-8.3E-13	C(0,10)	3.29E-14
21			C(4,1)	-1.3E-06	C(2,5)	3.4E-09	C(4,5)	-2.6E-12
	K	0	C(2,3)	-9.9E-07	C(0,7)	-1.7E-09	C(2,7)	-9.2E-13
	C(2,0)	0.028429	C(0,5)	-6.1E-07	C(8,0)	2.33E-12	C(0,9)	1.91E-12
	C(0,2)	0.011865	C(6,0)	8.35E-10	C(6,2)	2.38E-11	C(10,0)	-5.5E-16
	C(2,1)	0.001007	C(4,2)	-1.8E-08	C(4,4)	5.95E-11	C(8,2)	-2.2E-14
	C(0,3)	0.000596	C(2,4)	1.32E-08	C(2,6)	6.51E-11	C(6,4)	-2.8E-14
	C(4,0)	-7.9E-06	C(0,6)	-6.9E-09	C(0,8)	-5.8E-11	C(4,6)	-8.9E-14
	C(2,2)	-2.8E-06	C(6,1)	9.14E-10	C(8,1)	-1.1E-13	C(2,8)	-4.5E-14
	C(0,4)	-2.8E-05	C(4,3)	2.2E-09	C(6,3)	-1.5E-12	C(0,10)	1.23E-13
22			C(4,1)	-1.55E-08	C(2,5)	-3.17E-12	C(4,5)	-8.31E-17
	K	0	C(2,3)	1.79E-09	C(0,7)	1.00E-12	C(2,7)	-8.62E-16
	C(2,0)	0.003857	C(0,5)	5.04E-09	C(8,0)	-6.30E-15	C(0,9)	2.81E-16
	C(0,2)	0.001542	C(6,0)	5.14E-11	C(6,2)	5.88E-14	C(10,0)	2.50E-19
	C(2,1)	6.83E-05	C(4,2)	-3.38E-10	C(4,4)	-1.90E-14	C(8,2)	-3.80E-18
	C(0,3)	3.28E-05	C(2,4)	-1.19E-10	C(2,6)	-6.92E-14	C(6,4)	7.75E-18
	C(4,0)	-3.7E-07	C(0,6)	4.08E-11	C(0,8)	2.52E-14	C(4,6)	-4.39E-18
	C(2,2)	7.66E-07	C(6,1)	2.63E-12	C(8,1)	-2.66E-16	C(2,8)	-1.82E-18
	C(0,4)	4.96E-07	C(4,3)	-4.13E-12	C(6,3)	8.19E-16	C(0,10)	3.67E-19

Further, in the following table 20 are shown the inclination of each surface and magnitude of eccentricity according to this embodiment. However, in this table 20, "ADE" indicates the magnitude of inclination upon the surface in parallel with the cross-section of the figure, and it is assumed that the direction of inclination is positive when it rotates into the clockwise direction upon the cross-section surface in the figure, and is shown by the unit of degree. Also, "YDE" indicates the magnitude of eccentricity or offset, and this eccentricity or offset is set up on the

cross-section surface of the figure and also in the direction perpendicular to the optical axis, assuming that it is positive when offsetting below.

Table 20

Surface	ADE(°)	YDE(mm)
S3	3.251	1.647
S22	33.000	0.0

With the inclination or the eccentricity shown in this table 20, all of the surfaces after that, including the surface number shown therein, are disposed on the inclined optical axis on the surface displayed. However, the inclination of the surface S22 indicates only the inclination of the optical axis on the 22nd surface, and the 23rd surface thereafter is disposed on the optical axis, which is inclined two (2) times large in the amount of inclination of the 22nd surface.

The following table 21 shows changes the distances between the surfaces thereof, in particular, with the lens group, which are moved responding to the movement of the screen position.

Table 21

Surface	TH		
	Sc65	Sc67	Sc66
S13	41.959	41.935	41.991
S17	6.437	7.841	4.000
S19	11.138	10.169	12.785
S21	91.557	91.145	92.314
S22	-996.000	-1259.800	-732.335

Where, the values in the columns corresponding to “Sc65”, “Sc67” and “Sc66” in this table 9 indicate the distances between the lenses at the screen positions 65, 67 and 66.

Also, Figs. 25(a) to 25(c) attached herewith show situations of the distortions in cases where the screen is located at the positions 66, 65 and 67 in Fig. 19 mentioned above, respectively, and Fig. 26 attached herewith shows the conditions of the spot configurations in such the cases.

Thus, Figs. 25(a) to 25(c) show the graphic distortions in cases when projecting the region (12.16 × 0.84 mm) on the object surface (ratio = 16:9), enlargedely, onto the image surfaces of 60", 80" and 100", respectively. The vertical direction in those Figs. 25(a) to 25(c) corresponds to the up-down direction, i.e., the Y-axis direction, in Fig. 2 mentioned above. Also, the horizontal direction in those Figs. 26(a) to 26(c) corresponds to the direction perpendicular to the Y-axis on the screen, wherein the center of the oblong in the figure is the center of the screen. And, those Figs. 25(a) to 25(c) show the condition of the graphic distortions by showing the condition of curvatures of the straight lines on the screen, which are divided into four (4) in the vertical direction and eight (8) in the horizontal direction.

On the other hand, Fig. 26 shows the spot diagrams, which are obtained when disposing the screen at the positions 66, 65 and 67 (see Fig. 19 mentioned above), respectively. Further, in this figure are shown the spot diagram of the light flux emitting from eight (8) points on the display screen of the image display element 5; i.e., (8, 4.5), (0, 4.5), (4.8, 2.7), (8, 0), (0, 0), (4.8, -2.7), (8, -4.5) and (0, -4.5) with the values of the X and Y coordinates, in the sequential order from the top (i.e., (1) to (8)), and also, in the horizontal direction thereof are shown the screen positions (i.e., Sc66, Sc65 and Sc67) at the respective positions 66, 65 and 67. Moreover, the unit thereof is "mm", and the horizontal direction on each of the spot diagrams corresponds to the X-direction on the screen, and the vertical direction thereof to the Y-direction on the screen. Thus, as is apparent from those figures, it can be seen that both can maintain the preferable performances, in any case thereof.

And, in case of assuming that the size is "Lo" of the projection image obtained through the mentioned above, in the diagonal direction thereof, and the distance is "Lp" from the center of the free curved surface mirror 4 up to the projection image, since Lo=1,524 mm, Lp=700 × cos 45°□495 mm, then the ratio between them comes to be greater than two (L0/Lp>2), therefore it can be seen that an object surface can be projected, enlargedly, onto the screen, being sufficiently large, even with a relatively near distance, i.e., being superior in the

ratio of enlarged projection.

Next, Fig. 27 attached herewith shows the projection-type image display apparatus, according to other embodiment of the present invention. Thus, as is apparent from the figure, within the projection-type image display apparatus 100' according to this other embodiment, in addition to the element of projection optic unit, which is shown in Fig. 1 or 5 mentioned above, there is further provided a plane reflection mirror 21 on the optical path between that free curved surface reflection mirror 4 and the screen 5, thereby building up the projection optic unit. However, in the example shown in the figure, this plane reflection mirror 21 is provided in an upper portion thereof, to be freely opened/closed, as well as, functioning as a cover, in common, for covering over an opening portion, which is formed on the upper surface of the housing 110 of the apparatus corresponding to the reflection mirror of the free curved surface mentioned above.

With such the constructions of the projection optic unit mentioned above, as is shown in Fig. 28 attached herewith, the lights emitting from the image display element 1 through the prism 10 enters into the front lens group 2 building up the lens optic system. Thereafter, the lights emitting from this front lens group 2 also pass through the rear lens group 3, being build up with a plural number of lenses, including a plural number (two (2) pieces in the present example), each having the configuration of free curved surface, not being rotationally symmetric (rotationally asymmetric) on at least one of the surfaces thereof. And, after being reflected, enlargedly, upon the reflection optic system, including the reflection mirror (hereinafter, being called the "free curved surface mirror") 4 having the free curved surface configuration, not being rotationally symmetric, the lights emitting from this rear lens group 3 is further reflected upon the plane reflection mirror 21 mentioned above, thereby to be projected upon the screen 5 predetermined (for example, the wall surface of a room or the sheet-like screen, etc.). Thus, as is apparent from this figure, it is projected into the opposite direction to that of the embodiments mentioned above (for example, shown in Fig. 2 or 4). Also from this, with the constructions of the projection optic unit of the projection-type image display apparatus 100' according to this other embodiment, since the optical path from the

free curved surface mirror 4 to the screen is bent by means of the plane reflection mirror 21 mentioned above, it is possible to make the distance up to the screen 5 small, and thereby it is preferable for obtaining the wide view angle.

Also, with the structures of this projection optic unit, as shown by broken lines in Fig. 28, the plane reflection mirror 27 is made to be adjustable by a very fine angle in the inclination angle thereof. Thus, with this, also as shown by the broken lines and arrows in the figure, it is possible to change the position of the projection image, vertically (up and down) upon the screen 5, by changing the inclination angle of this plane reflection mirror 27, and this enable to provide a preferable function, in particular, for the projection-type image display apparatus. Further, this plane reflection mirror 27 is adjustable in the inclination angle thereof, for a user, depending upon the using condition of said projection-type image display apparatus, or alternately though not shown in the figure herein, but it is also possible to construct, so that it moves (or rises up) from the position for covering over the opening portion on the upper surface of the housing 110 and thereby to be disposed inclining at an angle preset by the user, by means of a driving mechanism, for example, including an electric motor, etc.

However, with the projection-type image display apparatus mentioned above, according to the embodiment of the present invention, the image (or the picture) from the image display element 1, emitting from the projection optic unit mentioned above, is reflected upon the free curved surface mirror 4, or alternately, it is further reflected upon the plane reflection mirror 27, to be projected upon the screen 5. For this reason, it is necessary to determine or locate the position of the said apparatus 100 or 100', correctly, with respect to the screen 5, upon which the image (or the picture) should be projected. Thus, it is important to make an adjustments on the arrangements, so that a beam of light at the center of the image shown in Fig. 5 mentioned above comes up to be vertical or perpendicular with respect to the surface of the screen 5, in particular, for obtaining a preferable projection image, with suppressing the distortion and/or aberration as a whole thereof.

Then, the projection-type image display apparatus according to the embodiment of the present invention includes a positioning mechanism for that apparatus in a part thereof, and an explanation will be given below, about an example of the details thereof.

Figs. 29(a) to 29(c) show the projection-type image display apparatus 100, including the positioning mechanism mentioned above, and in particular, Fig. 29(a) shows a perspective view of the projection-type image display apparatus 100 including the positioning mechanism, seeing from an upper surface thereof, Fig. 29(b) the perspective view of the said apparatus from the bottom surface thereof, and Fig. 29(c) an enlarged c-c cross-section in Fig. 29(b), respectively.

Thus, as is shown in Fig. 29(b), on the bottom surface of the housing 110 of the projection-type image display apparatus 100 are provided the followings; i.e., a center stopper 113, being made of an elastic material, such as, rubber, etc., into a conic shape, for example, is attached at the central portion thereof, neighboring to an edge portion in direction of light projection (i.e., the right-hand direction in the figure), while in the vicinity of both ends thereof, neighboring to an edge portion at the opposite side of the edge portion mentioned above, there are provided a pair of moving members 114 and 114, each being made from a rotating ball, for example.

However, in each of the pair of moving members 114 and 114, as is also shown in Fig. 29(c), a ball 116 is held within a receiving hole 115, which is formed on a bottom surface of the housing 110, and further, within an inside of that housing 110 is provided a restriction member (or a suppression member) 117, for stopping the rotation of the ball 116 mentioned above, accompanying the movement thereof into the direction of an arrow. Thus, pressing down of the restriction member (or the suppression member) 117 in the figure by a user (but, Fig. 29(c) shows it upside down) pushes the ball 116 onto an interior wall surface of the receiving hole 115, and thereby stopping the rotation thereof.

An example of the method of using the positioning mechanism mentioned above will be shown in Fig. 29(a). First of all, under the condition of shifting the

restriction member (or the suppression member) 117 upwards (i.e., brining the ball 116 into rotatable condition), the projection-type image display apparatus 100 is disposed in parallel on a disk or the like, for example, while directing the bottom surface of the housing 110 thereof downwards. And, as is shown by an arrow in the figure, the said apparatus 100 (100') is moved, rotating around the stopper 113 mentioned above, by pushing on a side surface thereof, etc., while projecting the image (or the picture) on the screen 5. And, at the time point when the projection-type image display apparatus 100 comes up to a desired angular position with respect to the screen 5, the pair of moving members 114 and 114 are pushed down, which are provided on both side-surfaces of the housing 110 of that apparatus. Thus, with the projection-type image display apparatus 100 equipped with the positioning mechanism mentioned above, it is possible to determine the position, correctly, with respect to the screen 5, with a simple manner, with the operations mentioned above, and further, with providing the moving mechanism, appropriately, for the plane reflection mirror 21 and/or the rear lens group 3 mentioned above, it is also possible to obtain a preferable projection image, with suppressing the distortion and the aberration down to the minimum as a whole thereof.

As was mentioned in the above, according to the present invention, because of no necessity of offsetting the lens(es) to be applied therein, as is shown in the conventional art mentioned above, it is possible to provide the projection-type image display apparatus for enabling the wide angle of view, but without necessity of providing the additional optic system having large aperture, also suppressing the distortion down to the minimum even when changing the position or distance up to the screen, and further being relatively easy in manufacturing thereof. And, with such the projection-type image display apparatus, it is possible to achieve a projection-type image display apparatus for enabling to obtain a preferable projection image, with suppressing the distortion and the aberration down to the minimum as a whole thereof, as well as, being superior in the operability thereof.

While we have shown and described several embodiments in accordance

with our invention, it should be understood that disclosed embodiments are susceptible of changes and modifications without departing from the scope of the invention. Therefore, we do not intend to be bound by the details shown and described herein but intend to cover all such changes and modifications that fall within the ambit of the appended claims.

What is claimed is:

1. A projection type image display apparatus, comprising:

an image display element;

a first lens group, being disposed in a light direction with respect to said image display element, which is configured to include a plural number of lenses;

a second lens group, being disposed in a light direction with respect to said first lens group, which is configured to include a plural number of lenses;

a reflection mirror, which is configured to reflect lights emitted from at least one of said first and second lens groups, so as to project upon said screen obliquely;

a first mounting base, on which said first lens group is mounted;

a second mounting base, on which said second lens group is mounted; and

a chassis, which is configured to store said first and second lens group, said reflection mirror, and said first and second mounting bases;

wherein said first mounting base is fixed at a bottom of said chassis, while said second mounting base is moveable.

2. The projection type image display apparatus, according to claim 1, wherein an optical axis of said first and second lens group is inclined to a normal line at a center of a surface of said image display element.

3. The projection type image display apparatus, according to claim 1, further comprising:

a rod member, which makes said second mounting base movable.

4. The projection type image display apparatus, according to claim 3, further comprising:

a slit portion being formed on an upper portion of said chassis;

wherein said rod member is projected from said slit portion.

5. The projection type image display apparatus, according to claim 3, wherein said rod member moves said second mounting base into an optical axis direction of said first and second lens groups.

6. The projection type image display apparatus, according to claim 1, further comprising:

a rotational portion, which is configured to rotate said first and second lens groups.

ABSTRACT OF THE DISCLOSURE

A projection type image display apparatus includes an image display element, a first lens group disposed in a light direction with respect to the image display element and configured to include a plurality of lenses, a second lens group disposed in a light direction with respect to the first lens group and configured to include a plurality of lenses, a reflection mirror, configured to reflect lights emitted from the first and/or second lens groups so as to project upon the screen obliquely, a first mounting base on which the first lens group is mounted, a second mounting base on which the second lens group is mounted, and a chassis configured to store the first and second lens groups, the reflection mirror, and the first and second mounting bases. The first mounting base is fixed at a bottom of the chassis, while the second mounting base is moveable.

FIG.1

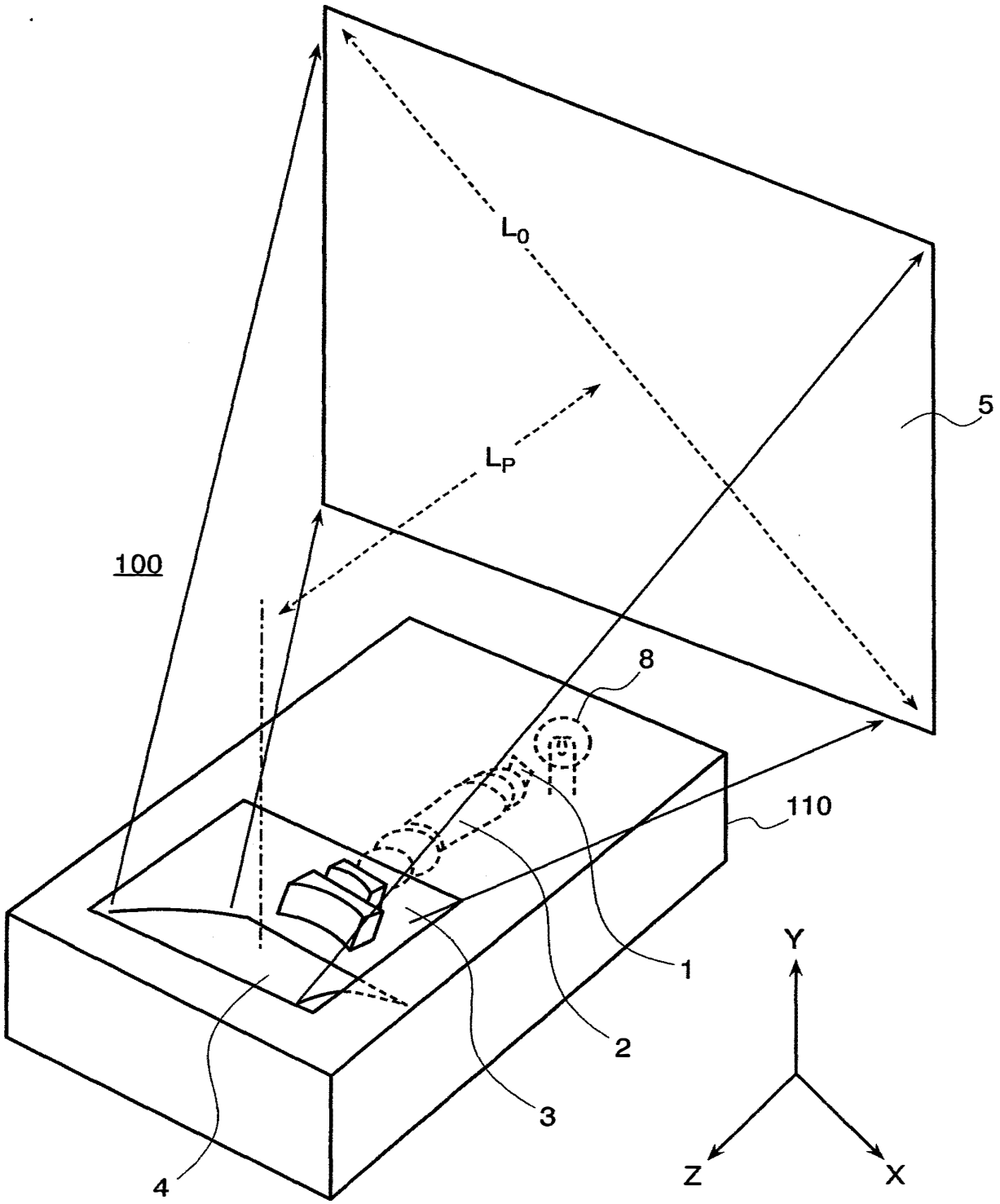


FIG.2

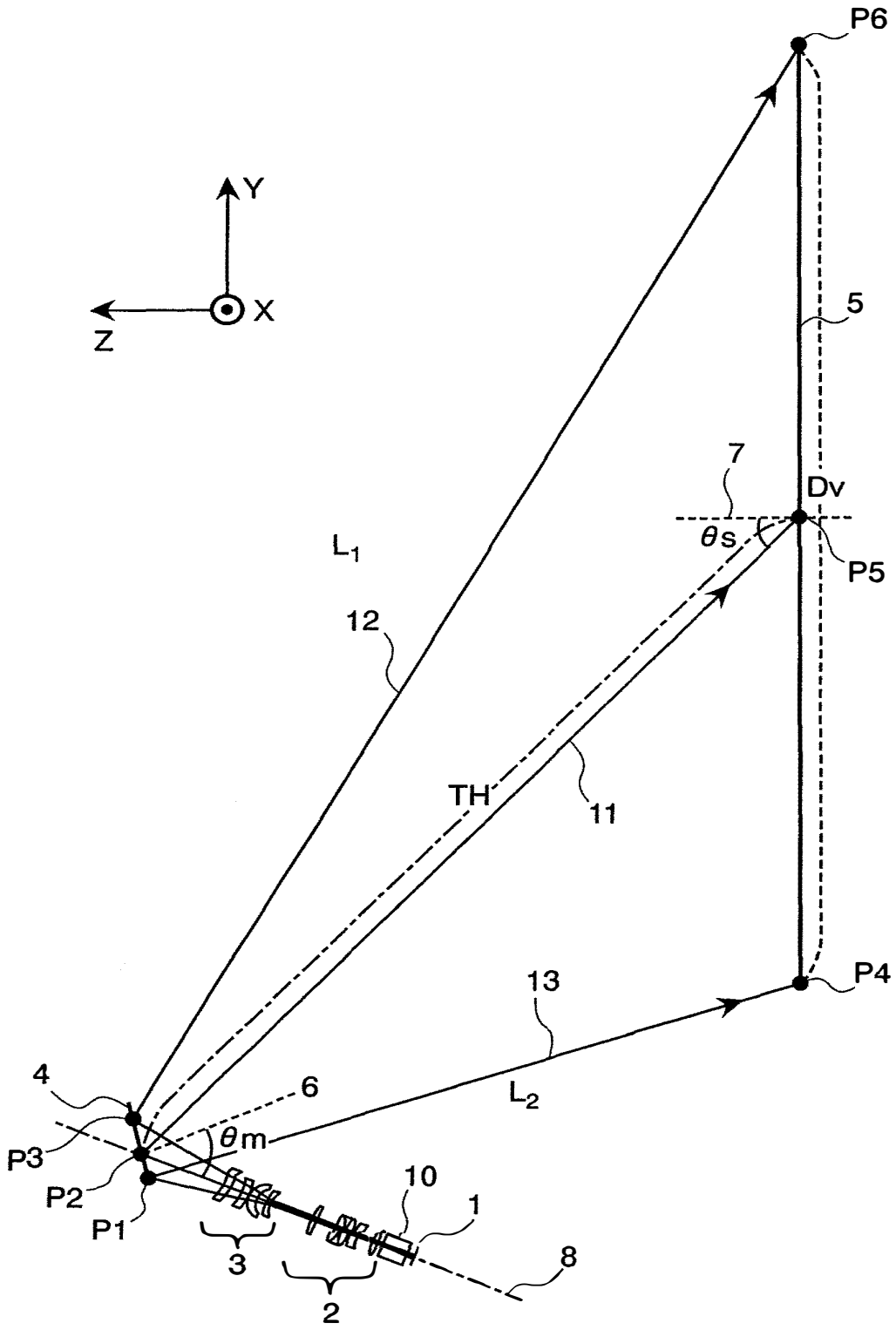


FIG.3

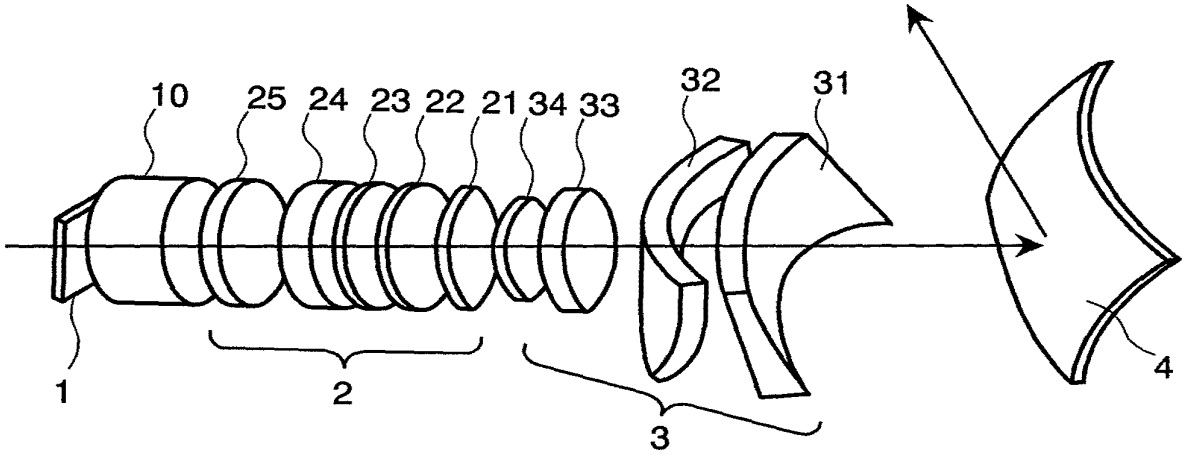


FIG.4(a)

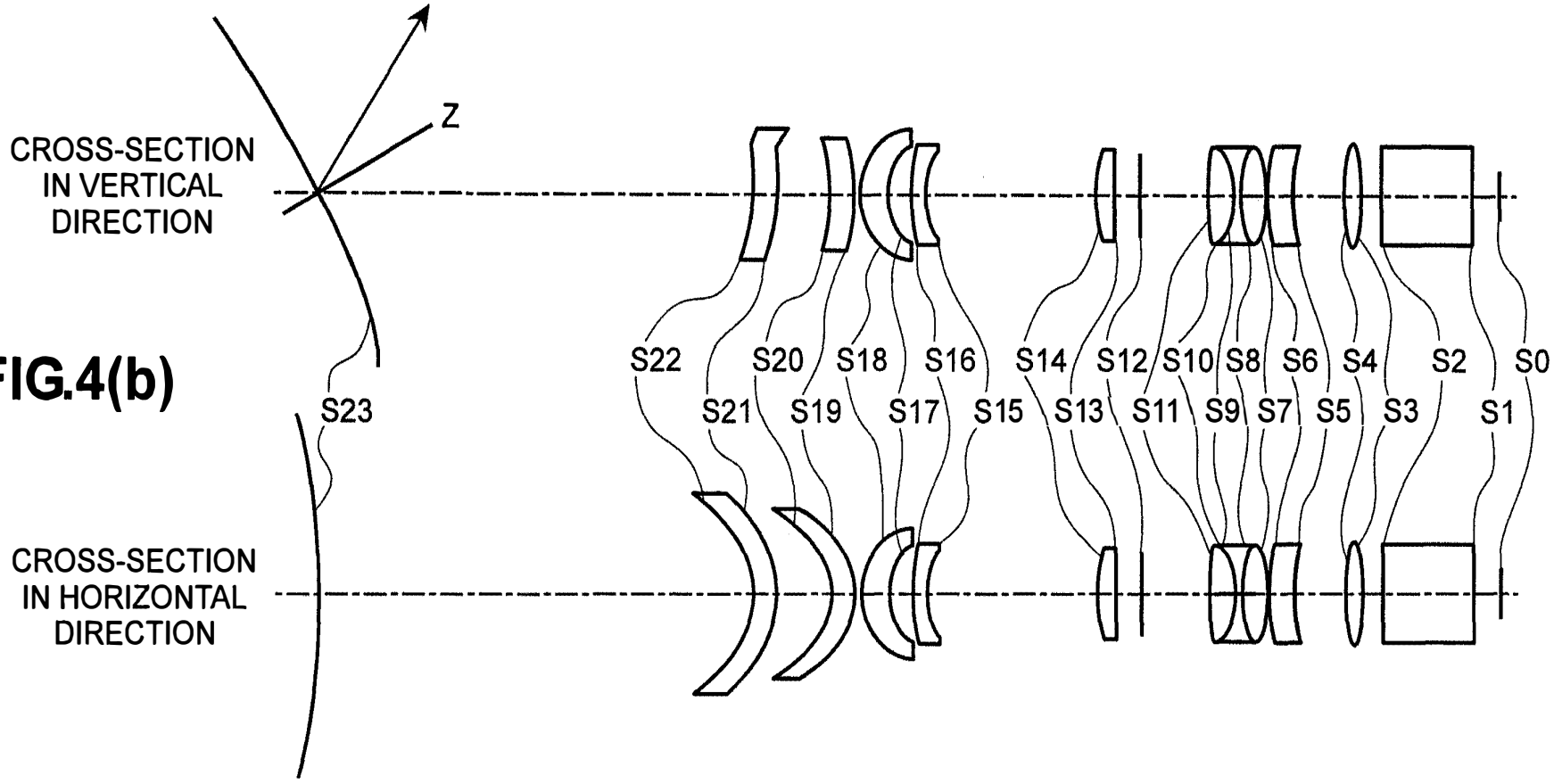

Z
CROSS-SECTION IN VERTICAL DIRECTION
CROSS-SECTION IN HORIZONTAL DIRECTION
S0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
S21
S22
S23

FIG.4(b)

FIG.5

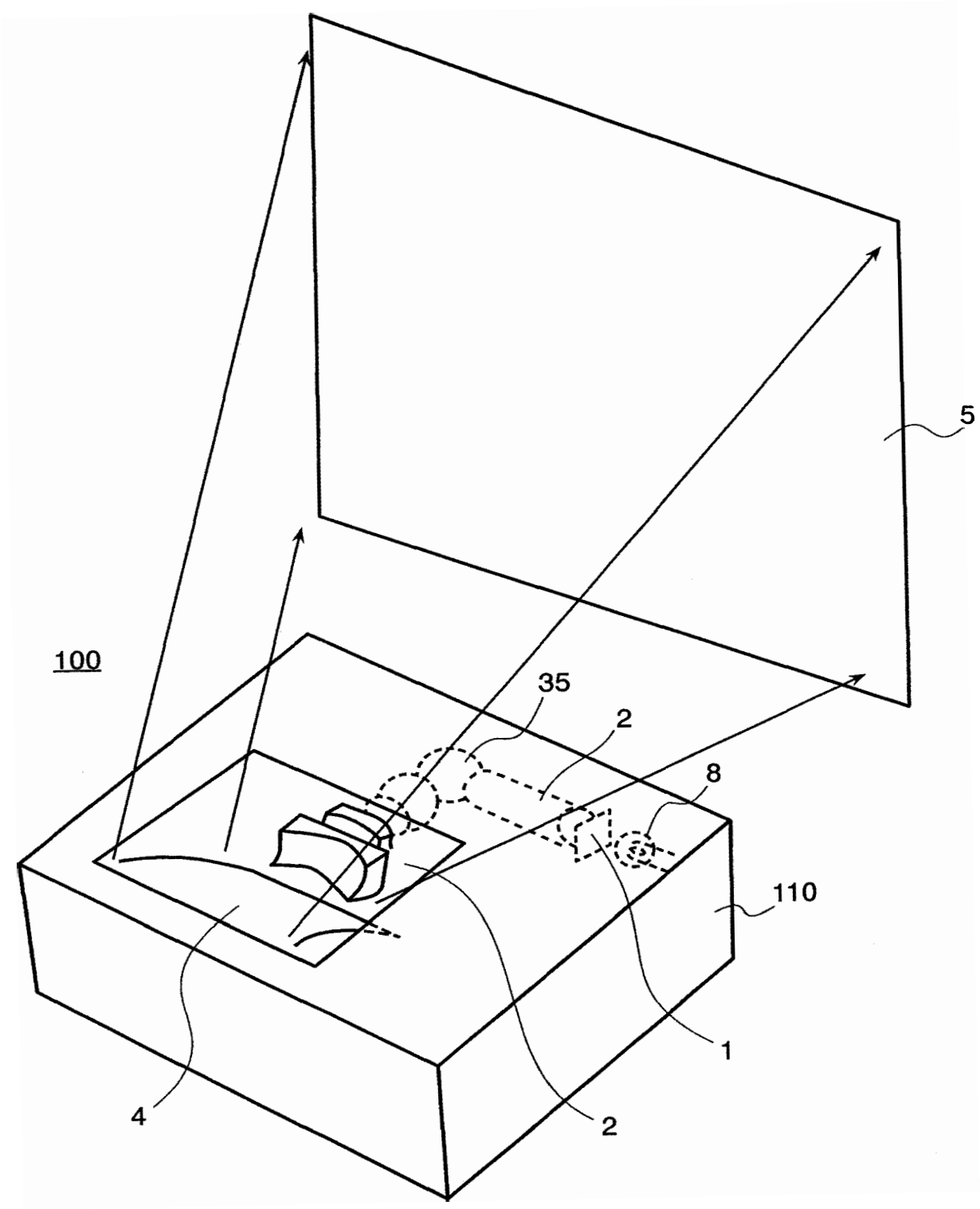


FIG.6

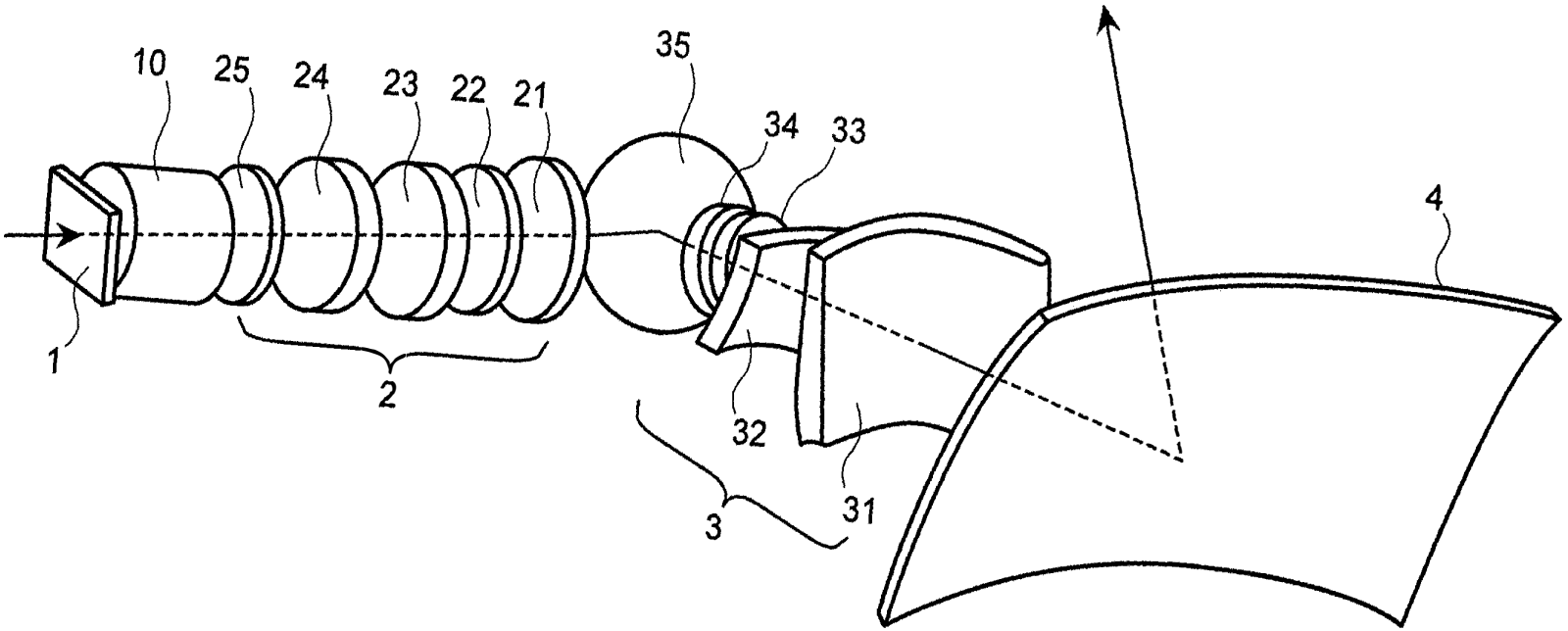


FIG.7

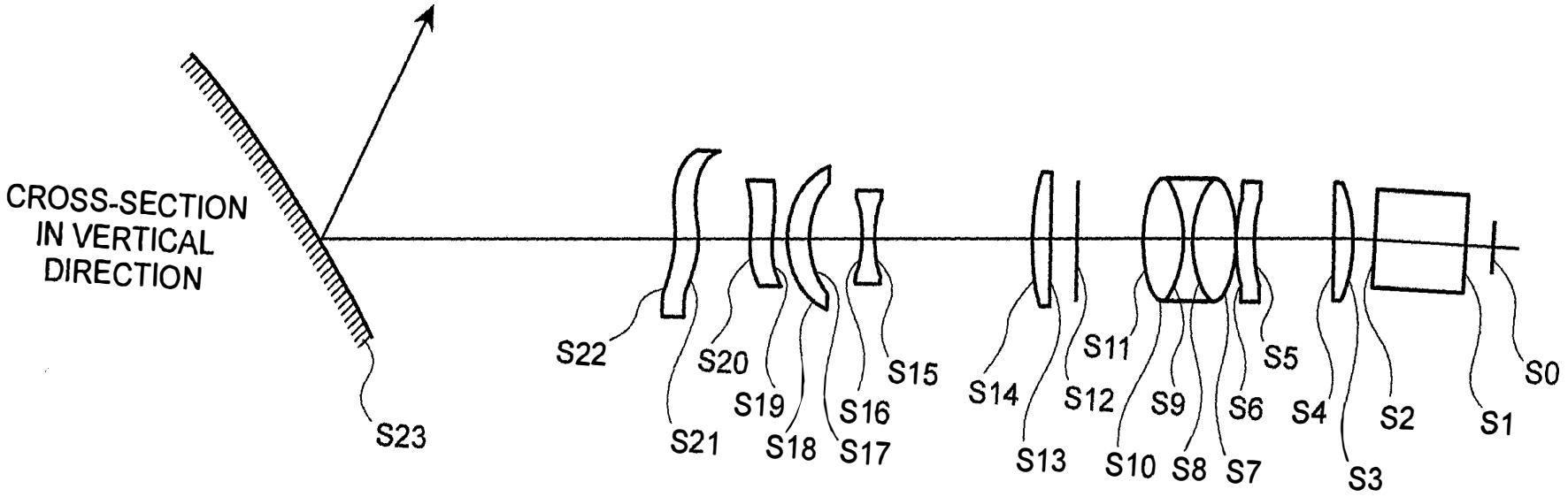

CROSS-SECTION
IN VERTICAL
DIRECTION
S23
S22
S21
S20
S19
S18
S17
S16
S15
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
S0

FIG.8

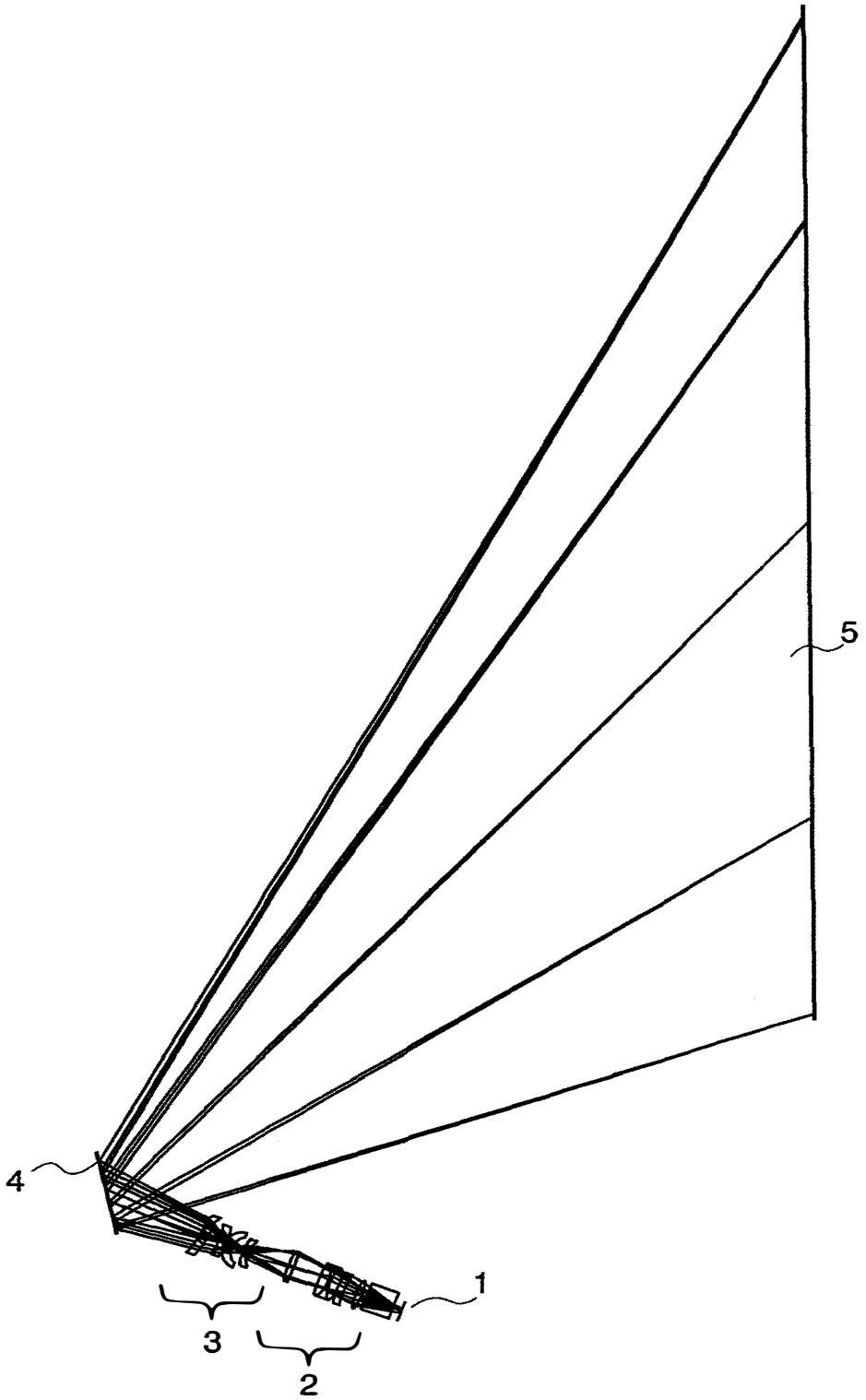


FIG.9

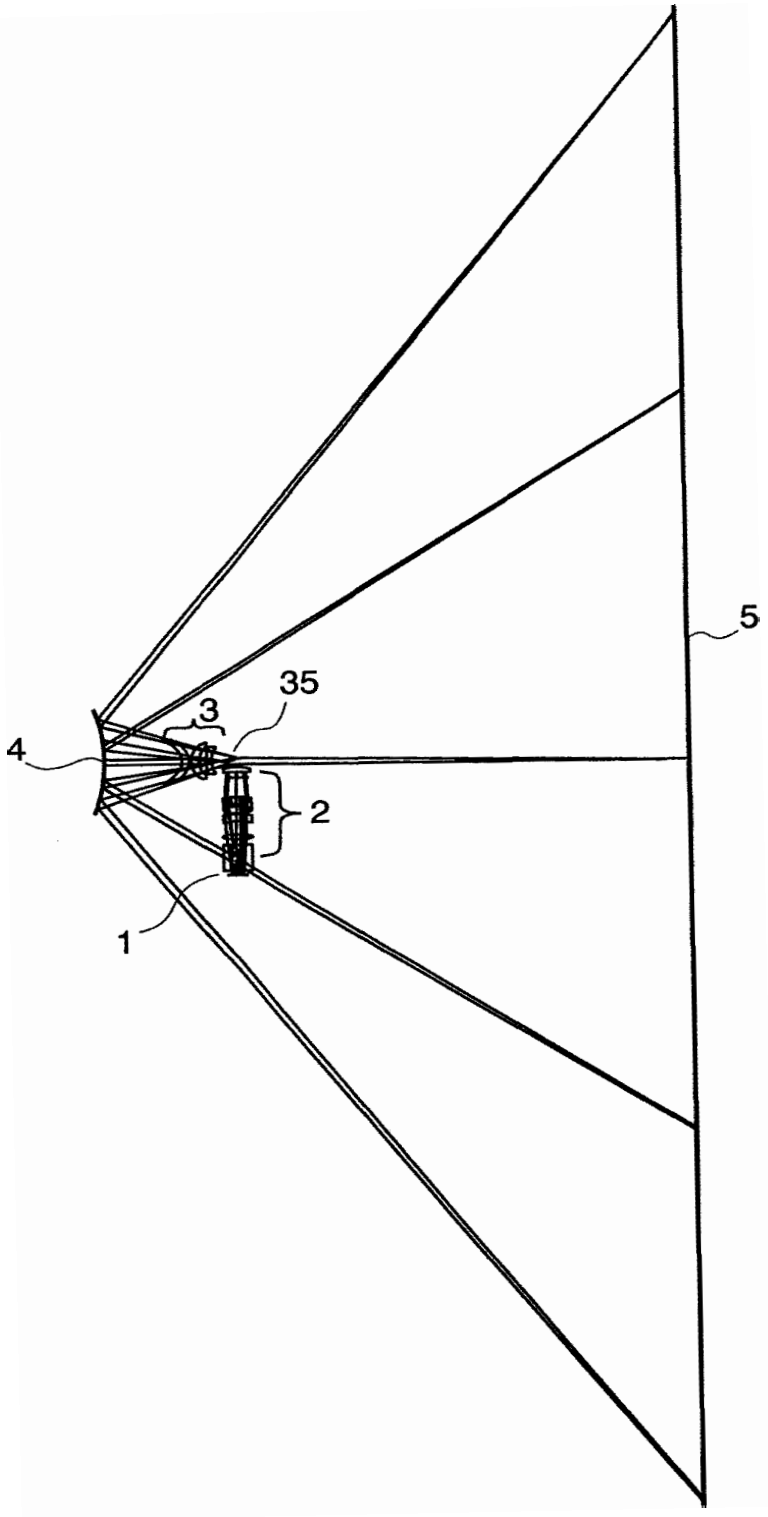


FIG.10

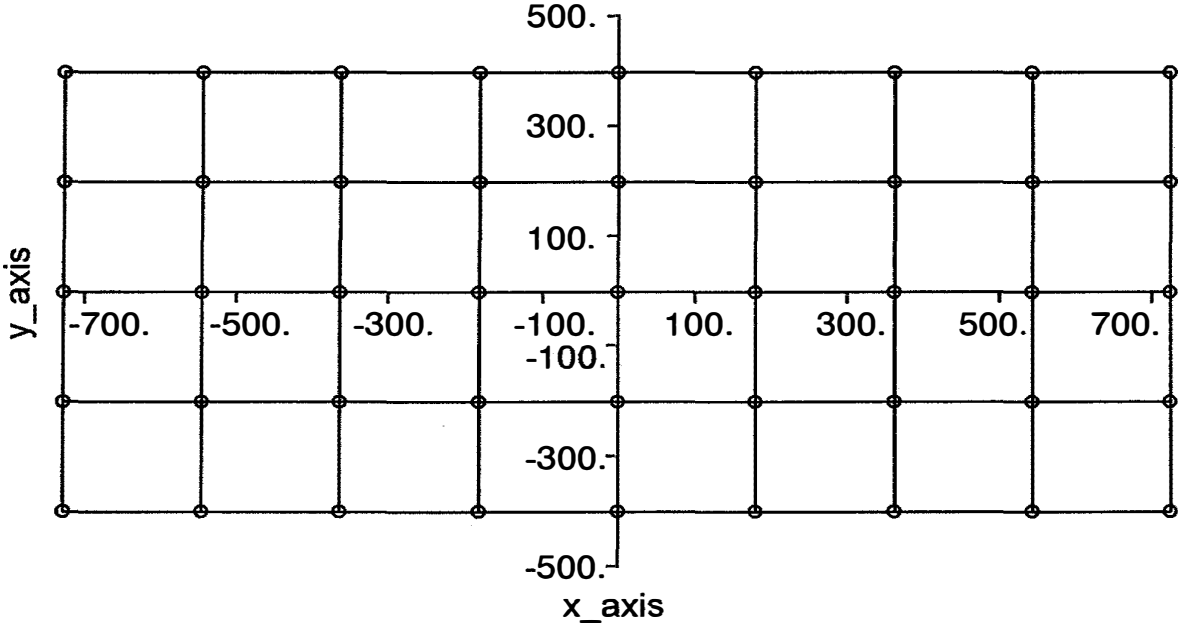

500.
300.
100.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
-100.
-300.
-500.
y_axis
x_axis

FIG.11

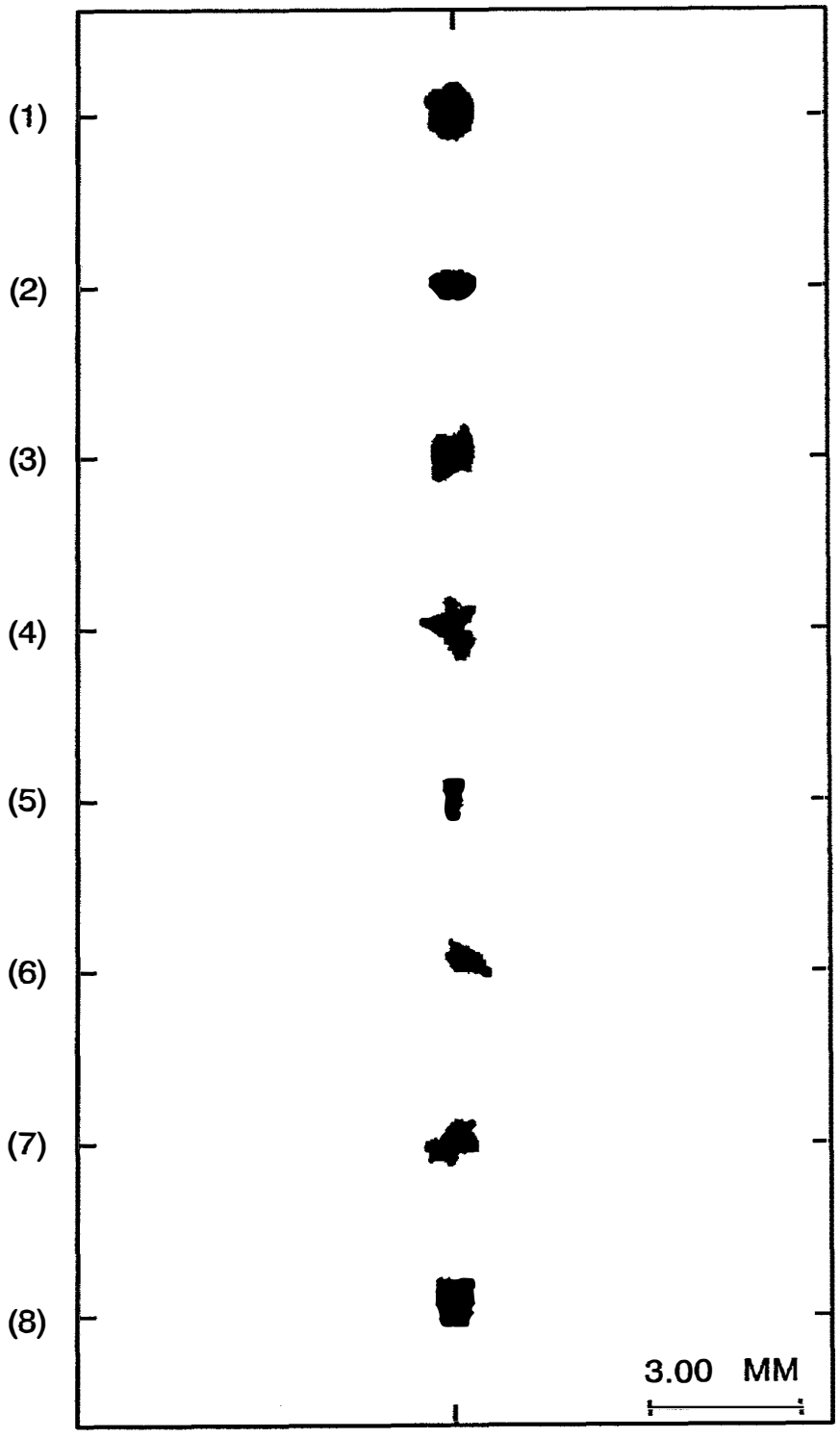
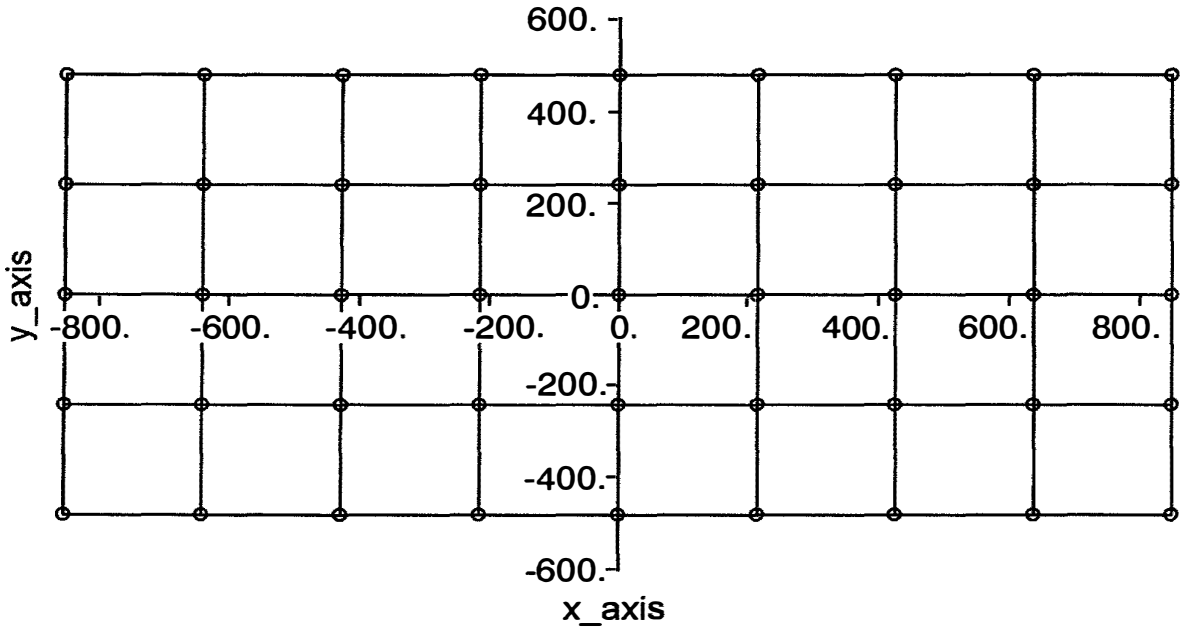


FIG.12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-200.
-400.
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-800.
-600.
-400.
-200.
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y_axis
x_axis

FIG.13

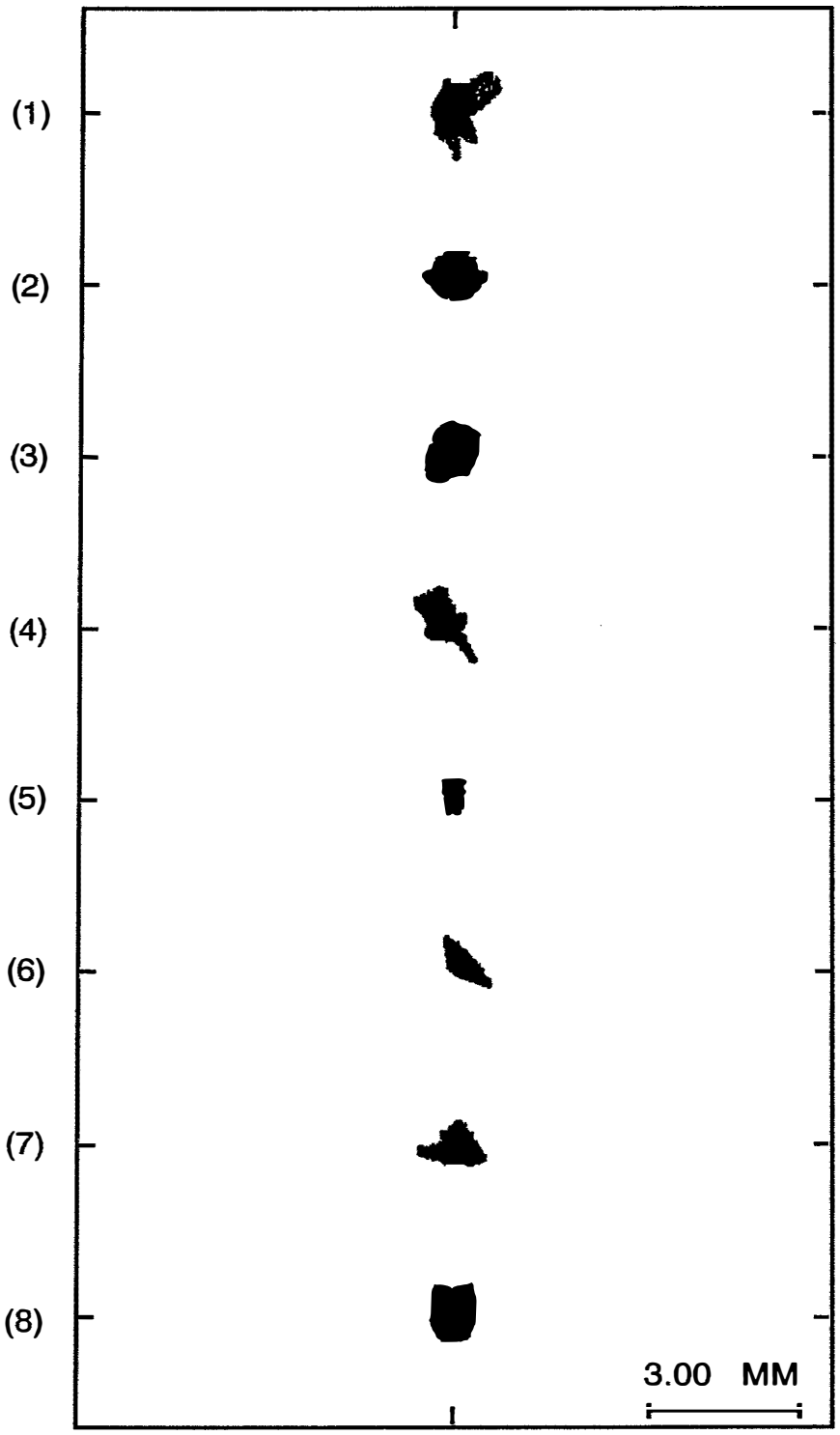
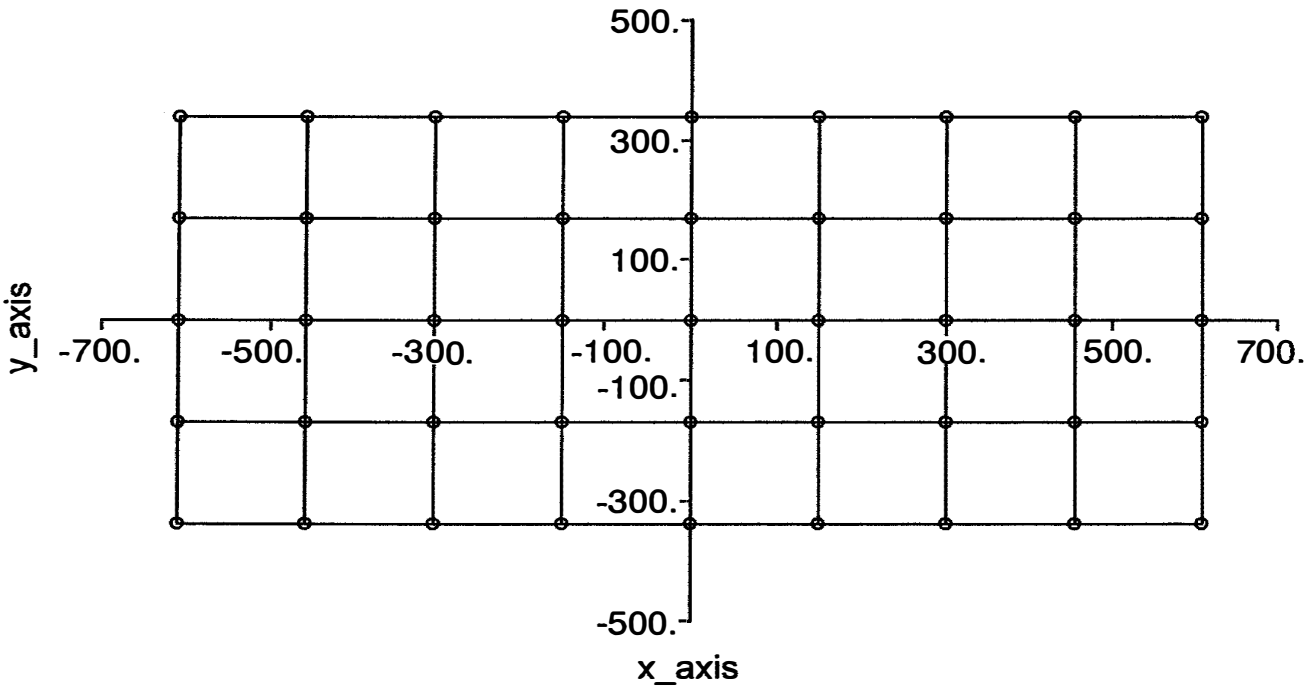


FIG.14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y_axis
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FIG.15

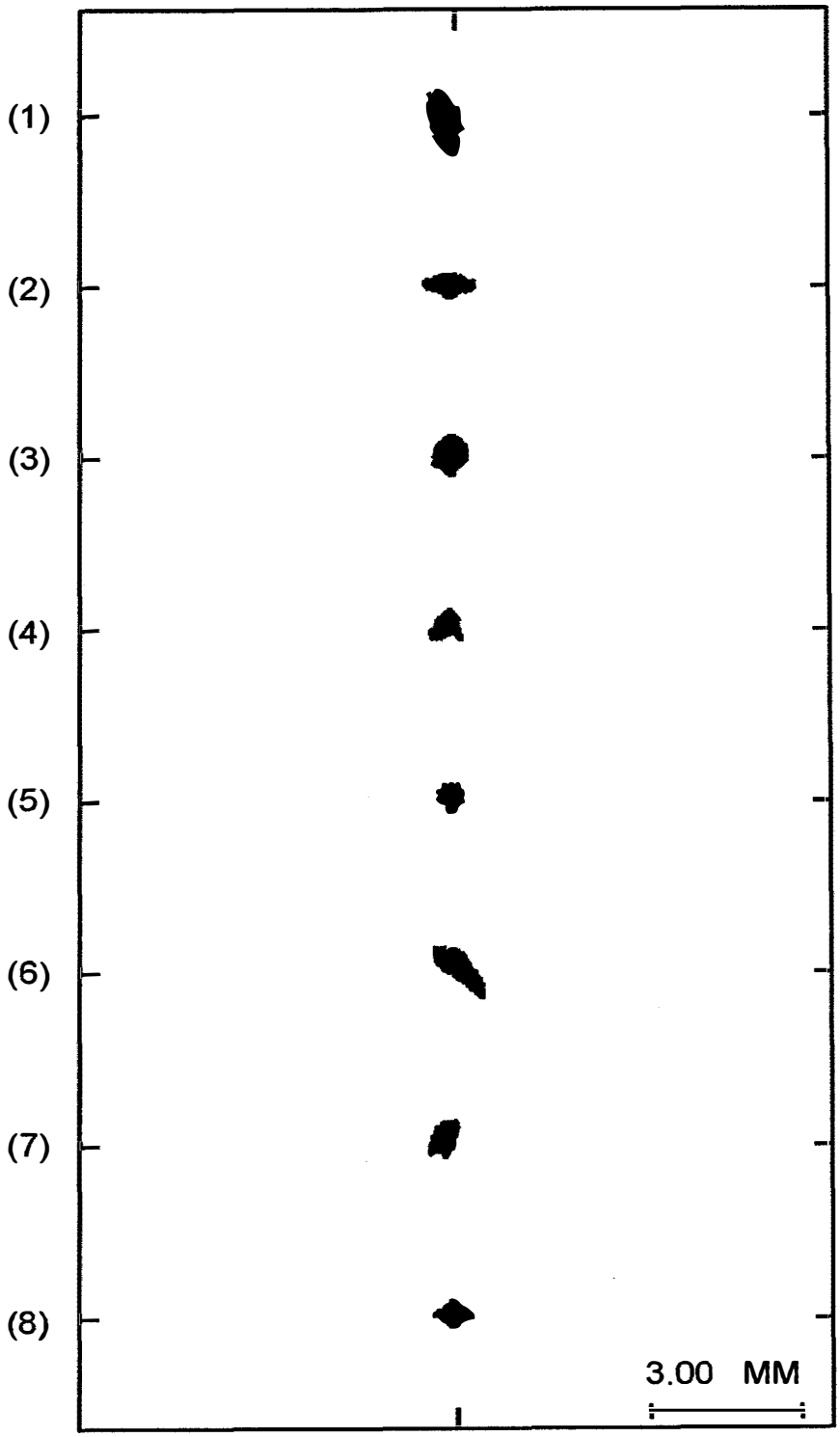
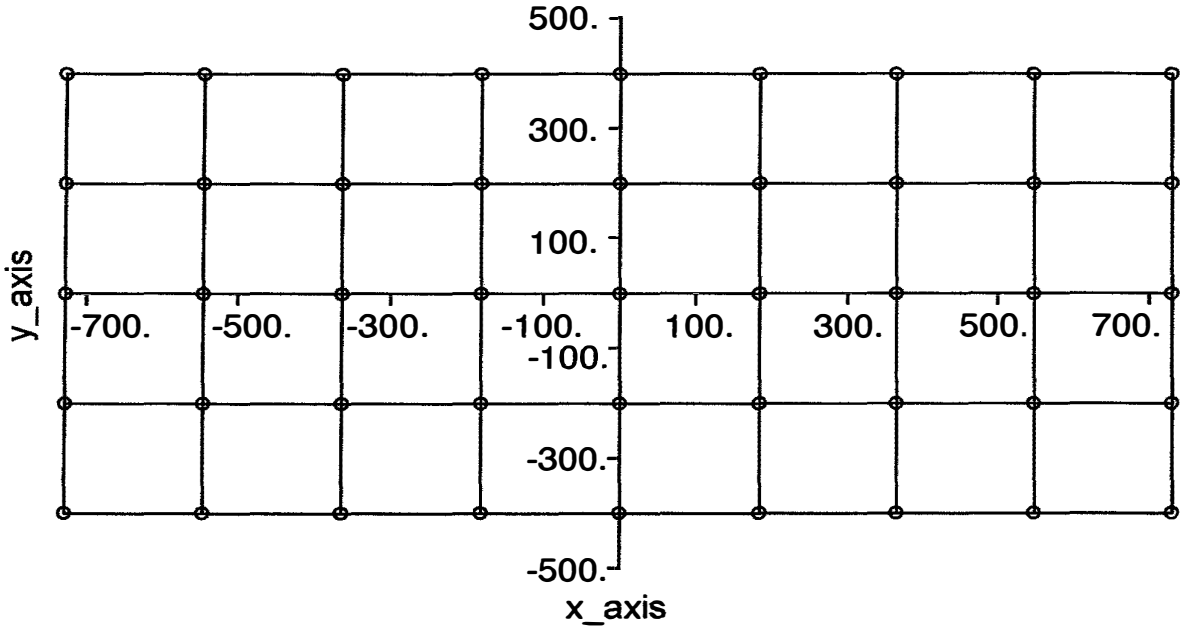


FIG.16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-100.
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700.
y_axis
x_axis

FIG.17

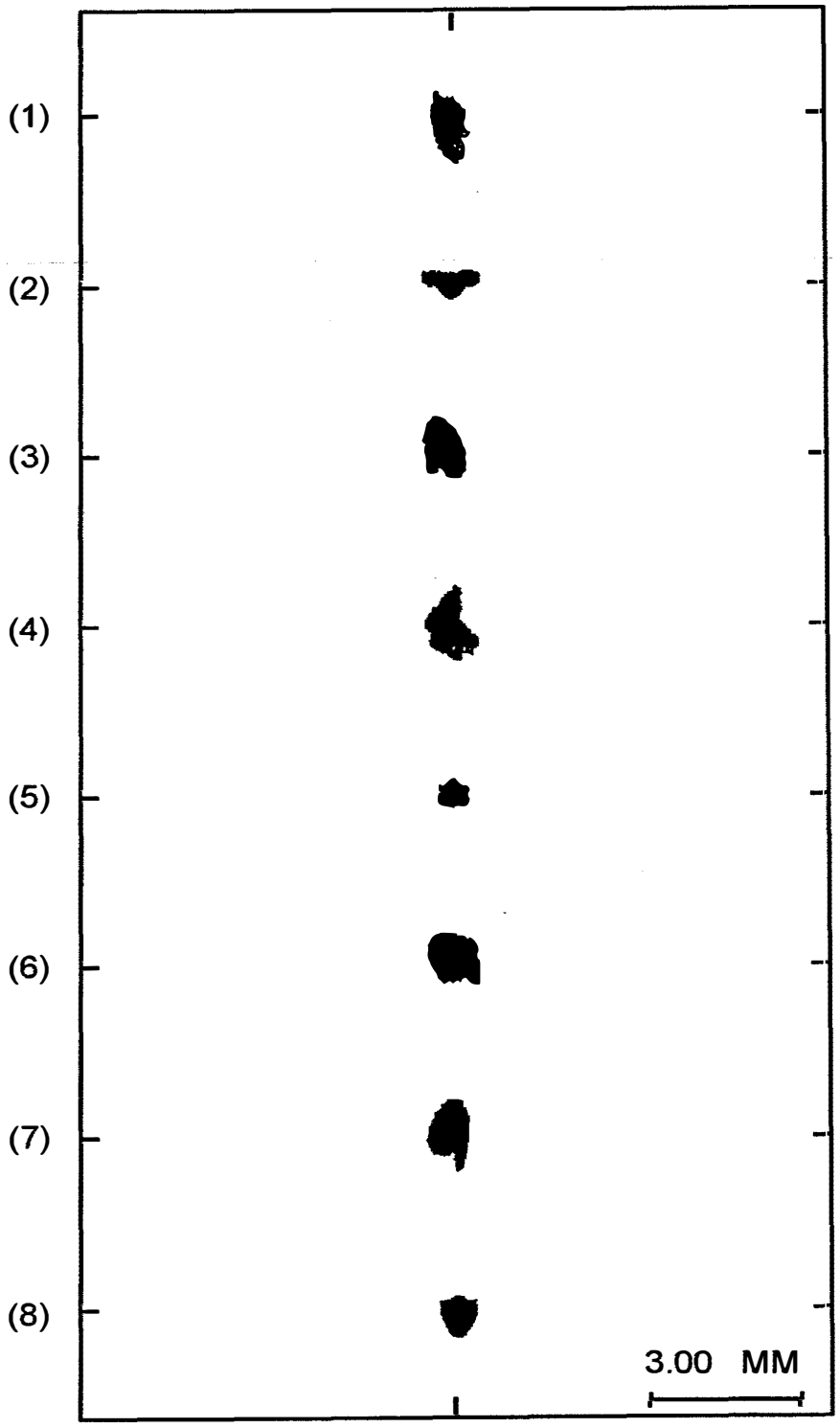


FIG.18

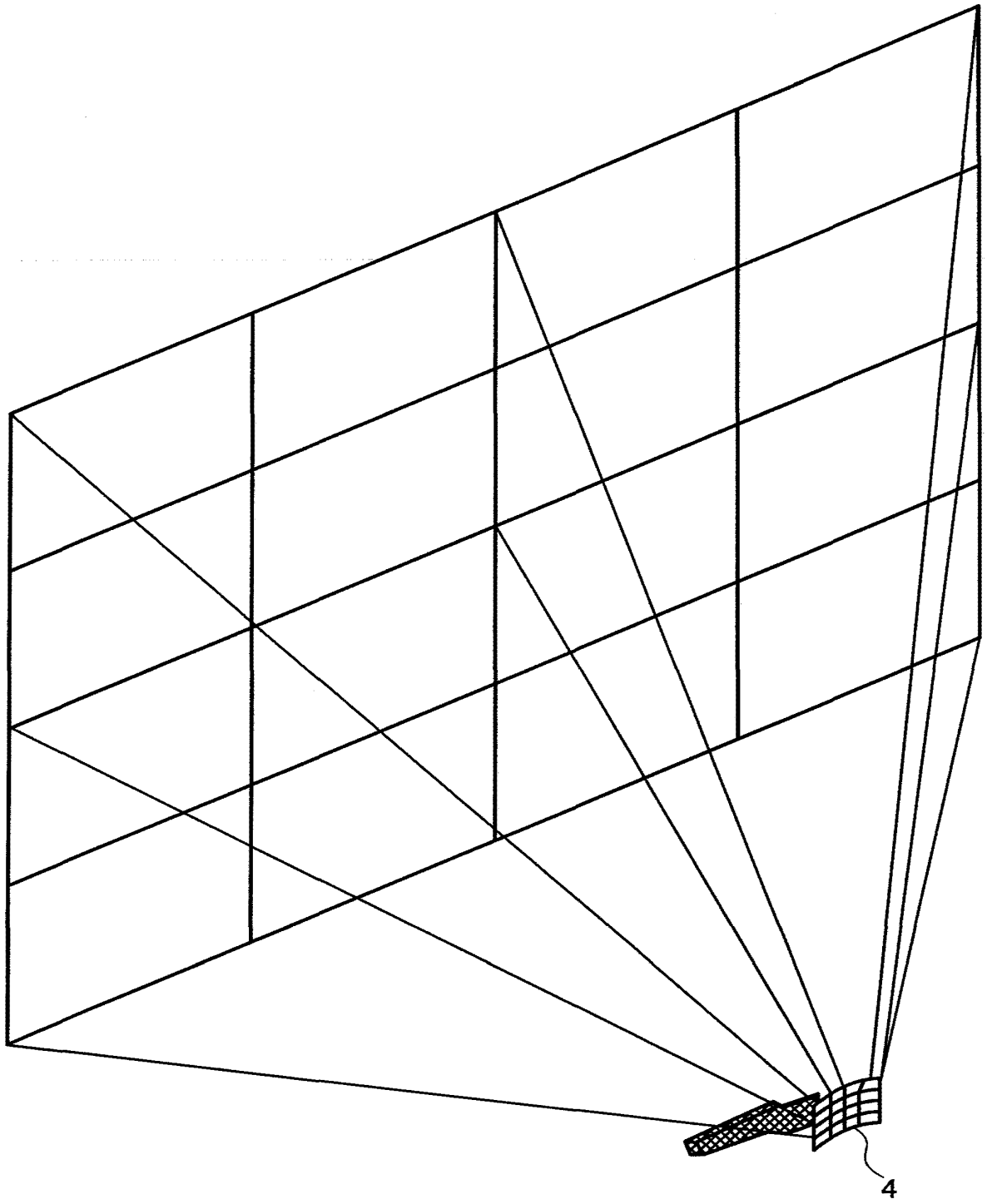


FIG.19

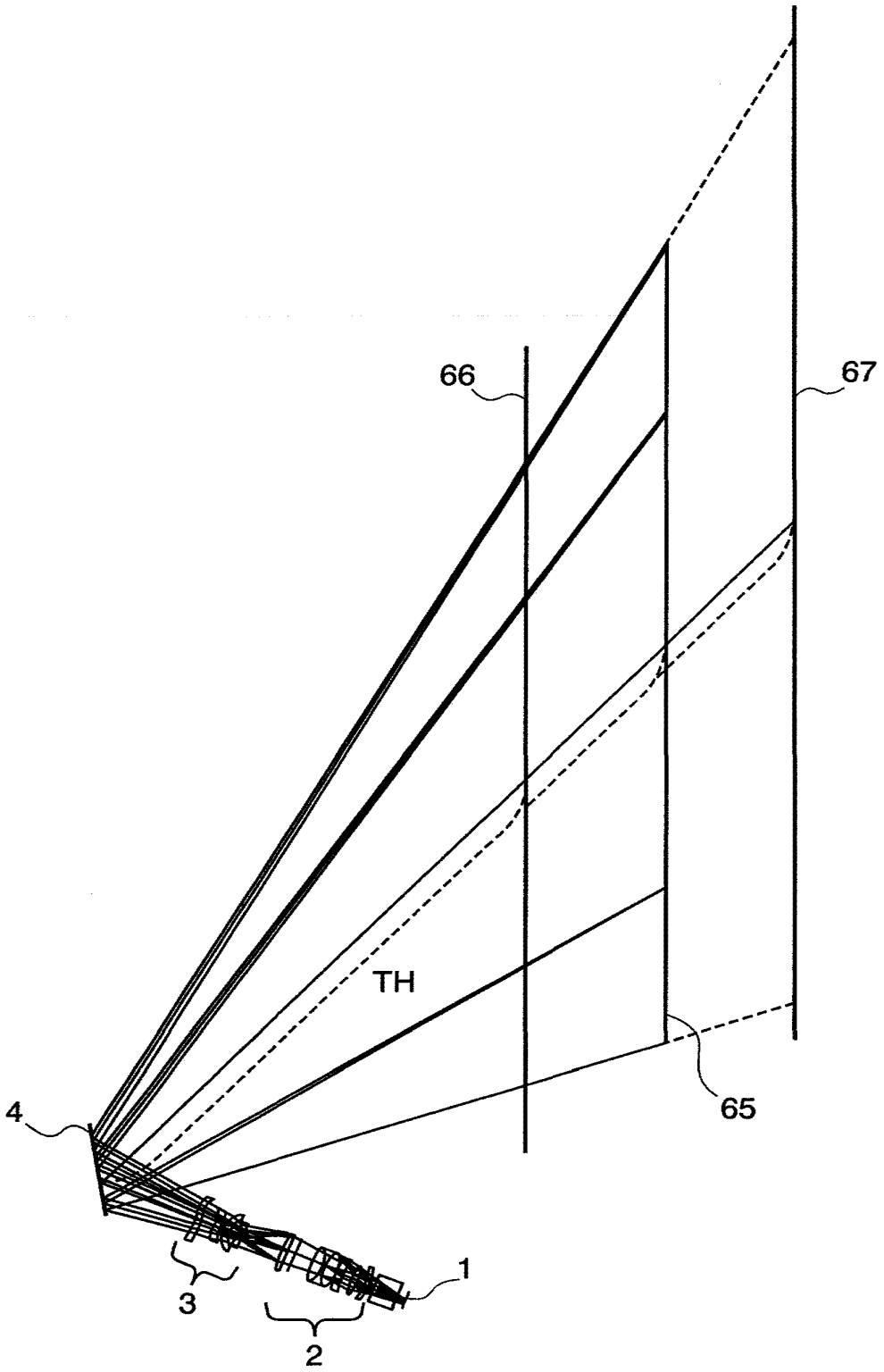


FIG.20(a)

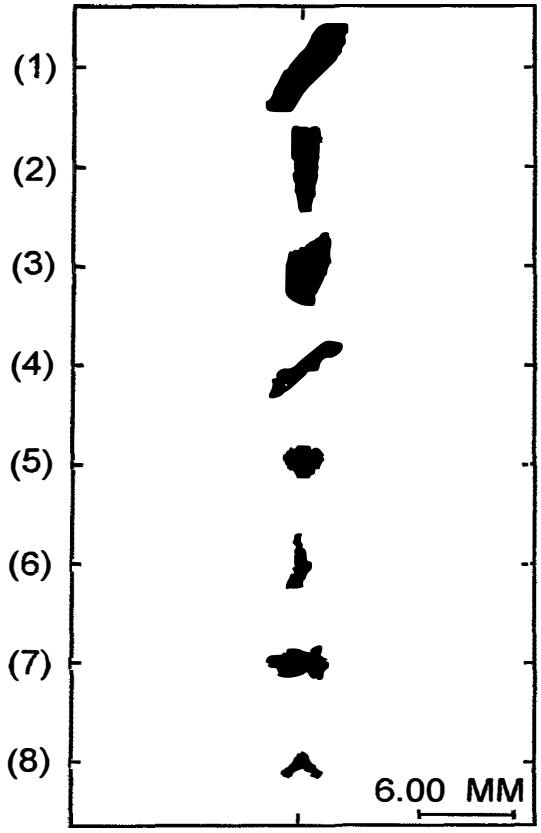


FIG.20(b)

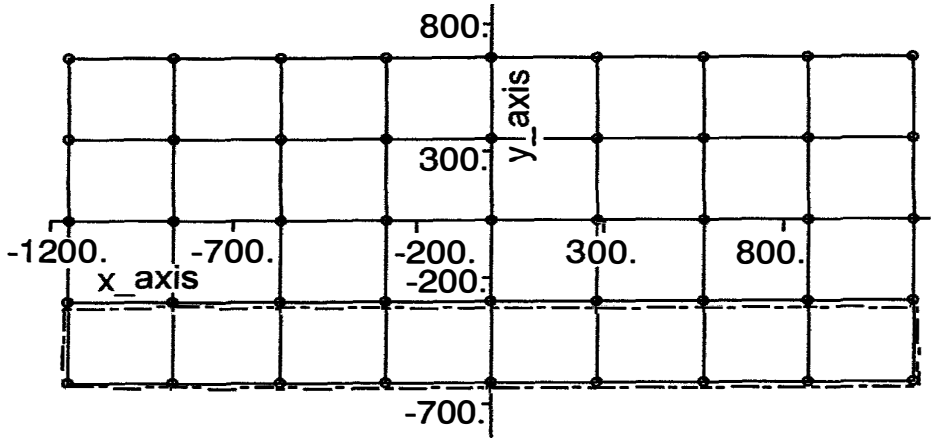


FIG.21(a)

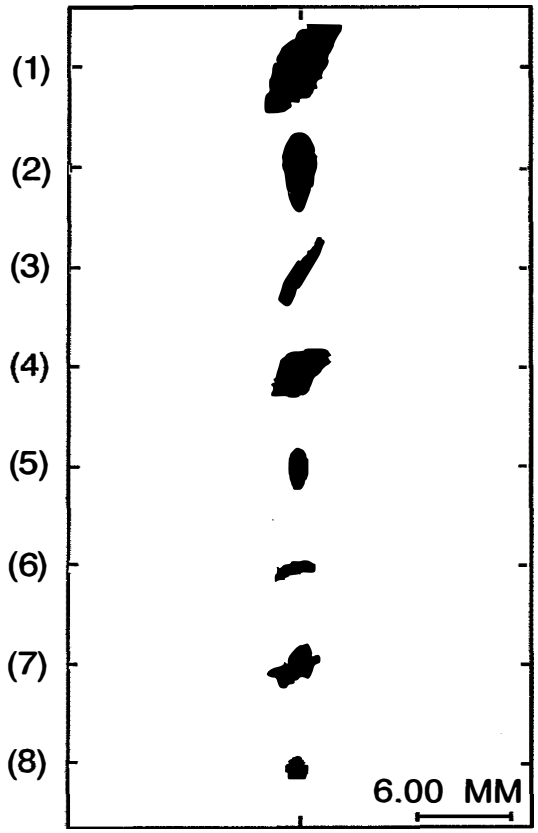


FIG.21(b)

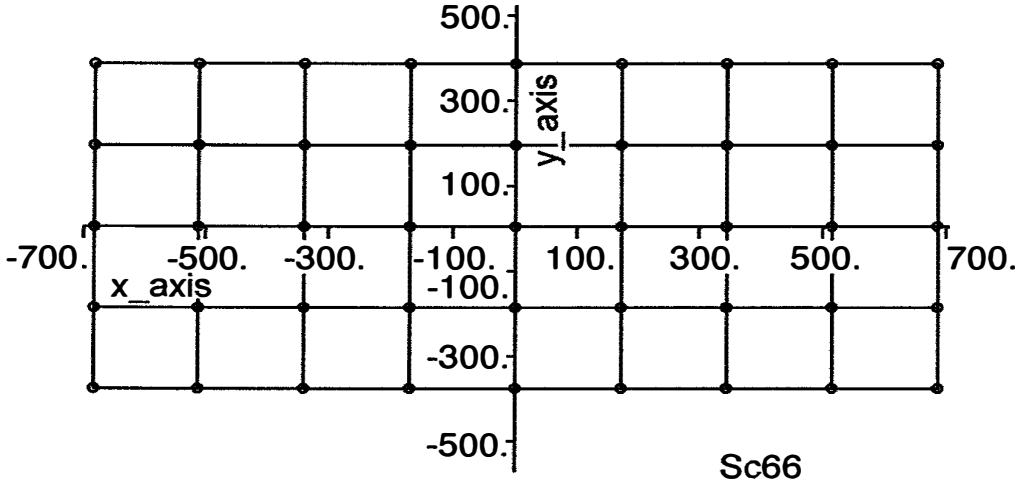


FIG.22(a)

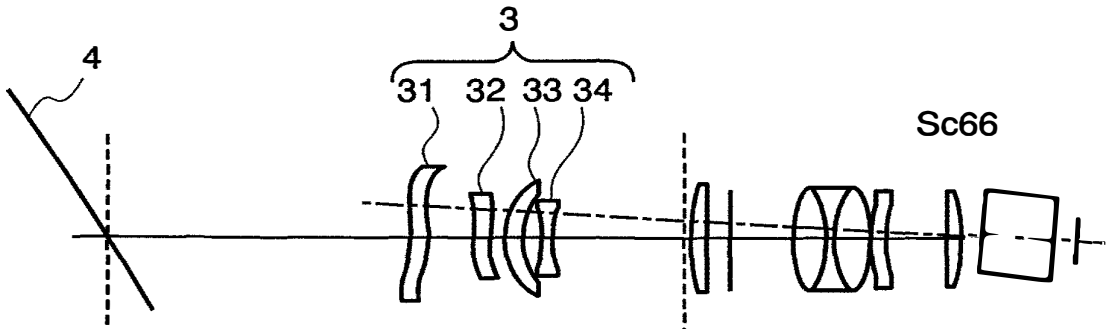


FIG.22(b)

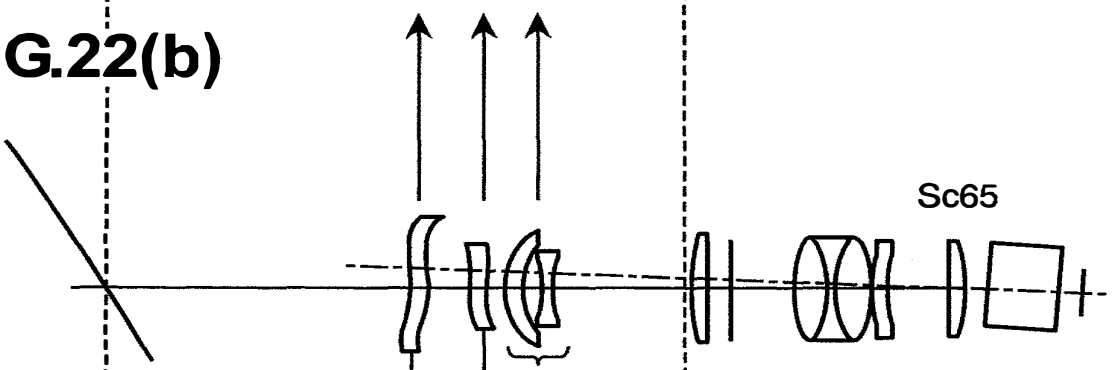


FIG.22(c)

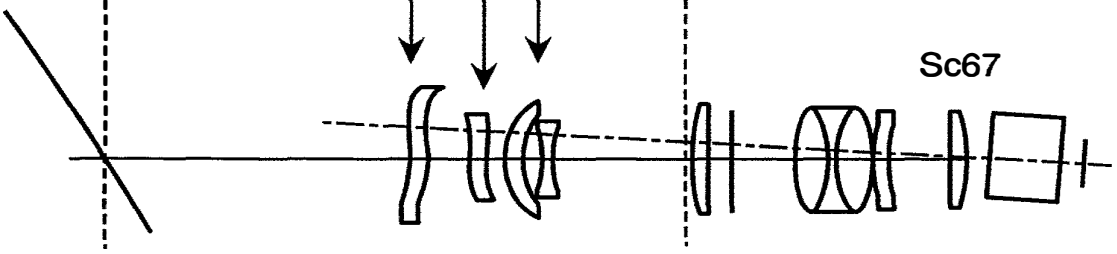


FIG.23(a)

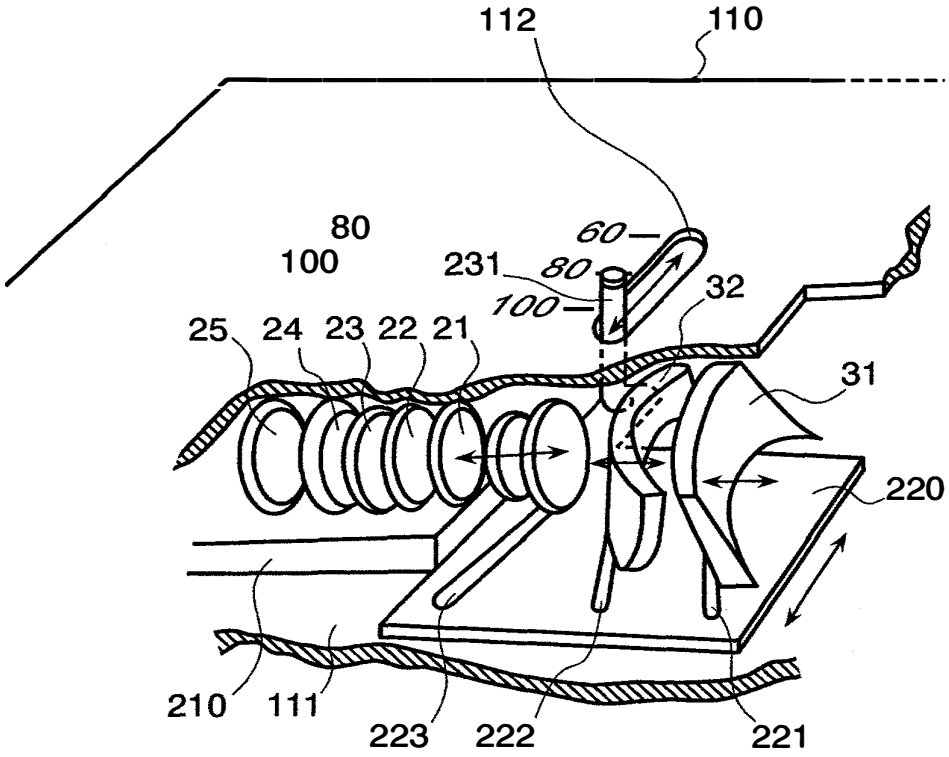


FIG.23(b)

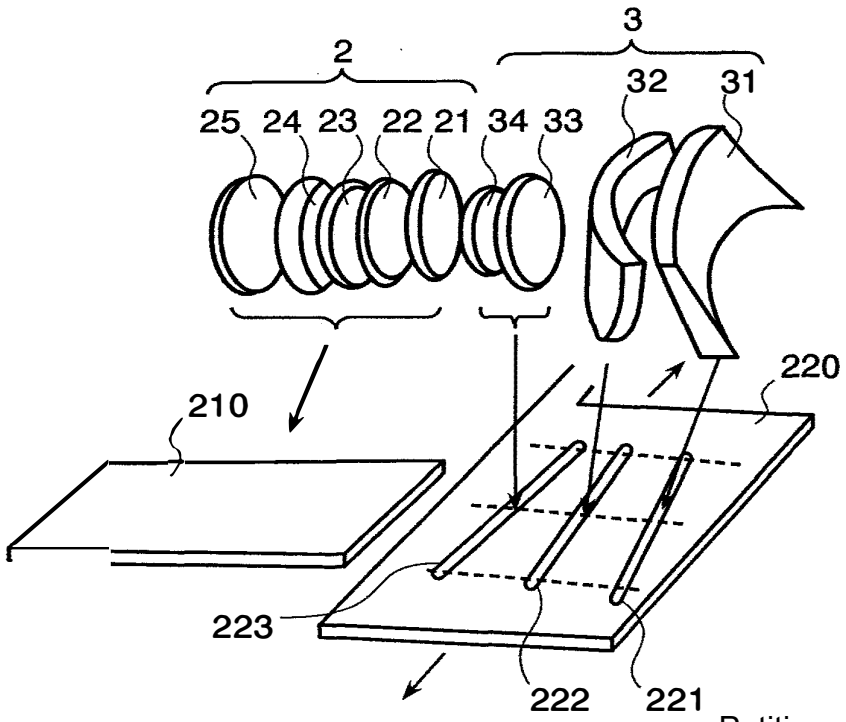
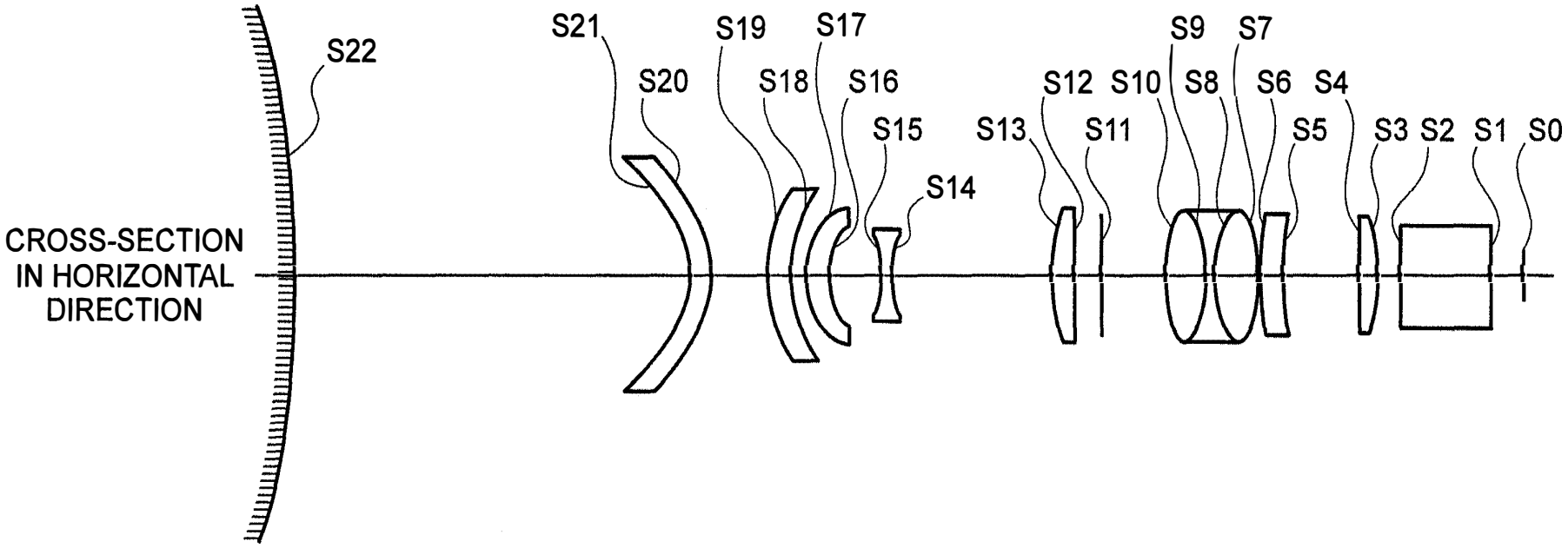


FIG.24


CROSS-SECTION
IN HORIZONTAL
DIRECTION
S22
S21
S20
S19
S18
S17
S16
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S14
S13
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S9
S8
S7
S6
S5
S4
S3
S2
S1
S0

FIG.25(a)

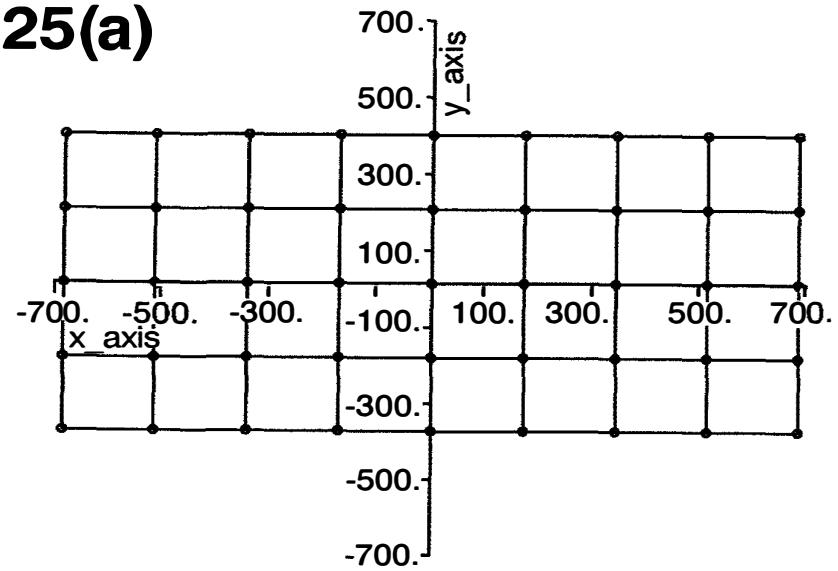


FIG.25(b)

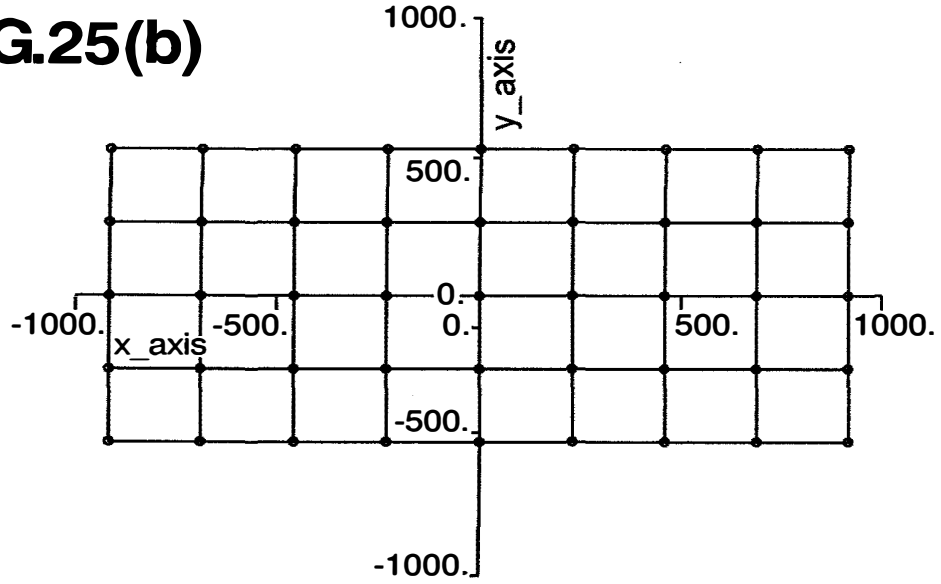


FIG.25(c)

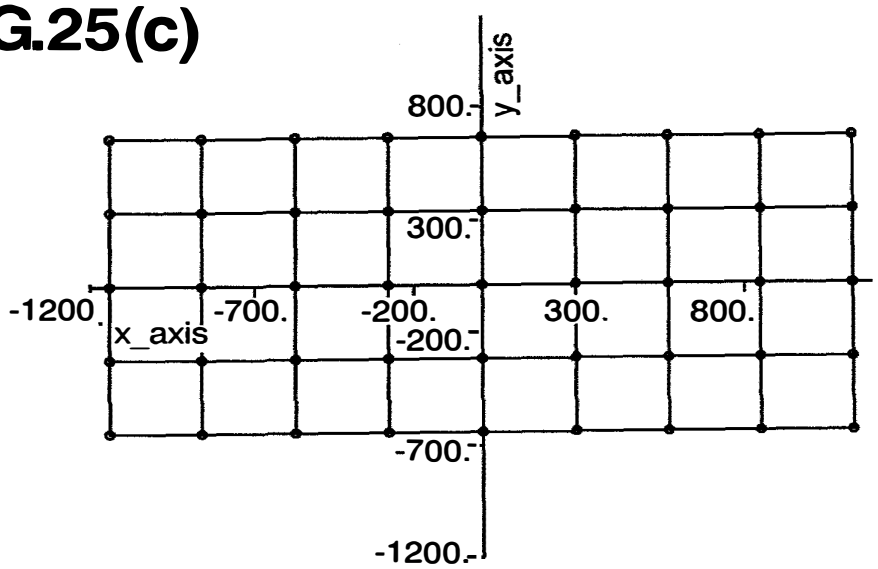


FIG.26

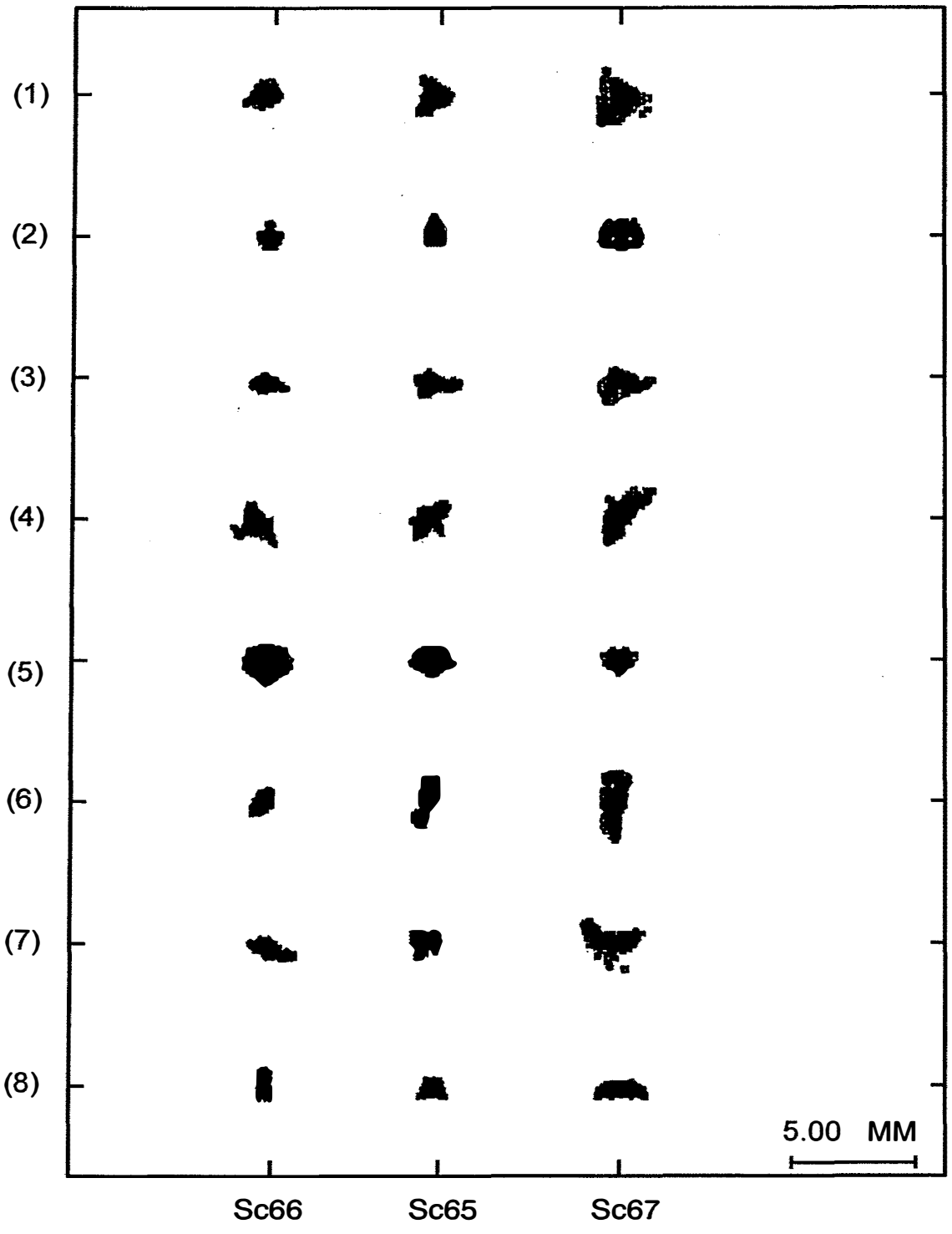


FIG.27

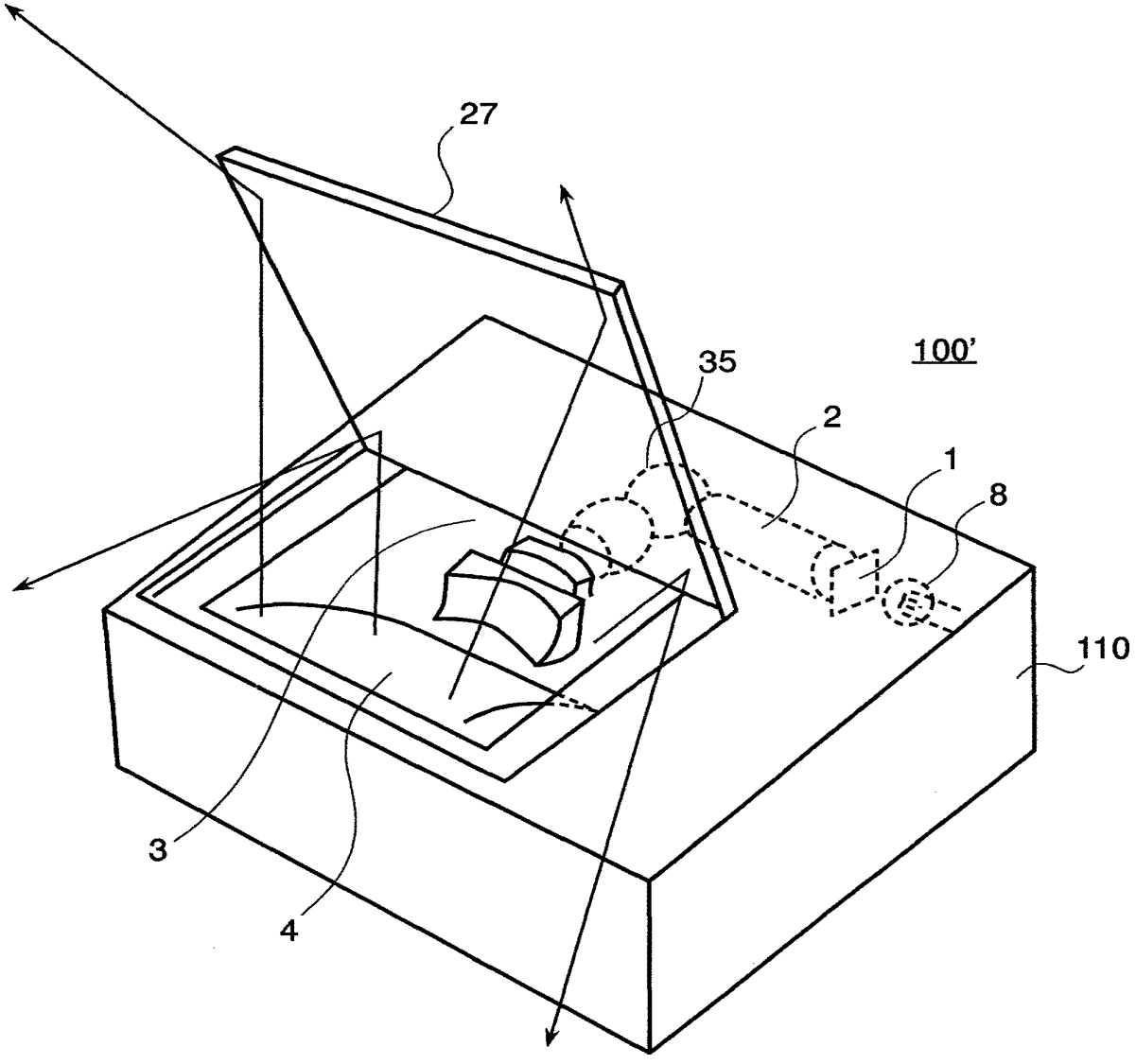


FIG.28

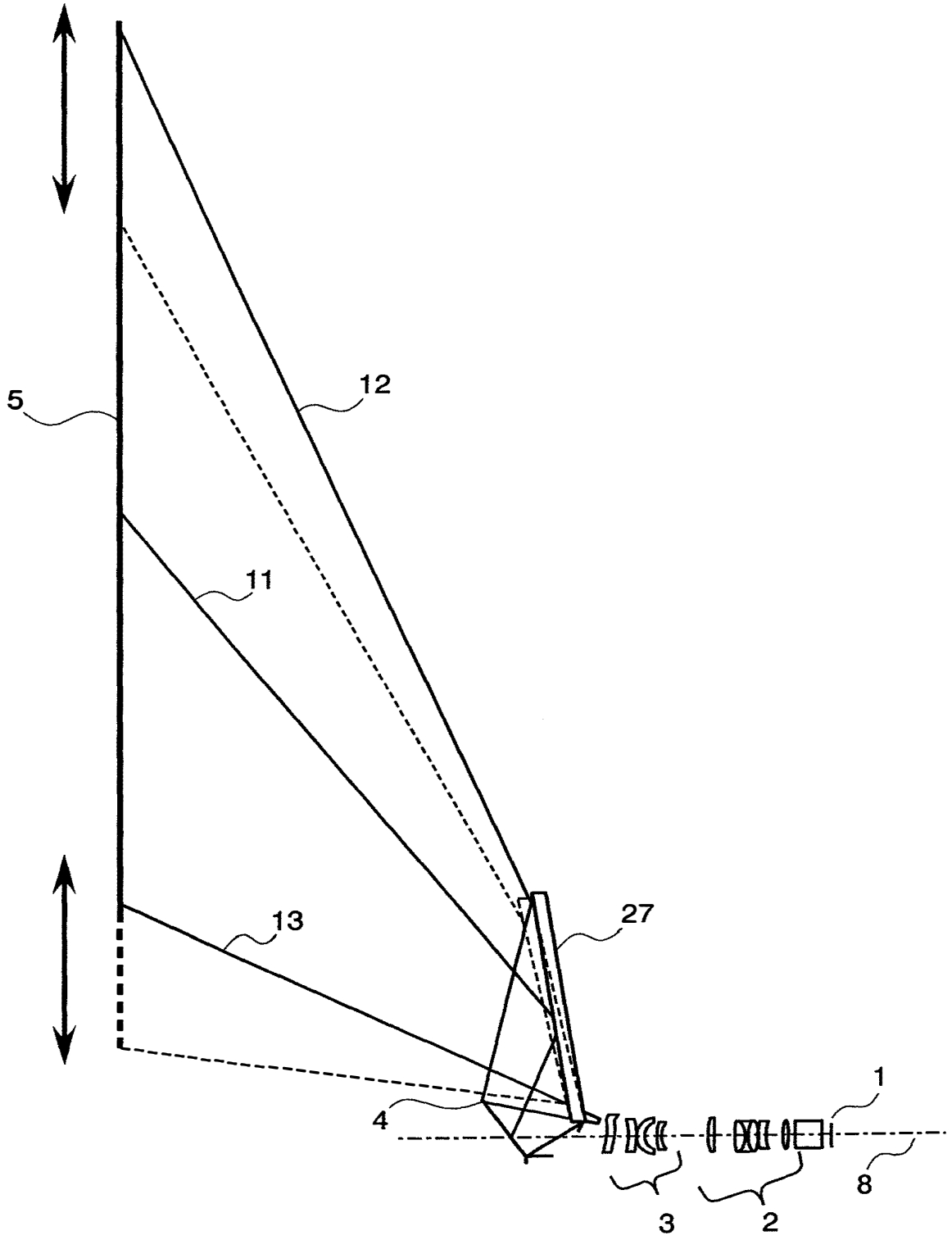


FIG.29(a)

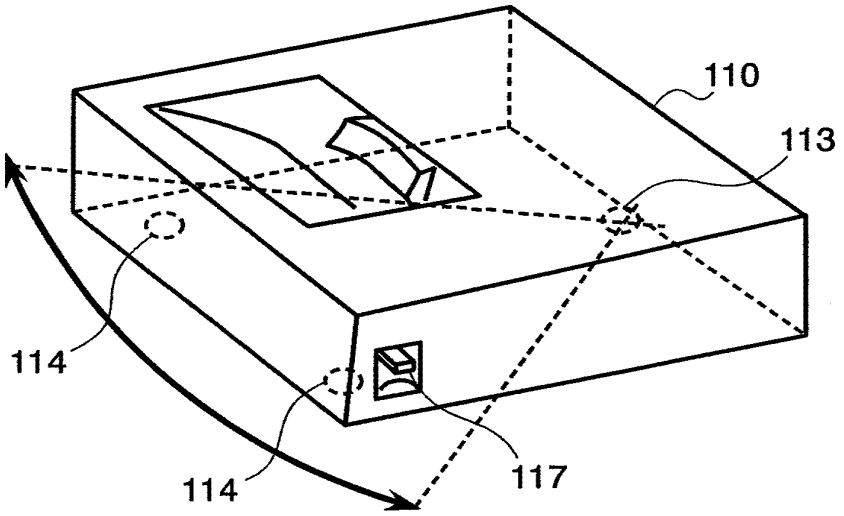


FIG.29(b)

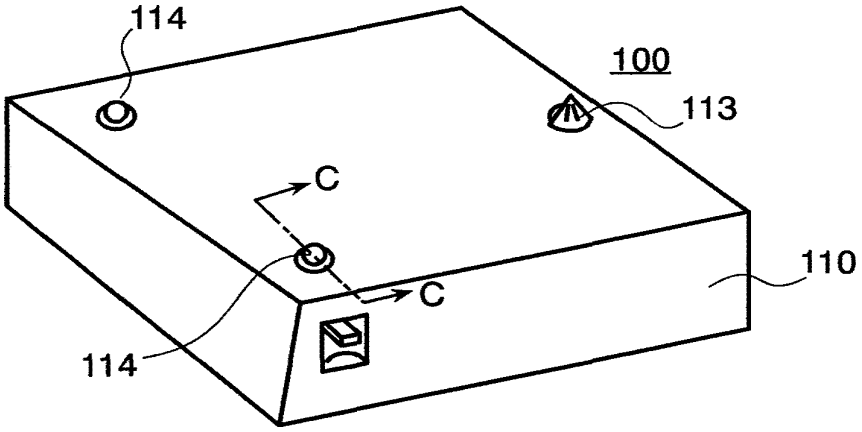
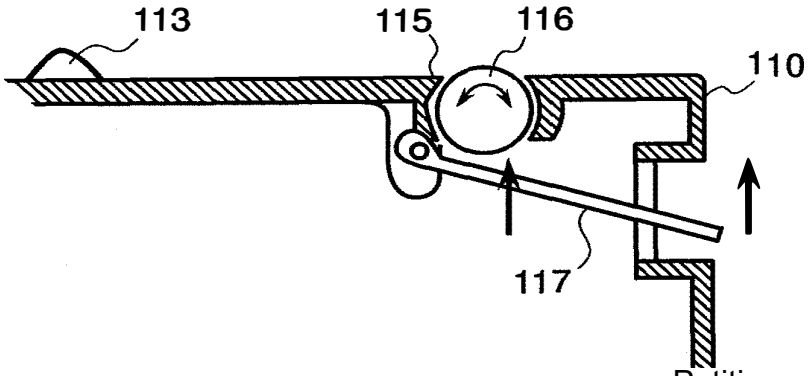


FIG.29(c)



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Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

私は、以下に記名された発明者として、ここに下記の通り宣言する ：	As a below named inventor, I hereby declare that:
私の住所、郵便の宛先そして国籍は、私の氏名の後に記載された通りである。	My residence, post office address and citizenship are as stated next to my name.
下記の名称の発明について、特許請求範囲に記載され、且つ特許が求められている発明主題に関して、私は、最初、最先且つ唯一の発明者である（唯一の氏名が記載されている場合）か、或いは最初、最先且つ共同発明者である（複数の氏名が記載されている場合）と信じている。	I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
_____	PROJECTION TYPE IMAGE DISPLAY APPARATUS
_____	_____
上記発明の明細書はここに添付されているが、下記の欄がチェックされている場合は、この限りでない ：	The specification of which is attached hereto unless the following box is checked:
☐ _____ に日に出願され、 この出願の米国出願番号またはＰＣＴ国際出願番号は、 _____ であり、且つ _____ の日に補正された出願（該当する場合）	☐ was filed on _____ as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).
私は、上記の補正書によって補正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。	I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
私は、連邦規則法典第３７編規則１．５６に定義されている、特許性について重量な情報を開示する義務があることを認める。	I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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Japanese Language Declaration
（日本語宣言書）

私は、ここに、以下に記載した外国での特許出願または発明者証の出願、或いは米国以外の少なくとも一国を指定している米国法典第３５編第３６５条(a)によるＰＣＴ国際出願について、同第１１９条(a)-(d)項又は第３６５条(b)項に基づいて優先権を主張するとともに、優先権を主張する本出願の出願日よりも前の出願日を有する外国での特許出願または発明者証の出願、或いはＰＣＴ国際出願については、いかなる出願も、下記の枠内をチェックすることにより示した。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International apllication which designated at least one country other than the United States listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application for which priority is claimed.

Prior Foreign Application(s) 外国での先行出願			Priority Not Claimed 優先権主張なし
2006-166434 (Number) （番号）	Japan (Country) （国名）	15/June/2006 (Day/Month/Year Filed) （出願日／月／年）	☐
(Number) （番号）	(Country) （国名）	(Day/Month/Year Filed) （出願日／月／年）	☐

私は、ここに、下記のいかなる米国仮特許出願についても、その米国法典第３５編１１９条(e)項の利益を主張する。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) 号　　）	(Filing Date) （出願日）	(Application No.) （出願番号）	(Filing Date) （出願日）

私は、ここに、下記のいかなる米国出願についても、その米国法典第３５編第１２０条に基づく利益を主張し、又米国を指定するいかなるＰＣＴ国際出願についても、その同第３６５条 (c)に基づく利益を主張する。また、本出願の各特許請求の範囲の主題が、米国法典第３５編第１１２条第１段に規定された態様で、先行する米国出願又はＰＣＴ国際出願に開示されていない場合においては、その先行出願の出願日と本国内出願日またはＰＣＴ国際出願日との間の期間中に入手された情報で、連邦規則法典第３７編規則１．５６に定義された特許性に関わる重要な情報について開示義務があることを承認する。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) 号　　）	(Filing Date) （出願日）	(Status: Patented, Pending, Abandoned) （現況 ： 特許許可、係属中、放棄）
(Application No.) 号　　）	(Filing Date) （出願日）	(Status: Patented, Pending, Abandoned) （現況 ： 特許許可、係属中、放棄）

私は、ここに表明された私自身の知識に係わる陳述が真実であり、且つ情報と信ずることに基づく陳述が、真実であると信じられることを宣言し、さらに、故意に虚偽の陳述などを行った場合は、米国法典第１８編第１００１条に基づき、罰金または拘禁、若しくはその両方により処罰され、またそのような故意による虚偽の陳述は、本出願またはそれに対して発行されるいかなる特許も、その有効性に問題が生ずることを理解した上で陳述が行われたことを、ここに宣言する。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

PTO/SB/106(5-00)
Approved for use through 10/31/02. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Japanese Language Declaration
（日本語宣言書）

委任状 ： 私は本出願を審査する手続を行い、且つ米国特許商標庁との全ての業務を遂行するために、記名された発明者として、下記の弁護士及び／または弁理士を任命する。（氏名及び登録番号を記載すること）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number).

The patent practitioners associated with
Customer Number 020457

書類送付先

Send Correspondence to:

Customer Number: 020457
ANTONELLI, TERRY, STOUT & KRAUS, LLP
Suite 1800, 1300 North Seventeenth Street
Arlington, Virginia 22209

直通電話連絡先 ：（氏名及び電話番号）

Direct Telephone Calls to: (name and telephone number)

Telephone: (703) 312-6600
Fax: (703) 312-6666

唯一または第一発明者氏名		Full name of sole or first inventor Koji HIRATA
発明者の署名	日付	Inventor's signature Koji Hirata Date Jun 19, 2007
住所		Residence Yokohama, Japan
国籍		Citizenship Japan
郵便の宛先		Post office Address c/o Hitachi, Ltd., Intellectual Property Group, 6-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第二共同発明者がいる場合、その氏名		Full name of second joint inventor, if any Takanori HISADA
第二共同発明者の署名	日付	Second inventor's signature Takanori Hisada Date Jun, 21, 2007
住所		Residence Yokohama, Japan
国籍		Citizenship Japan
郵便の宛先		Post office Address c/o Hitachi, Ltd., Intellectual Property Group, 6-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

（第三以下の共同発明者についても同様に記載し、署名をすること）

(Supply similar information and signature for third and subsequent joint unventors.)

第三共同発明者がいる場合、その氏名		Full name of third joint inventor, if any Masahiko YATSU	
第三共同発明者の署名	日付	Third inventor's signature Masahiko Yatsu	Date June 20, 2005
住所		Residence Fujisawa, Japan	
国籍		Citizenship Japan	
郵便の宛先		Post office Address c/o Hitachi, Ltd., Intellectual Property Group, 6-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第四共同発明者がいる場合、その氏名		Full name of fourth joint inventor, if any	
第四共同発明者の署名	日付	Fourth inventor's signature	Date
住所		Residence	
国籍		Citizenship	
郵便の宛先		Post office Address	
第五共同発明者がいる場合、その氏名		Full name of fifth joint inventor, if any	
第五共同発明者の署名	日付	Fifth inventor's signature	Date
住所		Residence	
国籍		Citizenship	
郵便の宛先		Post office Address	
第六共同発明者がいる場合、その氏名		Full name of sixth joint inventor, if any	
第六共同発明者の署名	日付	Sixth inventor's signature	Date
住所		Residence	
国籍		Citizenship	
郵便の宛先		Post office Address	

520.47611CX2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): HIRATA et al

Serial No.: (not yet assigned)

Filed: June 29, 2010

For: Projection Type Image Display Apparatus

REAFFIRMATION OF CLAIM FOR PRIORITY

Mail Stop: Application
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

June 29, 2010

Sir:

Under the provisions of 35 USC §119 and 37 CFR §1.55, Applicants hereby claim the right of priority based on Japanese Patent Application No. 2006-166434, filed in Japan on June 15, 2006.

The certified copy of the above-referred to Japanese Patent Application was filed on June 20, 2007 in prior application Serial No. 11/763,465, filed June 15, 2007.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

/Melvin Kraus/ MK

Melvin Kraus
Registration No. 22,466

MK/jla
(703) 312-6600

520.47611CX2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): HIRATA et al

Serial No.: (not yet assigned)

Filed: June 29, 2010

For: Projection Type Image Display Apparatus

INFORMATION DISCLOSURE STATEMENT UNDER 37 CFR 1.97 & 1.98

Mail Stop: DD
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

June 29, 2010

Sir:

In the matter of the above-identified application, this information disclosure statement is being submitted with the following citation as specified in 37 CFR 1.97(d).

> "A copy of any patent, publication or other information listed in an information disclosure statement is not required to be provided if it was previously cited by or submitted to the Office in a prior application, provided that the prior application is properly identified in the statement and relied upon for an earlier filing date under 35 U.S.C. 120."

Applicants are submitting herewith a copy of Form PTO-SB08A/SB08B which list documents cited in parent application Serial No. 11/763,465, filed June 15, 2007.

It is respectfully requested that this information disclosure statement be considered by the Examiner.

Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (Case: 520.47611CX2) and please credit any excess fees to such deposit account.

Respectfully submitted,

/Melvin Kraus/ MK

Melvin Kraus
Registration No. 22,466
ANTONELLI, TERRY, STOUT & KRAUS, LLP

MK/jla
Attachment
(703) 312-6600

PTO/SB/08A (08-03)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	
Filing Date	**June 29, 2010**
First Named Inventor	**Koji HIRATA, et al.**
Art Unit	
Examiner Name	
Attorney Docket Number	**520.47611CX2**

U.S. PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Document Number Number-Kind Code[2] (*if known*)		Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 5,648,871		07-15-1997	Canon Kabushiki Kaisha	
		US- 6,220,712		04-24-2001	Minolta Co., Ltd.	
		US- 2006/0114430		06-01-2006	T. Masubuchi, et al.	
		US- 2006/0164605		07-27-2006	T. Kuwa	
		US- 2006-0227299		10-12-2006	T. Hisada	
		US- 2006/0227432		10-12-2006	H. Yoshikawa, et al.	
		US- 2009/0115975		05-2009	Ogura	
		US-				
		US-				
		US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Foreign Patent Document Country Code[3]–Number[4]–Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
		JP 05-134213	05-28-1993	CANON INC		ABS
		JP 2000-162544	06-16-2000	MINOLTA CO LTD		ABS
		JP 2004-157560	06-03-2004	NEC VIEWTECHNOLOGY LTD		ABS
		JP 2006-138882	06-01-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-154041	06-15-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-292900	10-26-2006	HITACHI LTD		ABS
		JP 2006-292901	10-26-2006	HITACHI LTD		ABS

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5 Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Projection Type Image Display Apparatus
First Named Inventor/Applicant Name:	Koji Hirata
Filer:	Melvin Kraus/joy aiken
Attorney Docket Number:	520.47611CX2

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	330	330
Utility Search Fee	1111	1	540	540
Utility Examination Fee	1311	1	220	220
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1090**

Electronic Acknowledgement Receipt

EFS ID:	7915958
Application Number:	12825836
International Application Number:	
Confirmation Number:	2374
Title of Invention:	Projection Type Image Display Apparatus
First Named Inventor/Applicant Name:	Koji Hirata
Customer Number:	20457
Filer:	Melvin Kraus/joy aiken
Filer Authorized By:	Melvin Kraus
Attorney Docket Number:	520.47611CX2
Receipt Date:	29-JUN-2010
Filing Date:	
Time Stamp:	15:04:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1090
RAM confirmation Number	13597
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Transmittal of New Application	utl.pdf	179634 908937d1640d3196359cdd90abbae6c8bb070e20	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee.pdf	188022 ec100c2c309d1f5b0b700a29deb458d0ee5d9ce1	no	1
Warnings:					
Information:					
3	Specification	spc.pdf	7118826 47a4bb8127a808fa4b85b972debb31f643170382	no	55
Warnings:					
Information:					
4	Drawings-only black and white line drawings	dwg.pdf	813060 f3f0a91d159a764ee3aa29830e8e268df9b1cf49	no	29
Warnings:					
Information:					
5	Oath or Declaration filed	dec.pdf	604339 e8014fbcc2923219e004c7f5373d75802cda647f	no	4
Warnings:					
Information:					
6	Miscellaneous Incoming Letter	cop.pdf	55414 11bbfa845f19f615be680ad0cd9cd958399b7f1d	no	1
Warnings:					
Information:					
7	Transmittal Letter	ids.pdf	96263 043082eead7ed2f3df8c4d542246e3efba7ff938	no	2
Warnings:					
Information:					
8	Information Disclosure Statement (IDS) Filed (SB/08)	sb08.pdf	200370 2e4611e2ecc3c9a1be439d44450f8882cb59bce3	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
9	Fee Worksheet (PTO-875)	fee-info.pdf	32697 803fc61ed647df2c0cb0553b70c82ceb2ab49580	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	9288625

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (12-04)

Date: **06/29/10**

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/825,836

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	**330**
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	**540**
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	**220**
TOTAL CLAIMS (37 CFR 1.16(i))	**6** minus 20 =		x$26		OR	x$52	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	**1** minus 3 =	*	x$110			x$220	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			195			390	
			TOTAL			TOTAL	**1090**

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
12/825,836	06/29/2010	2878	1090	520.47611CX2	6	1

CONFIRMATION NO. 2374

20457
ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873

FILING RECEIPT

OC000000042483942

Date Mailed: 07/12/2010

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Koji Hirata, Yokohama, JAPAN;
Takanori Hisada, Yokohama, JAPAN;
Masahiko Yatsu, Fujisawa, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 020457

Domestic Priority data as claimed by applicant

This application is a CON of 11/763,465 06/15/2007

Foreign Applications

JAPAN 2006-166434 06/15/2006

Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

If Required, Foreign Filing License Granted: 07/08/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/825,836**

Projected Publication Date: 10/21/2010

Non-Publication Request: No

Early Publication Request: No

Title

Projection Type Image Display Apparatus

Preliminary Class

353

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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日 本 国 特 許 庁
JAPAN PATENT OFFICE

別紙添付の書類に記載されている事項は下記の出願書類に記載されている事項と同一であることを証明する。

This is to certify that the annexed is a true copy of the following application as filed with this Office.

出願年月日 Date of Application:	２００６年　６月１５日
出願番号 Application Number:	特願２００６－１６６４３４
パリ条約による外国への出願に用いる優先権の主張の基礎となる出願の国コードと出願番号 The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is	ＪＰ２００６－１６６４３４
出願人 Applicant(s):	株式会社日立製作所

２０１０年　７月１４日

特許庁長官
Commissioner,
Japan Patent Office　細野哲弘

【書類名】　特許願
【整理番号】　NT06P0160
【提出日】　平成18年 6月15日
【あて先】　特許庁長官　殿
【国際特許分類】　G02B 13/16
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【代理人】
　【識別番号】　110000350
　【氏名又は名称】　特許業務法人　日東国際特許事務所
　【代表者】　作田　康夫
　【電話番号】　03-3537-1621
【手数料の表示】
　【予納台帳番号】　289041
　【納付金額】　16,000円
【提出物件の目録】
　【物件名】　特許請求の範囲　1
　【物件名】　明細書　1
　【物件名】　図面　1
　【物件名】　要約書　1

【書類名】特許請求の範囲
【請求項１】
　映像表示素子と、当該映像表示素子に表示された映像を拡大して投写面に投写する投写光学ユニットとを備えた投写型映像表示装置であって、前記投写光学ユニットは、
　前記映像表示素子に隣接して配置され、かつ、複数の投写用レンズを含んで構成されるレンズ群と；
　前記レンズ群からの出射光を反射して前記投写面上に傾斜して投写する反射ミラーとを備えており、
　前記レンズ群は、前記映像表示素子と前記反射ミラーの間に配置され、回転非対称の自由曲面の形状を有する複数のレンズを備えており、かつ、前記レンズ群からの出射光を反射する前記反射ミラーは、その一部が反射方向に凸形状の回転非対称の凸面反射ミラーであることを特徴とする投写型映像表示装置。
【請求項２】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記後方レンズ群を構成する回転非対称の自由曲面の形状を有する複数のレンズの一部は、前記投写面の下端部に入射する光線が通過する部分の曲率と、前記投写面の上端部に入射する光線が通過する部分の曲率が異なるように形成されていることを特徴とする投写型映像表示装置。
【請求項３】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記後方レンズ群は、前記非対称レンズの他に、少なくとも一つの回転対称の球面レンズと、少なくとも一つの回転対称の非球面レンズを含むことを特徴とする投写型映像表示装置。
【請求項４】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記凸面反射ミラーは、前記投写面の下端部に入射する光線を反射する部分の曲率が、前記スクリーンの上端に入射する光線を反射する部分の曲率よりも大きく形成されていることを特徴とする投写型映像表示装置。
【請求項５】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記凸面反射ミラーは、前記スクリーンの下端に入射する光線を反射する部分がその反射方向に対し凸の形状を為し、前記スクリーンの上端に入射する光線を反射する部分がその反射方向に凹の形状を為すこと特徴とする投写光学ユニット。
【請求項６】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットでは、画面中央光線と当該画面中央光線が入射する位置における前記投写面の法線とを含む平面内において、前記反射ミラーの反射面から前記投写面の上端に入射する光線の経路の距離をＬ１、前記反射ミラーの反射面から前記投写面の下端に入射する光線の経路の距離をＬ２、前記投写面での画面の上端から下端までの距離をＤｖ、前記画面中央光線と前記投写面の法線との成す角度をθｓとしたとき、次の式を満足するように形成されていることを特徴とする投写型映像表示装置。
｜Ｌ１－Ｌ２｜＜１．２＊ｓｉｎθｓ＊Ｄｖ
【請求項７】
　請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記レンズ群のほぼ光軸上に配置された前記映像表示素子の表示面中央の法線を、前記レンズ群の光学系の光軸に対して傾けることを特徴とする投写型映像表示装置。
【請求項８】
　前記請求項１に記載の投写型映像表示装置において、前記投写光学ユニットを構成する前記レンズ群は、回転対称な面形状を有する正のパワーを有する複数の屈折レンズを含む前方レンズ群と、前記回転非対称の自由曲面の形状を有する複数のレンズを含む後方レン

ズ群とを備えていることを特徴とする投写型映像表示装置。
【請求項９】
　請求項８に記載の投写型映像表示装置において、前記投写光学ユニットの画面中央光線が前記投写面に向かう経路上における、前記レンズ群の最終面から前記反射ミラー反射面に至るまでの光路長が、前記レンズ群の前記前方レンズ群の焦点距離の５倍又はそれ以上であることを特徴とする投写型映像表示装置。
【請求項１０】
　前記請求項８に記載の投写型映像表示装置において、前記後方レンズ群は、更に、回転対称な面形状を有する負のパワーを有する屈折レンズを含んでおり、かつ、前記後方レンズ群は、前記前方レンズ群に対して、光軸方向に移動可能になっていることを特徴とする投写型映像表示装置。
【請求項１１】
　前記請求項８に記載の投写型映像表示装置において、更に、前記後方レンズ群を光軸方向に移動する手段を備えたことを特徴とする投写型映像表示装置。
【請求項１２】
　前記請求項１１に記載の投写型映像表示装置において、前記後方レンズ群移動手段は、当該装置の外部から操作可能となっていることを特徴とする投写型映像表示装置。
【請求項１３】
　請求項８に記載の投写型映像表示装置において、前記投写光学ユニットは、更に、前記回転非対称の凸面反射ミラーからの反射光を反射する平面ミラーを備えていることを特徴とする投写型映像表示装置。
【請求項１４】
　請求項１に記載の投写型映像表示装置において、更に、当該装置の筐体底面には、当該装置からの出射光の進行角度を調整するための位置決め機構を備えていることを特徴とする投写型映像表示装置。
【請求項１５】
　映像表示素子に隣接して配置され、かつ、複数の投写用レンズを含んで構成されるレンズ群と、前記レンズ群からの出射光を反射して前記投写面上に傾斜して投写する反射ミラーとを備えた投写光学ユニットであって、
　前記反射ミラーの中心から前記投写面までの距離（Ｌｐ）に対する当該投写面の対角寸法（Ｌｏ）との間の比（Ｌｏ／Ｌｐ）が、少なくとも２以上であることを特徴とする投写光学ユニット。
【請求項１６】
　映像表示素子と、当該映像表示素子に表示された映像を拡大して投写面に投写する投写光学ユニットとを備えた投写型映像表示装置であって、前記投写光学ユニットとして前記請求項１５に記載した投写光学ユニットを用いたことを特徴とする投写型映像表示装置。

【書類名】明細書
【発明の名称】投写型映像表示装置とそのための投写光学ユニット
【技術分野】
【０００１】
本発明は、映像表示素子の画像を拡大してスクリーンなどの透写面上に投写して画像表示を行う投写型映像表示装置、特に、フロント透写型の映像表示装置に適した投写型映像表示装置、更には、そのための投写光学ユニットに関する。
【背景技術】
【０００２】
映像表示素子の画像を、複数のレンズから構成される投写光学ユニットを介してスクリーン（透写面）上に拡大して投写するカラー映像表示装置においては、スクリーン上で充分な大きさの拡大映像を、歪みなく得ることが要求される。これを実現するため、例えば下記の特許文献１～２に記載されているように、投影画面を投影系の光軸に対して垂直方向にシフトすると共に、やはり投影系の光軸に対して所定の角度傾けて配置された付加光学系とを用いて、映像をスクリーンに対して斜め方向に拡大投影する投影装置又は光学系が既に知られている。なお、ここで言う付加光学系（アフォーカルコンバータ）とは、投影像の大きさを変換する作用を有する光学系であり、スクリーンに対する斜め方向からの透写に伴う投影像の歪を補正・低減して長方形の投影像を得るためのものである。
【０００３】
また、上記のレンズ（透過系光学素子）に代えて複数の反射鏡（反射系光学素子）を用い、映像表示素子の画像をスクリーン（透写面）上に拡大して投写する反射型結像光学系は、例えば下記の特許文献３によって、既に、知られている。
【０００４】
【特許文献１】特開平５－１３４２１３号公報
【特許文献２】特開２０００－１６２５４４号公報
【特許文献３】特開２００４－１５７５６０号公報
【発明の開示】
【発明が解決しようとする課題】
【０００５】
即ち、映像をスクリーンに対して斜め方向から投写すると、投写映像には、所謂、台形歪みが生じる。これを解消するために、上記特許文献１に記載の投写光学ユニットでは、スクリーン側に配置された付加光学系（アフォーカルコンバータ）を偏心させて台形歪み抑える構成としている。しかしながら、かかる偏心付加光学系を構成するレンズは、倍率が低いため広角化が困難であり、そのため、必要な倍率の投影像を得るためには、透写装置からスクリーンまでの距離が大きくなってしまい、また、投影画面と投影系との間の距離も大きくなってしまい、そのため、装置全体が大きく（特に、光学ユニットの光軸方向の長さ）なってしまうという問題点がある。加えて、上述した偏心付加光学系を構成するレンズとしては、口径の大きな付加光学系が必要となるが、それに伴って、透写光学ユニットのコスト上昇の原因となってしまうことにもなる。
【０００６】
また、上記特許文献２に記載の投写光学ユニットにおいても、上記特許文献１と同様、倍率が低いために広角化が困難であり、かつ、使用するレンズを個別に偏心させる必要があるため、その製造が難しく、加えて、やはり口径の大きな付加光学系が必要となり、透写光学ユニットのコスト上昇の原因となってしまう。
【０００７】
一方、上記特許文献３に記載の反射型結像光学系においては、従来の透過型の結像光学系（レンズ系）に代えて反射光学系（反射鏡）を利用することにより、結像光学系の大型化を抑え且つ広画角化を図るものである。しかしながら、反射鏡での光の偏心（偏向）量が大きなことから、特に、装置内において、その傾斜角度も含めて複数の反射鏡を正確な位置に配置することが難しく、また、振動によっても容易に反射鏡の傾斜角度等が変化し

てしまうことから、やはり、その製造が極めて難しいという問題点があった。
【０００８】
そこで、本発明では、上記従来技術における問題点に鑑み、装置の外形が大きくすることなく広角化を可能とすると共に、その製造も比較的容易な投写型映像表示装置と、そのための投写光学ユニットとを提供することをその目的とする。即ち、口径の大きな付加光学系を必要とすることなく、かつ、台形歪みが生じず、投写形表示装置自体を、よりコンパクトな外形寸法とするのに好適な技術を提供することを目的とする。
【課題を解決するための手段】
【０００９】
本発明によれば、上記の目的を達成するため、まず、映像表示素子と、当該映像表示素子に表示された映像を拡大して投写面に投写する投写光学ユニットとを備えた投写型映像表示装置であって、前記投写光学ユニットは、前記映像表示素子に隣接して配置され、かつ、複数の投写用レンズを含んで構成されるレンズ群と；前記レンズ群からの出射光を反射して前記投写面上に傾斜して投写する反射ミラーとを備えており、前記レンズ群は、前記映像表示素子と前記反射ミラーの間に配置され、回転非対称の自由曲面の形状を有する複数のレンズを備えており、かつ、前記レンズ群からの出射光を反射する前記反射ミラーは、その一部が反射方向に凸形状の回転非対称の凸面反射ミラーである投写型映像表示装置が提供される。
【００１０】
また、本発明では、前記の投写型映像表示装置において、前記投写光学ユニットを構成する前記後方レンズ群を構成する回転非対称の自由曲面の形状を有する複数のレンズの一部は、前記投写面の下端部に入射する光線が通過する部分の曲率と、前記投写面の上端部に入射する光線が通過する部分の曲率が異なるように形成することが好ましく、又は、前記投写光学ユニットを構成する前記後方レンズ群は、前記非対称レンズの他に、少なくとも一つの回転対称の球面レンズと、少なくとも一つの回転対称の非球面レンズを含むことが好ましい。或いは、前記投写光学ユニットを構成する前記凸面反射ミラーは、前記投写面の下端部に入射する光線を反射する部分の曲率が、前記スクリーンの上端に入射する光線を反射する部分の曲率よりも大きく形成されていることが好ましい。
【００１１】
更に、本発明では、前記の投写型映像表示装置において、前記投写光学ユニットを構成する前記凸面反射ミラーは、前記スクリーンの下端に入射する光線を反射する部分がその反射方向に対し凸の形状を為し、前記スクリーンの上端に入射する光線を反射する部分がその反射方向に凹の形状を為すことが好ましく、又は、前記投写光学ユニットでは、画面中央光線と当該画面中央光線が入射する位置における前記投写面の法線とを含む平面内において、前記反射ミラーの反射面から前記投写面の上端に入射する光線の経路の距離をＬ１、前記反射ミラーの反射面から前記投写面の下端に入射する光線の経路の距離をＬ２、前記投写面での画面の上端から下端までの距離をＤｖ、前記画面中央光線と前記投写面の法線との成す角度をθｓとしたとき、次の式を満足するように形成されていることが好ましい。
｜Ｌ１－Ｌ２｜＜１．２＊ｓｉｎθｓ＊Ｄｖ
また、本発明では、前記の投写型映像表示装置において、前記投写光学ユニットを構成する前記レンズ群のほぼ光軸上に配置された前記映像表示素子の表示面中央の法線を、前記レンズ群の光学系の光軸に対して傾けることが好ましい。
【００１２】
また、本発明では、前記の投写型映像表示装置において、前記投写光学ユニットを構成する前記レンズ群は、回転対称な面形状を有する正のパワーを有する複数の屈折レンズを含む前方レンズ群と、前記回転非対称の自由曲面の形状を有する複数のレンズを含む後方レンズ群とを備えていることが好ましく、更には、前記投写光学ユニットの画面中央光線が前記投写面に向かう経路上における、前記レンズ群の最終面から前記反射ミラー反射面に至るまでの光路長が、前記レンズ群の前記前方レンズ群の焦点距離の５倍又はそれ以上

であることが好ましい。或いは、前記後方レンズ群は、更に、回転対称な面形状を有する負のパワーを有する屈折レンズを含んでおり、かつ、前記後方レンズ群は、前記前方レンズ群に対して、光軸方向に移動可能になっていることが好ましい。

【００１３】

更に、本発明では、前記の投写型映像表示装置において、更に、前記後方レンズ群を光軸方向に移動する手段を備えることが好ましく、又は、前記後方レンズ群移動手段は、当該装置の外部から操作可能となっていることが好ましい。或いは、前記投写光学ユニットは、更に、前記回転非対称の凸面反射ミラーからの反射光を反射する平面ミラーを備えていることが好ましく、又は、前記の投写型映像表示装置において、更に、当該装置の筐体底面には、当該装置からの出射光の進行角度を調整するための位置決め機構を備えていることが好ましい。

【００１４】

また、本発明によれば、やはり上述の目的を達成するため、映像表示素子に隣接して配置され、かつ、複数の投写用レンズを含んで構成されるレンズ群と、前記レンズ群からの出射光を反射して前記投写面上に傾斜して投写する反射ミラーとを備えた投写光学ユニットであって、前記反射ミラーの中心から前記投写面までの距離（Ｌｐ）に対する当該投写面の対角寸法（Ｌｏ）との間の比（Ｌｏ／Ｌｐ）が、少なくとも２以上である投写光学ユニットが提供される。

【００１５】

そして、本発明では、映像表示素子と、当該映像表示素子に表示された映像を拡大して投写面に投写する投写光学ユニットとを備えた投写型映像表示装置であって、前記投写光学ユニットとして前記に記載した投写光学ユニットを用いた投写型映像表示装置が提供される。

【発明の効果】

【００１６】

以上の本発明によれば、口径の大きな付加光学系を必要とすることなく、広角角化を可能とすると共に、投写面（スクリーン）までの位置が変更しても歪みや収差を最小限に抑えることが可能であり、性能が良好で、かつ、便利で使い勝手にも優れた投写型映像表示装置装置を実現することを可能とするという優れた効果を発揮する。

【発明を実施するための最良の形態】

【００１７】

以下、本発明の実施形態について、添付の図面を参照しながら詳細に説明する。

まず、添付の図１は、本発明の一実施の形態になる投写型映像表示装置の全体構成を示す斜視図である。即ち、この図において、投写型映像表示装置１００を構成する略箱型の筐体１１０の内部には、例えば、外部のパーソナルコンピュータから入力される画像又は映像を表示する画像表示素子１と、高輝度の白色光を発生するランプなどの光源８とを備えており、更に、その構造については以下に詳細に説明するが、当該光源８から照射されて画像表示素子１で変調された光を拡大して照射するための投写光学ユニットが搭載されている。そして、この投写型映像表示装置を室内で使用する場合、当該投写光学ユニットから出射した光は、図に矢印で示すように、その筐体１１０の一方向（図では、長手方向）に対向して位置する部屋の壁面やシート状のスクリーン等、所謂、スクリーン５上に投写されることとなる。

【００１８】

次に、添付の図２の断面図を参照しながら、上記投写型映像表示装置を構成する投写光学ユニットの基本的な光学構成について説明する。なお、この図２の断面は、上記図１の右下方向（図の白抜きの矢印を参照）から見た断面を示しており、この図２に示したＸＹＺ直交座標系（図中に矢印で示す）におけるＹＺ断面に相当する。

【００１９】

この図２にも示すように、本発明になる投写光学ユニットは、光源８からの光を入射して所望の映像を射出する画像表示素子１とプリズム１０、前方レンズ群２と後方レンズ群

３とを含む２つのレンズ群から構成される透過（レンズ）光学系、そして、回転対称でない（即ち、非回転対称）の自由曲面形状の反射面を有する反射鏡（以下、自由曲面ミラーと言う）４を含む反射光学系とによって構成される。

【００２０】

ここでは、上記画像表示素子１として、例えば、液晶パネルに代表される透過型のものを採用した例を示しているが、本発明では、これに限らず、例えば、ＣＲＴのような自発光型のものでもよい。また、上記画像表示素子１として、例えば上述した液晶パネルなどの透過型のものを採用する場合には、液晶パネルを照射する光源８となるランプが必要となる。また、当該液晶パネルとして、所謂、３板式のように、Ｒ、Ｇ、Ｂの複数の画像を合成する方式でもよく、その場合には、映像合成用のプリズム等が必要となる。しかしながら、これら液晶パネルの詳細やこれを照射する光源８となるランプ等については、後に説明することとし、ここでは直接的に関係しないため、その図示は省略している。一方、ＣＲＴのような自発光型のものでは、上記光源８を必要としないことは明らかであろう。

【００２１】

以上のような構成になる本発明の投写光学ユニットでは、上記画像表示素子１からプリズム１０を介して射出した光は、まず、レンズ光学系を構成する前方レンズ群２に入射される。なお、後にもその詳細を説明するが、この前方レンズ群２は、回転対称な面形状を有する、正のパワー及び負のパワーを有する複数の屈折レンズを含んで構成されている。その後、この前方レンズ群２から射出した光は、少なくとも一方の面が回転対称でない（回転非対称の）自由曲面の形状を有する複数（本例では２枚）のレンズを含めた複数のレンズから構成される後方レンズ群３を通過する。そして、この後方レンズ群３から射出した光は、更に、回転対称でない自由曲面形状の反射面を有する反射鏡（以下、自由曲面ミラーと言う）４を含む反射光学系で拡大反射された後、所定のスクリーン５（例えば、部屋の壁面やシート状のスクリーン等）上に投写されることとなる。

【００２２】

なお、本実施の形態では、上記図２からも明らかなように、従来技術（特に、上述の特許文献１や２）のように投影画面（表示素子）を投影系の光軸に対して垂直方向にシフトし、更には、投影系の光軸に対して所定の角度傾けて付加光学系を配置する光学系とは異なり、上記画像表示素子１は、その表示画面の中央がレンズ光学系のほぼ光軸上に位置するように配置されている（即ち、共軸光学系を形成している）。従って、上記画像表示素子１の表示画面の中央から出てレンズ光学系の入射瞳の中央を通ってスクリーン５上の画面中央に向かう光線１１は、ほぼ、レンズ光学系（上記前方レンズ群２と後方レンズ群３を含む）の光軸に沿って進む（以下、これを「画面中央光線」という）。その後、この画面中央光線１１は、上記反射光学系（自由曲面ミラーを含む）の自由曲面形状を有する反射面４上の点Ｐ２で反射された後、スクリーン５上の画面中央の点Ｐ５に、スクリーンの法線７に対して下方から斜めに入射する。この角度を以下、「斜め入射角度」と称し、θｓで表わすこととする。このことは、即ち、前記レンズ光学系の光軸に沿って通過した光線がスクリーンに対して斜めに入射していることで、実質的にレンズ光学系の光軸がスクリーンに対して斜めに設けられている（斜め入射系となる）ことを意味することとなる。

【００２３】

なお、上述したように、スクリーンに対して光線を斜めに入射すると、上記画像表示素子１から投写された長方形の形状が台形になる、所謂、台形歪を含め、その他にも、光軸に対して回転対称でないことによる種々の収差が生じることとなるが、しかしながら、本発明では、これらを前記レンズ光学系を構成する後方レンズ群３と、そして、前記反射光学系の反射面とで補正するものである。

【００２４】

特に、上記画像表示素子１から投写された光線を、前記反射光学系を構成する反射鏡４の反射面で拡大反射してスクリーン５上に斜めに入射することによれば、レンズにより得られる光の偏心量（偏向角）に比較し、より大きな偏心量（偏向角）が得られ、また、収差も生じ難くいことから、装置の大型化を抑え、且つ、広画角化を図ることが可能となる

。即ち、上記前方レンズ群２と後方レンズ群３を含むレンズ光学系を、上述した従来技術（特に、上述の特許文献１や２）の付加光学系（アフォーカルコンバータ）を偏心させて台形歪み抑える構成に比較して、より口径の小さな光学系として構成することが可能となる。

【００２５】

また、上記反射光学系を構成する反射鏡４の反射面に入射する光を、上述したように、前記レンズ光学系により所定の大きさまで拡大して投射することから、従来の反射鏡だけで拡大投射系を構成する構造（例えば、上述した特許文献３）に比較しても、その製造が容易となる。即ち、レンズ光学系を反射光学系とは個別に製造し、その後、装置筐体内において、これら両者の位置を固定調整する構成とすることにより、特に、量産に適したものとなる。また、上記のように、台形歪等を補正するための後方レンズ群３を、前記前方レンズ群２の前方に配置する構成によれば、この後方レンズ群３と前方レンズ群２との間の間隔を小さくして配置することが可能となることから、当該投写光学ユニットを搭載する装置を全体的にコンパクトとすることができ、特に、スクリーンの下部での高さを小さく出来るという好適な効果が得られる。

【００２６】

このように、自由曲面形状を有する透過型のレンズ光学系と、自由曲面形状を有する反射光学系とを組み合わせることによれば、特に、フロント透写型の映像表示装置に適した場合、フロント透写型で強く要求される広画角化を、確実かつ比較的容易に、かつ、装置全体を小さくしたコンパクトな投写型映像表示装置として実現することが可能となる。

【００２７】

次に、添付の図３及び図４には、上記投写型映像表示装置を構成する投写光学ユニットのレンズ光学系及び反射光学系を含む光学素子の詳細が示されている。即ち、図３は上記投写光学ユニットの斜視図であり、図４はその垂直方向断面（図４（ａ））及びその水平方向断面（図４（ｂ））をそれぞれ示している。

【００２８】

これらの図にも示されるように、レンズ光学系では、映像表示素子１からプリズム１０を介して出射される映像は、まず、回転対称形状を有する複数のレンズを含む前方レンズ群２に入射される。上述したように、前方レンズ群２は、回転対称の球面レンズと非球面レンズとを含んでいる。又は、添付の図５や図６に示すように、前方レンズ群２と後方レンズ群３の途中に折り曲げミラー３５を配置して光線を直角に折り曲げる構成としてもよい。

【００２９】

また、後方レンズ群３は、少なくとも２つの自由曲面レンズにより構成されている。これらの図にも示すように、反射鏡４の反射面Ｓ２２に最も近い自由曲面レンズ３１は、その光の射出方向に凹部を向けており、かつ、前記スクリーンの下端に入射する光線が通過する部分の曲率が、前記スクリーンの上端に入射する光線が通過する部分の曲率よりも大きく設定されている。即ち、自由曲面レンズとは、その光の射出方向に凹部を向けて湾曲されており、かつ、スクリーンの下端に入射する光線が通過する部分の曲率が、前記スクリーンの上端に入射する光線が通過する部分の曲率よりも大きい形状を有するものとする。

【００３０】

また、本実施形態では、次の条件を満たすように構成されている。即ち、上記の図２に示す断面内において、上記画像表示素子１の画面下端から射出されて前方レンズ群２の入射瞳の中央を通り、スクリーン５の画面上端の点Ｐ６に入射する光線を光線１２とする。この光線１２が自由曲面ミラー４を通過する点Ｐ３からスクリーン上の点Ｐ６にまで至る光路長をＬ１とする。また、上記画像表示素子１の画面上端から射出されて前方レンズ群２の入射瞳の中央を通り、スクリーン５の画面下端の点Ｐ４に入射する光線を光線１３とする。この光線１３が自由曲面ミラー４を通過する点Ｐ１からスクリーン上の点Ｐ４にまで至る光路長をＬ２とする。そして、上述した投写光学ユニットでは、上記Ｌ１、Ｌ２が

次の式を満足するように構成されている。

【００３１】

【数１】

$$|L1-L2|<1.2*\sin\theta s*Dv$$

【００３２】

但し、ここで、Ｄｖは図２の断面内でのスクリーン上の画面の大きさであり、言い換えると、スクリーン上の画面上端の点Ｐ６から画面下端の点Ｐ４までの距離である．また、θｓは上記斜め入射角度である。

【００３３】

一方、前記画像表示素子１は、その表示画面の中央を前記レンズ光学系の光軸上に位置するように配置されているが、或いは、添付の図７にも示すように、当該表示画面の法線は前記レンズ光学系の光軸に対して僅かに傾けて配置することが望ましいであろう。

【００３４】

なお、上記の図２を見ると、前述したように、点Ｐ３から点Ｐ６に到る光路長は、点Ｐ１から点Ｐ４に到る光路長よりも長くなっている。これは、レンズ光学系から見て、スクリーン上の像点Ｐ６が像点Ｐ４よりも遠くにあることを意味している。そこで、スクリーン上の像点Ｐ６に対応する物点（表示画面上の点）がよりレンズ光学系に近い点に、また、像点Ｐ４に対応する物点がよりレンズ光学系から遠い点にあれば、像面の傾きを補正できる。そのためには、上記図７にも示すように、前記画像表示素子１の表示画面中央の法線ベクトルを、スクリーン５の法線と画面中央光線を含む平面内において、レンズ光学系の光軸に対して僅かに傾けるようにすることが好ましい。そして、その傾斜の方向は、スクリーン５が位置する方向と反対方向とすることが好ましい。

【００３５】

なお、光軸に対して傾いた像平面を得るのに物平面を傾ける方法は知られているが、実用的な大きさの画角では、物平面の傾きによる像面は、光軸に対して非対称な変形を生じ、回転対称な投写レンズでは補正が困難であった。本実施形態では、上記の後方レンズ群３において、回転非対称の自由曲面レンズ３１を、更には、やはり自由曲面レンズ３２を用いているため、非対称な像面の変形に対応することができる。このため、物平面を傾けること、すなわち映像表示素子の表示面を傾けることで、低次の像面の歪を大きく低減できることから、自由曲面による収差補正を補助する上で効果的である。

【００３６】

次に、上記した各光学要素の作用については、前記レンズ光学系ではその前方レンズ群２（レンズ２１～２５）が、前記画像表示素子１の表示画面をスクリーン５上に投写するための主レンズを構成しており、回転対称な光学系における基本的な収差を補正する。また、前記レンズ光学系の後方レンズ群３（レンズ３１～３４）は回転対称でない（回転非対称）自由曲面形状を有するレンズで構成されている。更に、前記反射光学系４は、回転対称でない自由曲面形状を有する反射面で構成されるため、主として、斜め入射によって生じる収差の補正を行う。このように、前記反射光学系をなすミラー４が主として台形歪を補正し、他方、レンズ光学系の後方レンズ系群３が主として像面の歪みなどの非対称な収差の補正を行う構成となっている。

【００３７】

以上のように、本発明の実施形態では、前記反射光学系は回転対称でない自由曲面形状を有する１枚の反射面（ミラー）４で構成され、前記レンズ光学系の後方レンズ群３は、両面共に回転非対称な自由曲面形状を有する２枚の透過型レンズを（反射ミラー４側のレンズ３１及び３２）含んで構成されている。なお、ここで、自由曲面ミラー４は、その反射方向に凸部を向けるように湾曲されている。そして、自由曲面ミラー４のスクリーンの下端に入射する光線を反射する部分の曲率は、前記スクリーンの上端に入射する光線を反射する部分の曲率よりも大きく設定されている。また、スクリーンの下端に入射する光線を反射する部分がその反射方向に対し凸形状を為し、他方、前記スクリーンの上端に入射

する光線を反射する部分がその反射方向に凹形状を為すようにしてもよい。

【００３８】

反射光学系の反射面（ミラー）４における座標原点と、前方レンズ群２のうち最も反射面（ミラー）４に近いレンズ面との間の光軸方向での距離は、前方レンズ群２の焦点距離の５倍、又は、それ以上に設定することが望ましい。これによれば、反射光学系の自由曲面形状を有する反射面により、台形歪収差をより効果的に補正し、もって、良好な性能を得ることができる。

【００３９】

以下、本発明の具体的な数値実施例について説明する。

【実施例１】

【００４０】

まず、添付の図８及び図９、更には、以下の表１～表４を用いて、上記に説明した本実施例になる投写光学ユニットの詳細を、特に、そのレンズ光学系及び反射光学系を含む光学素子の具体的な数値を示しながら説明する。なお、これらの図は、第１の数値例に基づく本発明に係る光学系の光線図を示している。即ち、図８は、前述した図２のＸＹＺ直交座標系におけるＹＺ断面、即ち、光学系をＺ軸方向に展開して示している。また、図９はＸＺ断面での構成を示している。なお、図９では、その詳細構造を添付の図５及び図６に示すように、レンズ光学系を構成するレンズ光学系の前方レンズ群２と後方レンズ群３との途中に折り曲げミラー３５を設置し、もって、光路をＸ軸方向に一度折り曲げている例を示している。

【００４１】

本例において、図４の下側に表示した映像表示素子１から射出した光は、複数のレンズを含むレンズ光学系のうち、まず回転対称形状の面のみを有するレンズのみで構成される前方レンズ群２を通過する。そして、回転非対称の自由曲面レンズを含む後方レンズ群３を通り、反射光学系である自由曲面ミラー４の反射面で反射される。その反射光は、その後スクリーン５に入射される。

【００４２】

ここで、レンズ光学系の前方レンズ群２は、全て、回転対称な形状の屈折面を持つ複数のレンズにより構成されており、これらレンズの屈折面のうち４つは回転対称な非球面であり、他は球面である。なお、ここに用いられた回転対称な非球面は、各面毎のローカルな円筒座標系を用いて、次の式で表される。

【００４３】

【数２】

$$Z=\frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}}+A\cdot r^4+B\cdot r^6+C\cdot r^8+D\cdot r^{10}+E\cdot r^{12}+F\cdot r^{14}+G\cdot r^{16}+H\cdot r^{18}+J\cdot r^{20}$$

【００４４】

ここで、「ｒ」は光軸からの距離であり、「Ｚ」はサグ量を表している。また、「ｃ」は頂点での曲率、「ｋ」は円錐定数、「Ａ」から「Ｊ」は上記「ｒ」のべき乗の項の係数である。

【００４５】

一方、前記レンズ光学系の後方レンズ群３を構成する自由曲面は、各面の面頂点を原点とするローカルな直交座標系（ｘ、ｙ、ｚ）を用い、Ｘ、Ｙの多項式を含む次の式で表わされる。

【００４６】

【数３】

$$Z=\frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}}+\sum_m\cdot\sum_n(C(m,n)\cdot x^m\cdot y^n)$$

【００４７】

ここで、「Ｚ」はＸ、Ｙ軸に垂直な方向で自由曲面の形状のサグ量を表わしており、「ｃ」は頂点での曲率、「ｒ」はＸ、Ｙ軸の平面内での原点からの距離、「ｋ」は円錐定数、「Ｃ（ｍ、ｎ）」は多項式の係数である。

【００４８】

次に、以下の表１は、本実施例に係る光学系の数値データを示している。この表１において、Ｓ０～Ｓ２３は、上記図３示された符号Ｓ０～Ｓ２３にそれぞれ対応している。ここで、符号Ｓ０は映像表示素子１１の表示面、すなわち物面を示しており、Ｓ２３は自由曲面ミラー５の反射面を示している。また、符号Ｓ２４は、これらの図では示されていないが、上記図１のスクリーン５の入射面、すなわち、像面を示している。

【００４９】

【表１】

表１

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	7.06		
S3	246.358	4.65	1.85306	17.2
S4	-84.858	18.00		
S5 *	-83.708	9.00	1.49245	42.9
S6 *	-75.314	0.10		
S7	41.651	9.32	1.49811	60.9
S8	-42.282	2.50	1.76014	20.0
S9	29.550	0.10		
S10	29.476	9.00	1.49811	60.9
S11	-79.153	25.90		
S12	Infinity	9.10		
S13	-265.353	6.00	1.85306	17.2
S14	-53.869	65.00		
S15	-24.898	4.19	1.74702	33.2
S16	-58.225	9.00		
S17 *	-27.332	10.00	1.49245	42.9
S18 *	-32.424	2.50		
S19 #	Infinity	8.00	1.49245	42.9
S20 #	Infinity	20.51		
S21 #	Infinity	8.00	1.49245	42.9
S22 #	Infinity	160.99		
S23 #	Infinity	-705.00	REFL	

【００５０】

また、上記表１において、「Ｒｄ」は各面の曲率半径であり、上記図３において面の左側に曲率の中心がある場合は正の値で、逆の場合は負の値で表わしている。また、上記表１において、「ＴＨ」は面間距離であり、そのレンズ面の頂点から次のレンズ面の頂点までの距離を示す。そのレンズ面に対して、次のレンズ面が図の中で左側にある時には面間距離は正の値、右側にある場合は負の値で表している。

【００５１】

更に、上記表１において、Ｓ５、Ｓ６、Ｓ１７、Ｓ１８は回転対称な非球面であり、この表１では面の番号の横に「＊」を付けて分かり易く表示しており、これら４つ面の非球面の係数を以下の表２に示している。

【００５２】

【表２】

表２

Surface	非球面係数							
S5	K	-11.7678542	C	-1.159E-11	F	2.98642E-20	J	-1.255E-26
	A	-2.7881E-06	D	-3.2834E-14	G	1.05201E-21		
	B	9.67791E-09	E	1.09359E-16	H	1.96001E-24		
S6	K	-5.4064901	C	2.0324E-12	F	3.0211E-19	J	-1.4982E-26
	A	6.14967E-07	D	-2.2078E-14	G	4.30049E-22		
	B	4.60362E-09	E	-8.0538E-17	H	4.79618E-24		
S17	K	1.016429122	C	-9.0262E-11	F	-1.0521E-18	J	-6.0837E-26
	A	-1.1068E-05	D	-1.3984E-13	G	-8.1239E-23		
	B	7.21301E-08	E	3.1153E-16	H	3.86174E-23		
S18	K	0.742867686	C	-2.2719E-11	F	1.09398E-19	J	9.02232E-29
	A	1.51788E-07	D	-4.6853E-14	G	1.62146E-22		
	B	2.10472E-08	E	2.9666E-17	H	-3.0801E-25		

【００５３】

また、上記表１においてＳ１９からＳ２２は前記レンズ光学系の後方レンズ群を構成する自由曲面形状を有する屈折面であり、Ｓ２３は反射光学系の自由曲面Ｓ２３形状を有する反射面であって、面の番号の横に＃を付けて表示した。これら５つの自由曲面の形状を表す係数の値を以下の表３に示す。

【００５４】

【表３】

表３

Surface	自由曲面係数							
			C17	5.38933E-07	C34	-1.2381E-09	C51	-7.4126E-14
	K	0	C19	8.33432E-07	C36	1.13944E-09	C53	2.05074E-12
S19	C4	0.013500584	C21	-4.6367E-08	C37	3.87771E-12	C55	-9.2166E-13
	C6	0.003493312	C22	-6.2643E-09	C39	1.04779E-11	C56	-2.5867E-15
	C8	-0.00083921	C24	-2.2449E-08	C41	1.80038E-11	C58	-8.7122E-15
	C10	-0.00032098	C26	-5.6706E-08	C43	5.23019E-11	C60	2.85321E-14
	C11	8.59459E-06	C28	9.69952E-10	C45	1.69253E-11	C62	-8.5084E-14
	C13	2.14814E-06	C30	-1.1968E-10	C47	-2.7E-14	C64	1.25198E-13
	C15	7.54355E-06	C32	-1.3638E-09	C49	7.30978E-13	C66	-5.6277E-14
			C17	7.49262E-07	C34	-5.7462E-10	C51	-3.6141E-13
	K	0	C19	1.19039E-06	C36	1.27396E-09	C53	8.54188E-14
S20	C4	0.015488689	C21	-1.2953E-07	C37	-4.7746E-12	C55	-5.3469E-13
	C6	0.006553414	C22	5.115E-10	C39	7.32855E-12	C56	8.92545E-17
	C8	-0.00116756	C24	-2.1936E-08	C41	5.30157E-11	C58	-5.3434E-15
	C10	-0.00033579	C26	-5.9543E-08	C43	5.05014E-11	C60	1.96533E-14
	C11	7.5015E-06	C28	2.03972E-08	C45	-2.1894E-11	C62	-1.3923E-13
	C13	-2.5728E-06	C30	1.16701E-11	C47	-1.2515E-13	C64	1.06322E-13
	C15	-1.3543E-06	C32	-1.6198E-09	C49	7.64489E-13	C66	-4.6602E-15
			C17	-1.0379E-07	C34	2.81743E-10	C51	-8.1775E-15
	K	0	C19	3.0082E-08	C36	6.05663E-10	C53	3.06022E-14
S21	C4	0.015096874	C21	7.95521E-08	C37	8.39381E-13	C55	-9.1775E-13
	C6	0.009982808	C22	-1.3911E-09	C39	1.98531E-12	C56	-7.8543E-17
	C8	0.000358347	C24	9.33292E-10	C41	1.37477E-11	C58	-8.9588E-16
	C10	0.000209267	C26	3.54468E-09	C43	-1.0671E-11	C60	-6.0768E-15
	C11	-3.8593E-07	C28	4.1615E-09	C45	9.04109E-12	C62	-1.9528E-14
	C13	-6.8336E-06	C30	-1.2331E-11	C47	2.48401E-14	C64	2.6781E-14
	C15	-2.2455E-05	C32	-2.3367E-10	C49	6.92603E-14	C66	-1.4324E-14
			C17	-3.6973E-07	C34	4.8045E-10	C51	-2.9795E-13
	K	0	C19	-3.0682E-07	C36	1.43328E-10	C53	-2.5306E-14
S22	C4	0.022813527	C21	4.12093E-08	C37	-2.0707E-12	C55	-3.9401E-13
	C6	0.012060543	C22	4.07969E-09	C39	-4.9221E-12	C56	6.88651E-16
	C8	0.000638931	C24	8.5986E-09	C41	-2.3681E-12	C58	1.55006E-15
	C10	0.000196027	C26	2.1713E-08	C43	-2.1567E-11	C60	-1.4674E-15
	C11	-7.1204E-06	C28	1.63499E-08	C45	-2.3679E-12	C62	-9.9822E-15
	C13	-1.269E-05	C30	1.38704E-10	C47	-5.7167E-15	C64	2.72925E-14
	C15	-2.5184E-05	C32	2.02372E-10	C49	-9.0337E-14	C66	-1.1966E-14
			C17	-1.1083E-09	C34	-4.9118E-14	C51	-5.4918E-19
	K	0	C19	-5.7768E-10	C36	8.12546E-14	C53	-2.2569E-18
S23	C4	0.001597194	C21	1.60076E-10	C37	-7.486E-17	C55	-3.5657E-18
	C6	0.001324181	C22	1.91534E-12	C39	6.80626E-16	C56	1.09883E-21
	C8	1.37885E-05	C24	-1.0665E-11	C41	-5.1295E-17	C58	-2.1535E-20
	C10	1.34349E-05	C26	-8.6063E-12	C43	-3.6526E-16	C60	2.01763E-20
	C11	-4.8064E-08	C28	-1.1125E-12	C45	1.46399E-15	C62	-1.2016E-20
	C13	5.24071E-08	C30	6.24714E-14	C47	-2.1563E-18	C64	3.21408E-21
	C15	9.53861E-08	C32	-3.4381E-14	C49	2.86073E-18	C66	-1.4922E-19

【００５５】

また、本発明では、上記の図７に示すように、画像表示素子１の表示画面である物面を、前記レンズ光学系の光軸に対して－１．１６３度傾けている。なお、傾斜の方向は、この図７の断面内で物面の法線が時計回りに回転する方向を正の値で表わすことにする。従って、本実施例では物面を図７の断面内で、前記レンズ光学系の光軸に垂直な位置から反時計回り方向に１．１６３度傾けていることになる。

【００５６】

また、上記の図３又は図７中の符号Ｓ２３で示す自由曲面ミラー４は、そのローカル座標の原点を前記レンズ光学系の光軸上に置き、ローカル座標の原点での法線、すなわち、Ｚ軸を、前記レンズ光学系の光軸と平行な位置から約＋２９度だけ傾斜して配置している。なお、この傾きの方向は、前記物面と同様に、上記図３又は図７の断面内で反時計回りに回転する方向を正とし、従って、反時計回りに傾けていることになる。これによって、画像表示素子１の画面中央から出て、ほぼ、前記レンズ光学系の光軸に沿って進んできた画面中央光線は、Ｓ２３で反射後、前記レンズ光学系の光軸に対して前記傾き角度の２倍の５８度だけ傾いた方向に進む（図の矢印を参照）。

【００５７】

更に、本実施例における、各面のローカル座標系の傾き又は偏心の様子を以下の表４に示す。この表４において、面番号の右側に傾き角度、偏心の値を示しており、「ＡＤＥ」は図４の断面と平行な面内での傾きの大きさであり、その表示規則は上に示した通りである。また、「ＹＤＥ」は偏心の大きさであり、偏心は上記図４の断面と平行な面内でかつ光軸に垂直な方向で設定され、上記図４の断面において下側への偏心を正とする。なお、以降に説明する実施例においても、光学要素の傾きや偏心は、表示した断面に平行な断面内での方向で設定される。

【００５８】

【表４】

表４

Surface	ADE (°)	YDE(mm)
S0	-1.163	0.0
S23	29.000	0.0

【００５９】

なお、上記の表１、表３を見ると、本実施例では、曲率「ｃ」とコーニック係数「ｋ」が零（０）となっていることがわかる。即ち、斜め入射による台形歪は、斜め入射の方向に極端に大きく発生し、これと垂直な方向での歪量は小さい。従って、斜め入射の方向とこれに垂直な方向とでは、大幅に異なる機能が必要であり、回転対称で全方向に機能する上記曲率「ｃ」やコーニック係数「ｋ」を利用しないことにより、非対称な収差を良好に補正することが可能となる。

【００６０】

また、上記表４において、面Ｓ２３の「ＡＤＥ」は、上記図２に示すθｍと同じであり、スクリーン５の面上での「ＡＤＥ」は、上記図２に示すように、θｓである。これらの両者の値から、前記条件を満足しており、従って、スクリーンの下部の高さをより小さくして、コンパクトな光学系を実現している。

【００６１】

また、上記の式１に示す光路長の差｜Ｌ１－Ｌ２｜の値は、スクリーンの画面の高さの０．４２倍であり、θｓが３０度であることから、上記数１の条件を満足している。上記表１～表４の数値は、物面（例えば、比率１６：９の液晶パネル）上の範囲（１２．１６×６．８４ｍｍ）の映像を像面（６０”＋over-scan：１４５２．８×８１７．２ｍｍ）上に拡大して投写する場合の一例である。そのときの図形歪を、添付の図１０に示す。この図１０の縦方向は、上記図８の上下方向であり、上記図２におけるＹ軸の方向である。また、この図１０の横方向はスクリーン上でＹ軸の垂直な方向であり（上記図９の縦方向）、図の長方形における中央部が画面の中央である。なお、この図１０は、画面の縦方向を４分割、横方向を８分割して表示した場合における、各直線の曲がりの状態を表示し、もって、図形歪の様子を示している。

【００６２】

更に、スポットダイアグラムを添付の図１１に示す。この図１１では、映像表示素子５の表示画面上、即ち、Ｘ、Ｙ座標の値で、（８，４．５）、（０，４．５）、（４．８，２．７）、（８，０）、（０，０）、（４．８、－２．７）、（８、－４．５）、（０、

－４．５）の８点から射出した光束のスポットダイアグラムを上から順に（図では、丸で囲んだ（１）～（８）の順に）示す。なお、単位はｍｍである。各スポットダイアグラムの横方向はスクリーン上でのＸ方向、縦方向はスクリーン上でのＹ方向である。両者ともに、良好な性能を維持している。

【００６３】

加えて、上記によって得られた投射画像（例えば、図１のスクリーン５）の対角寸法を「Ｌｏ」とし、自由曲面ミラー５の中心から投射画像までの距離を「Ｌｐ」とした場合（上記図１を参照）、Ｌｏ＝１５２４ｍｍ、Ｌｐ＝７００×ｃｏｓ４５°≒４９５ｍｍであることから、これらの間の比率が２以上（Ｌｏ／Ｌｐ＞２）となり、比較的近い距離（Ｌｐ）でも、物面を十分大きな画面に拡大して投射することが出来ること、即ち、投射拡大率に優れていることが分る。

【実施例２】

【００６４】

次に、図１２及び図１３と表５～表８を用いて第２の実施例について説明する。ここで、レンズ光学系の前方レンズ群２は、全て、回転対称な形状の屈折面で構成されており、これらレンスの屈折面のうち４つは回転対称な非球面であり、他は球面である。ここに用いられた軸対称な非球面は、各面ごとのローカルな円筒座標系を用いて、前記に示した式、［数２］で表される。

【００６５】

また、前記レンズ光学系の後方レンズ群３を構成するレンズの自由曲面は、各面の面頂点を原点とするローカルな直交座標系（ｘ、ｙ、ｚ）を用い、Ｘ、Ｙの多項式を含む、前記に示した式、［数３］で表される。

【００６６】

以下の表５は、本数値実施例のレンズデータを示しており、面番号は物面をＳ０、順にＳ１からＳ２３までである。この表５において、「Ｒｄ」は各面の曲率半径であり、また、「ＴＨ」は面間距離であり、そのレンズ面の頂点から次のレンズ面の頂点までの距離を示す。

【００６７】

【表５】

表５

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	7.65		
S3	210.000	4.65	1.85306	17.2
S4	−92.276	18.00		
S5 *	−119.154	9.00	1.49245	42.9
S6 *	−99.255	0.10		
S7	41.165	9.32	1.49811	60.9
S8	−43.298	2.50	1.76014	20.0
S9	29.535	0.10		
S10	29.472	9.00	1.49811	60.9
S11	−81.846	25.90		
S12	Infinity	9.10		
S13	−259.960	6.00	1.85306	17.2
S14	−54.061	65.00		
S15	−24.878	4.19	1.74702	33.2
S16	−64.884	9.00		
S17 *	−29.009	10.00	1.49245	42.9
S18 *	−28.892	2.50		
S19 #	Infinity	8.00	1.49245	42.9
S20 #	Infinity	20.51		
S21 #	Infinity	8.00	1.49245	42.9
S22 #	Infinity	159.95		
S23 #	Infinity	−852.00	REFL	

【００６８】

この表５において面Ｓ５、Ｓ６、Ｓ１７、Ｓ１８は回転対称な非球面であり、表１では面の番号の横に「＊」を付けて分かり易く表示しており、これら４つ面の非球面の係数を以下の表６に示している。

【００６９】

【表６】

表６

Surface	非球面係数							
S5	K	−23.3033479	C	−9.6351E−12	F	6.40059E−20	J	5.14145E−27
	A	−2.4809E−06	D	−3.1244E−14	G	−2.06E−22		
	B	6.68597E−09	E	1.70809E−16	H	−1.9587E−24		
S6	K	−7.95321673	C	−2.8461E−12	F	1.68916E−19	J	−4.2604E−27
	A	8.81129E−07	D	−4.2436E−16	G	−4.7764E−22		
	B	3.27597E−09	E	−2.4174E−17	H	3.1265E−24		
S17	K	1.294916014	C	−8.1246E−11	F	−8.1666E−19	J	−9.4083E−26
	A	−1.7719E−05	D	−1.8651E−13	G	7.81036E−22		
	B	5.73314E−08	E	2.9427E−16	H	3.77766E−23		
S18	K	0.463935076	C	−1.1724E−11	F	1.23091E−19	J	−2.0819E−28
	A	−3.417E−06	D	−5.4303E−14	G	1.99428E−22		
	B	1.57331E−08	E	1.37371E−17	H	−3.4914E−25		

【００７０】

また、上記表５において、面Ｓ１９からＳ２２は前記レンズ光学系の後群を構成する自由曲面形状を有する屈折面であり、Ｓ２３は前記反射光学系の自由曲面形状を有する反射面であって、面の番号の横に「＃」を付けて表示した。これら５つの自由曲面の形状を表す係数の値を以下の表７に示す。

【００７１】

【表７】

表７

Surface	自由曲面係数							
S19			C17	5.06259E-07	C34	-1.4837E-09	C51	-1.0027E-12
	K	0	C19	4.85077E-07	C36	1.31263E-09	C53	6.99745E-13
	C4	0.017559144	C21	-1.5853E-07	C37	1.83299E-12	C55	-1.6619E-12
	C6	0.001733207	C22	-5.42E-09	C39	-4.3583E-13	C56	-1.9766E-15
	C8	-0.00066382	C24	-1.5702E-08	C41	2.72981E-11	C58	1.40369E-15
	C10	-0.00013226	C26	-5.9063E-08	C43	3.0878E-11	C60	1.05828E-14
	C11	8.28618E-06	C28	-7.7982E-09	C45	2.26152E-11	C62	-8.9296E-14
	C13	1.03545E-06	C30	-1.0233E-10	C47	2.99348E-14	C64	7.84407E-14
	C15	8.99822E-06	C32	-8.8036E-10	C49	4.57827E-13	C66	-9.1078E-14
S20			C17	7.92636E-07	C34	-1.6758E-09	C51	-3.5813E-13
	K	0	C19	8.89146E-07	C36	1.45469E-09	C53	6.84539E-13
	C4	0.021458089	C21	-1.4324E-07	C37	-7.7649E-12	C55	-1.511E-12
	C6	0.004154169	C22	-1.0382E-09	C39	-2.0012E-12	C56	1.77674E-15
	C8	-0.00099953	C24	-1.3146E-08	C41	5.28532E-11	C58	5.96659E-15
	C10	-0.00011911	C26	-5.677E-08	C43	2.30872E-11	C60	-2.0891E-15
	C11	8.42605E-06	C28	6.05026E-09	C45	1.03045E-11	C62	-9.4541E-14
	C13	-6.6069E-06	C30	2.65443E-11	C47	-1.2622E-13	C64	1.01913E-13
	C15	-3.2455E-07	C32	-1.5185E-09	C49	7.4513E-13	C66	-8.0588E-14
S21			C17	-1.0996E-07	C34	6.726E-11	C51	-1.0707E-13
	K	0	C19	1.27907E-07	C36	7.7809E-10	C53	-6.8789E-14
	C4	0.016481821	C21	1.59073E-07	C37	1.78369E-12	C55	-1.3595E-12
	C6	0.009814027	C22	-2.3156E-09	C39	5.1641E-12	C56	-4.5963E-16
	C8	0.000360473	C24	-1.533E-10	C41	1.45879E-11	C58	-1.5431E-15
	C10	0.000256882	C26	6.12508E-09	C43	4.21499E-12	C60	-9.4112E-15
	C11	-1.2641E-06	C28	4.69033E-09	C45	2.24112E-11	C62	-1.7181E-14
	C13	-7.1071E-06	C30	-3.0818E-11	C47	5.4765E-14	C64	1.14179E-14
	C15	-2.6709E-05	C32	-3.7474E-10	C49	3.77477E-14	C66	-1.4481E-14
S22			C17	-4.2509E-07	C34	6.03428E-10	C51	-4.5666E-13
	K	0	C19	-2.8996E-07	C36	2.79273E-10	C53	-1.1058E-13
	C4	0.024865431	C21	1.2041E-08	C37	-1.9296E-12	C55	-5.1945E-13
	C6	0.013574823	C22	4.59025E-09	C39	-4.3532E-12	C56	5.15206E-16
	C8	0.000656946	C24	9.31761E-09	C41	-1.0393E-11	C58	1.80646E-15
	C10	0.00023588	C26	3.01345E-08	C43	-1.737E-11	C60	-1.4435E-16
	C11	-9.5439E-06	C28	2.56904E-08	C45	-6.9004E-13	C62	-1.1182E-14
	C13	-1.3485E-05	C30	1.87694E-10	C47	-2.2366E-16	C64	1.55635E-14
	C15	-3.0664E-05	C32	1.26944E-10	C49	-1.2748E-13	C66	-1.4201E-14
S23			C17	-9.3593E-10	C34	-4.9686E-14	C51	1.8026E-18
	K	0	C19	-6.409E-10	C36	-5.1319E-14	C53	-8.6197E-18
	C4	0.001494744	C21	3.91751E-10	C37	-8.103E-17	C55	1.1354E-17
	C6	0.001287983	C22	1.80884E-12	C39	5.19251E-16	C56	1.89778E-21
	C8	1.19776E-05	C24	-8.191E-12	C41	1.38639E-16	C58	-1.6083E-20
	C10	1.18228E-05	C26	-7.7154E-12	C43	-8.0016E-16	C60	9.98054E-21
	C11	-4.3922E-08	C28	9.92084E-14	C45	2.67935E-16	C62	4.42337E-21
	C13	3.28597E-08	C30	4.90899E-14	C47	-1.5465E-18	C64	-1.4286E-20
	C15	8.20779E-08	C32	-1.3332E-14	C49	1.58291E-18	C66	6.04404E-21

【００７２】

更に、以下の表８には、この第２の実施例における各面の傾きと偏心の大きさとを示している。この表８における「ＡＤＥ」、「ＹＤＥ」の値の表示の規則は前述した通りである。また、本実施例における各面の傾きは、先の実施例１とほぼ同じ量である。

【００７３】

【表８】

表８

Surface	ADE (°)	YDE(mm)
S0	-1.289	0.0
S15	0.0	-0.193
S17	0.0	0.193
S23	28.814	0.0

【００７４】

なお、上記表８において、Ｓ２３のＡＤＥ（＝θｍ）と、スクリーン面５のＡＤＥ（＝θｓ）から、前記条件を満足してスクリーンの下部の高さが小さいコンパクトな光学系を実現している。

【００７５】

また、式１に示す光路長の差｜Ｌ１－Ｌ２｜の値は、スクリーンの画面の高さの０．４３倍であり、θｓが３０度であることから、上記［数１］の条件を満足していることがわかる。

【００７６】

一方、この第２の実施例では、上記表８に示すように、Ｓ１５を－０．１９３ｍｍだけ偏心させ、Ｓ１７面を逆に０．１９３ｍｍだけ偏心させている。ある面を偏心させた場合、以後の面ではその偏心量だけ光軸が移動する。従って、このＳ１５とＳ１７の偏心は、Ｓ１５とＳ１６で構成される１枚のレンズを光軸から－０．１９３ｍｍ偏心させることを意味している。なお、この偏心量は微量であり、レンズのサイズを大きくするような悪影響は生じないが、この偏心によって、非対称な色収差の微調整を実現している。

【００７７】

また、上記の表５及び表７を見ると、この実施例では、曲率「ｃ」とコーニック係数「ｋ」が零（０）となっていることがわかる。斜め入射による台形歪は、斜め入射の方向に極端に大きく発生し、これと垂直な方向に歪量は小さい。従って、斜め入射の方向とこれに垂直な方向とでは、大幅に異なる機能が必要であり、回転対称で全方向に機能する上記曲率「ｃ」やコーニック係数「ｋ」を利用しないことにより、図形歪を良好に補正することが可能となる。

【００７８】

以上に述べた数値による第２の実施例の有効範囲は、物面（比率１６：９）上の範囲を像面（７０”＋over-scan：１６９４．９×９５３．４ｍｍ）上に拡大して投写しており、その図形歪を図１２に示す。この図１２の縦方向は図１の上下方向であり、Ｙ軸の方向である。図１２の横方向はスクリーン上でＹ軸の垂直な方向であり、図の長方形の中央が画面の中央である。図は画面の縦方向を４分割、横方向を８分割した直線の曲がりの状態を表示して図形歪の様子を示している。

【００７９】

また、第２の実施例のスポットダイアグラムを図１３に示す。この図１３では、映像表示素子６１の表示画面上、Ｘ，Ｙ座標の値で、（８，４．５）、（０，４．５）、（４．８，２．７）、（８，０）、（０，０）、（４．８、－２．７）、（８、－４．５）、（０、－４．５）の８点から射出した光束のスポットダイアグラムを上から順に（図では、丸で囲んだ（１）～（８）の順に）示す。単位はｍｍである。各スポットダイアグラムの横方向はスクリーン上でのＸ方向、縦方向はスクリーン上でのＹ方向である。即ち、両者ともに、良好な性能を維持していることが分る。

【００８０】

また、この例でも、得られる投射画像の対角寸法を「Ｌｏ」と、自由曲面ミラー５の中心から投射画像までの距離を「Ｌｐ」として、Ｌｏ＝１５２４ｍｍ、Ｌｐ＝７００×ｃｏｓ４５°≒４９５ｍｍであることから、これらの間の比率が２以上（Ｌｏ／Ｌｐ＞２）となり、比較的近い距離（Ｌｐ）でも、物面を十分大きな画面に拡大して投射することが出来ることが、即ち、投射拡大率に優れていることが分る。

【実施例３】

【００８１】

次に、図１４及び図１５と表９～表１２を用いて、本発明になる第３の実施例について説明する。ここでも、レンズ光学系の前方レンズ２群は、全て、回転対称な形状の屈折面で構成されており、これら屈折面の内の４つは回転対称な非球面であり、他は球面である。ここに用いられた軸対称な非球面も、各面ごとのローカルな円筒座標系を用いて、前記に示した式［数２］で表される。

【００８２】

前記レンズ光学系の後方レンズ群３を構成する自由曲面は、各面の面頂点を原点とするローカルな直交座標系（ｘ、ｙ、ｚ）を用い、Ｘ、Ｙの多項式を含む、前記に示した［数３］で表わされる。

【００８３】

以下の表９は、第３の実施例におけるレンズデータを示しており、面番号は物面をＳ０、順にＳ１からＳ２３までである。この表９において「Ｒｄ」は各面の曲率半径である。また、「ＴＨ」は面間距離を示しており、そのレンズ面の頂点から次のレンズ面の頂点までの距離を示す。

【００８４】

【表９】

表 9

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	5.00		
S3	69.501	4.65	1.85306	17.2
S4	-477.064	18.00		
S5 *	-54.329	9.00	1.49245	42.9
S6 *	-53.208	0.10		
S7	48.857	9.32	1.49811	60.9
S8	-29.376	2.50	1.76014	20.0
S9	40.402	0.10		
S10	40.607	9.00	1.49811	60.9
S11	-54.359	25.90		
S12	Infinity	9.10		
S13	2090.112	6.00	1.85306	17.2
S14	-66.019	65.00		
S15	-45.540	4.19	1.74702	33.2
S16	108.965	9.00		
S17 *	-37.449	10.00	1.49245	42.9
S18 *	-75.474	2.50		
S19 #	Infinity	8.00	1.49245	42.9
S20 #	Infinity	19.35		
S21 #	Infinity	8.00	1.49245	42.9
S22 #	Infinity	122.15		
S23 #	Infinity	-605.00	REFL	

【００８５】

この表９においても、面Ｓ５、Ｓ６、Ｓ１７、Ｓ１８は回転対称な非球面であり、面の番号の横に「＊」を付けて分かり易く表示しており、また、これら４つ面の非球面の係数を以下の表１０に示している。

【００８６】

【表１０】

表１０

Surface	非球面係数							
S5	K	-13.108806	C	1.46508E-11	F	-2.0555E-19	J	8.25281E-27
	A	-2.6018E-06	D	-4.7767E-14	G	1.12416E-21		
	B	1.95435E-08	E	-1.5302E-16	H	-7.5179E-25		
S6	K	-8.59084843	C	1.51155E-11	F	-1.6279E-19	J	1.22719E-26
	A	7.67114E-07	D	-4.743E-15	G	-1.8394E-21		
	B	9.20816E-09	E	-9.3745E-17	H	3.4992E-24		
S17	K	3.170476396	C	-4.2843E-12	F	1.18119E-18	J	2.06192E-26
	A	-8.7308E-06	D	1.96465E-13	G	-4.5716E-21		
	B	-3.8136E-08	E	7.89179E-16	H	-1.5681E-23		
S18	K	9.315246698	C	2.51005E-11	F	-5.9791E-20	J	3.13406E-28
	A	-4.2604E-06	D	3.09426E-14	G	-6.6563E-23		
	B	-1.5518E-08	E	-8.892E-18	H	7.14735E-26		

【００８７】

また、上記の表９において、面Ｓ１９からＳ２２は前記レンズ光学系の後方レンズ群を構成する自由曲面形状を有する屈折面であり、Ｓ２３は前記反射光学系の自由曲面形状を有する反射面であって、面の番号の横に「＃」を付けて表示した。なお、これら５つの自由曲面の形状を表す係数の値を以下の表１１に示す。

【００８８】

【表１１】

表１１

Surface	自由曲面係数							
			C17	3.43096E-07	C34	-2.7065E-10	C51	1.99077E-13
	K	0	C19	2.13857E-06	C36	1.31926E-09	C53	-5.2135E-12
S19	C4	-0.00503963	C21	9.15856E-08	C37	2.1077E-12	C55	-2.1831E-12
	C6	0.020700865	C22	-1.9441E-09	C39	-6.1349E-11	C56	-3.3204E-15
	C8	-0.0007276	C24	-9.6181E-09	C41	-6.9182E-11	C58	1.52276E-14
	C10	-0.00062901	C26	2.71279E-09	C43	-1.1634E-10	C60	4.722E-14
	C11	4.83792E-06	C28	1.5813E-08	C45	1.55247E-11	C62	3.79581E-14
	C13	1.58097E-05	C30	-4.1204E-10	C47	1.79452E-14	C64	3.11821E-14
	C15	-1.9636E-05	C32	-2.3107E-09	C49	-6.0452E-13	C66	-1.876E-13
			C17	6.40078E-08	C34	-1.0668E-09	C51	-4.5767E-13
	K	0	C19	2.35312E-06	C36	-3.2106E-10	C53	-3.1387E-12
S20	C4	-0.00417899	C21	9.31605E-07	C37	1.82824E-12	C55	1.09346E-12
	C6	0.031326266	C22	-5.0811E-10	C39	-2.9101E-11	C56	-1.6513E-15
	C8	-0.00077771	C24	-3.1548E-08	C41	1.04208E-10	C58	8.47256E-15
	C10	-0.00097819	C26	-8.825E-08	C43	7.01421E-11	C60	-1.694E-15
	C11	2.05947E-06	C28	3.84368E-08	C45	-1.0493E-10	C62	-1.7011E-13
	C13	2.31241E-05	C30	-9.4717E-11	C47	2.95795E-14	C64	6.71828E-14
	C15	-3.0456E-05	C32	-8.4146E-10	C49	-7.9902E-13	C66	1.92712E-14
			C17	-1.4263E-07	C34	-1.7091E-10	C51	-4.2269E-14
	K	0	C19	-3.1384E-08	C36	-2.9029E-10	C53	2.21959E-14
S21	C4	0.016712489	C21	3.78605E-07	C37	2.14998E-13	C55	-9.5144E-15
	C6	0.024854646	C22	7.83561E-10	C39	1.12281E-12	C56	-1.3876E-16
	C8	0.000280556	C24	-1.1076E-09	C41	3.49849E-12	C58	-2.0224E-16
	C10	-5.99E-05	C26	-5.1644E-09	C43	2.81764E-12	C60	4.00029E-17
	C11	-4.5381E-06	C28	-1.9091E-09	C45	-1.5444E-12	C62	-4.1764E-15
	C13	-7.3701E-06	C30	2.60008E-11	C47	-3.3945E-15	C64	1.05212E-15
	C15	-1.0002E-05	C32	2.73923E-11	C49	2.75972E-14	C66	-3.6542E-15
			C17	-1.7327E-07	C34	-3.122E-10	C51	-3.8555E-14
	K	0	C19	-1.5061E-07	C36	-6.1374E-10	C53	2.3681E-13
S22	C4	0.016645995	C21	5.38912E-07	C37	9.78887E-14	C55	1.87115E-13
	C6	0.021101685	C22	8.11263E-10	C39	1.08112E-12	C56	-9.9798E-17
	C8	0.00032094	C24	-1.1477E-10	C41	3.69407E-12	C58	-2.3837E-16
	C10	-5.1172E-05	C26	-4.8707E-09	C43	-5.8299E-13	C60	-2.2734E-16
	C11	-4.3183E-06	C28	-1.1809E-09	C45	-3.7079E-12	C62	-3.0547E-15
	C13	-8.5909E-06	C30	3.39643E-11	C47	-2.9359E-15	C64	5.55175E-15
	C15	-1.0155E-05	C32	1.47622E-10	C49	-5.9302E-15	C66	-1.0145E-15
			C17	-2.203E-09	C34	8.2099E-14	C51	-1.2799E-17
	K	0	C19	2.39237E-09	C36	-4.3614E-14	C53	4.0335E-18
S23	C4	0.002149003	C21	1.39506E-09	C37	-1.7915E-16	C55	-3.2746E-18
	C6	0.000317113	C22	4.22192E-12	C39	1.80308E-15	C56	3.62609E-21
	C8	2.85992E-05	C24	-3.3322E-11	C41	-2.7999E-15	C58	-3.5037E-20
	C10	9.52914E-06	C26	1.45814E-11	C43	7.24461E-16	C60	6.79833E-20
	C11	-8.2644E-08	C28	1.00262E-11	C45	-1.0528E-15	C62	-3.7507E-20
	C13	2.89938E-07	C30	1.34005E-13	C47	-4.0973E-18	C64	5.06597E-21
	C15	1.20082E-07	C32	-3.6767E-13	C49	1.4053E-17	C66	5.93238E-21

【００８９】

更に、以下の表１２には、第３の実施例における各面の傾きと偏心の大きさを示している。なお、この表１２における「ＡＤＥ」、「ＹＤＥ」の値の表示の規則は前述した通りである。

【００９０】

【表１２】

表１２

Surface	ADE（°）	YDE(mm)
S0	-2.000	0.0
S15	0.0	0.304
S17	0.0	-0.304
S23	35.000	0.0

【００９１】

なお、この表１２からは、前述した条件は満足していないことが分る。しかしながら、この第３の実施例では、その分奥行きが小さく、奥行きを優先した構成となっている。

【００９２】

また、上記表１２に示すように、先の実施例２と同様に、面Ｓ１５とＳ１６で構成される１枚のレンズを、光軸から－０．３０４ｍｍ偏心させている。この偏心量は微量であり、レンズのサイズを大きくするような悪影響は生じないが、この偏心によって、非対称な色収差の微調整を実現している。

【００９３】

さらに、上記［数１］に示す光路長の差｜Ｌ１－Ｌ２｜の値は、スクリーンの画面高さの０．６２倍であり、θｓが４５度であることから、上述の条件を満足している。

【００９４】

また、上記の表９及び表１１からは、この第３の実施例では、曲率「ｃ」とコーニック係数「ｋ」が零（０）となっていることがわかる。斜め入射による台形歪は、斜め入射の方向に極端に大きく発生し、これと垂直な方向に歪量は小さい。従って、斜め入射の方向とこれに垂直な方向とでは、大幅に異なる機能が必要であり、回転対称で全方向に機能する上記曲率「ｃ」やコーニック係数「ｋ」を利用しないことにより、図形歪を良好に補正することが可能である。

【００９５】

また、上記第３の実施例の有効範囲は、物面（比率１６：９）上の範囲を像面（５０”＋over-scan：１２１０．７×６８１．０）上に拡大して投写しており、その際の図形歪を図１４に示す。この図１４の縦方向は上記図２の上下方向であり、即ち、Ｙ軸の方向である。図１４の横方向はスクリーン上でＹ軸に垂直な方向（横方向）であり、図の長方形の中央が画面の中央である。図１４は画面の縦方向を４分割、横方向を８分割した直線の曲がりの状態を表示して図形歪の様子を示している。

【００９６】

本数値実施例のスポットダイアグラムを図１５に示す。この図１５では、映像表示素子６１の表示画面上、Ｘ，Ｙ座標の値で、（８，４．５）、（０，４．５）、（４．８，２．７）、（８，０）、（０，０）、（４．８、－２．７）、（８、－４．５）、（０、－４．５）の８点から射出した光束のスポットダイアグラムを上から順に（図では、丸で囲んだ（１）～（８）の順に）示す。なお、単位はｍｍである。各スポットダイアグラムの横方向はスクリーン上でのＸ方向、縦方向はスクリーン上でのＹ方向である。即ち、両者ともに、良好な性能を維持していることが分る。

【００９７】

また、この例でも、得られる投射画像の対角寸法を「Ｌｏ」と、自由曲面ミラー５の中心から投射画像までの距離を「Ｌｐ」として、Ｌｏ＝１５２４ｍｍ、Ｌｐ＝７００×ｃｏｓ４５°≒４９５ｍｍであることから、これらの間の比率が２以上（Ｌｏ／Ｌｐ＞２）となり、比較的近い距離（Ｌｐ）でも、物面を十分大きな画面に拡大して投射することが出来ること、即ち、投射拡大率に優れていることが分る。

【実施例４】

【００９８】

図１６及び図１７と表１３～表１６を用いて、本発明による第４の実施例について説明

する。

【００９９】

ここでも、画像表示素子１から射出した光は、回転対称な面形状を有する透過型レンズで構成されるレンズ光学系の前方レンズ群２、自由曲面形状を有する透過型レンズで構成されるレンズ光学系の後方レンズ群３の順で通過後、反射光学系の自由曲面形状を有する反射面４で反射され、スクリーン５に入射する。

【０１００】

即ち、ここでも、レンズ光学系の前方レンズ群２は、全て、回転対称な形状の屈折面で構成されており、各屈折面の内の４つは回転対称な非球面であり、他は球面である。また、ここに用いられた軸対称な非球面は、各面ごとのローカルな円筒座標系を用いて、前述した式［数１］で表される。

【０１０１】

前記レンズ光学系の後方レンズ群３を構成する自由曲面は、やはり、各面の面頂点を原点とするローカルな直交座標系（ｘ、ｙ、ｚ）を用い、Ｘ、Ｙの多項式を含む前述した［数２］で表わされる。

【０１０２】

以下の表１３は、第４の実施例のレンズデータを示しており、面番号は物面をＳ０、順にＳ１からＳ２４までありＳ２５は像面である。表１３において「Ｒｄ」は各面の曲率半径であり、上記図３又は図７の中で面の左側に曲率の中心がある場合は正の値で、逆の場合は負の値で表わしている。

【０１０３】

【表１３】

表１３

Surface	Rd	TH	nd	νd
S0	Infinity	10.00		
S1	Infinity	31.34	1.51827	48.0
S2	Infinity	4.97		
S3	49.017	4.65	1.85306	17.2
S4	201.672	18.00		
S5 *	-60.233	9.00	1.49245	42.9
S6 *	-55.360	0.10		
S7	56.669	9.32	1.49811	60.9
S8	-27.651	2.50	1.76014	20.0
S9	46.949	0.10		
S10	47.407	9.00	1.49811	60.9
S11	-46.719	25.90		
S12	Infinity	9.10		
S13	-9457.081	6.00	1.85306	17.2
S14	-64.870	65.00		
S15	-42.429	4.19	1.74702	33.2
S16	137.716	9.00		
S17 *	-34.874	10.00	1.49245	42.9
S18 *	-63.364	2.50		
S19 #	Infinity	8.00	1.49245	42.9
S20 #	Infinity	19.55		
S21 #	Infinity	8.00	1.49245	42.9
S22 #	Infinity	121.95		
S23 #	Infinity	-742.00	REFL	

【０１０４】

この表１３において、「ＴＨ」は面間距離であり、そのレンズ面の頂点から次のレンズ面の頂点までの距離を示す。また、そのレンズ面に対して、次のレンズ面が左側にある時には、面間距離は正の値で、右側にある場合は負の値で表している。

【０１０５】
この表１３においてＳ５、Ｓ６、Ｓ１７、Ｓ１８は回転対称な非球面であり、表１３では面の番号の横に「＊」を付けて分かり易く表示しており、これら４つ面の非球面の係数を、以下の表１４に示している。
【０１０６】
【表１４】

表１４

Surface	非球面係数							
S5	K	-7.49933947	C	8.20794E-12	F	1.67212E-19	J	2.75191E-26
	A	-4.2871E-06	D	-3.3905E-14	G	1.22978E-22		
	B	1.47929E-08	E	5.30418E-18	H	-9.2584E-24		
S6	K	-5.10683146	C	2.31215E-12	F	1.4876E-19	J	1.40237E-26
	A	-4.215E-08	D	-8.8141E-15	G	-2.1285E-21		
	B	9.97857E-09	E	2.96852E-17	H	3.39217E-25		
S17	K	2.729972673	C	-6.3329E-11	F	-5.5239E-19	J	2.95633E-25
	A	-6.7402E-06	D	3.24143E-13	G	-2.1415E-20		
	B	-1.1095E-08	E	1.38117E-15	H	-4.6503E-23		
S18	K	5.628556104	C	2.5008E-11	F	-6.694E-20	J	4.08388E-28
	A	-1.8686E-06	D	1.72887E-14	G	-5.6024E-23		
	B	-1.1602E-08	E	-2.9081E-17	H	5.15556E-26		

【０１０７】
また、この表１３において、Ｓ１９からＳ２２は前記レンズ光学系の後方レンズ群３を構成する自由曲面形状を有する屈折面であり、Ｓ２３は前記反射光学系の自由曲面形状を有する反射面であって、面の番号の横に「＃」を付けて表示した。これら５つの自由曲面の形状を表す係数の値を、以下の表１５に示す。
【０１０８】

【表１５】

表１５

Surface	自由曲面係数							
			C17	3.06092E-07	C34	-1.504E-09	C51	1.89916E-12
	K	0	C19	2.31689E-06	C36	9.24213E-10	C53	-2.6408E-12
S19	C4	-0.00523704	C21	3.17855E-07	C37	2.73895E-12	C55	-2.2305E-12
	C6	0.022327058	C22	-2.18E-09	C39	-5.7332E-11	C56	-2.3991E-15
	C8	-0.00076156	C24	-1.35E-08	C41	-6.5197E-11	C58	2.74339E-14
	C10	-0.00059005	C26	-4.4124E-09	C43	-1.4355E-10	C60	9.09554E-14
	C11	4.88728E-06	C28	2.72086E-08	C45	-2.1121E-11	C62	2.42098E-14
	C13	1.92499E-05	C30	-4.0242E-10	C47	4.94771E-14	C64	1.85581E-13
	C15	-1.9167E-05	C32	-2.6688E-09	C49	5.78829E-13	C66	-1.2907E-13
			C17	4.41515E-08	C34	-2.1067E-09	C51	1.36481E-13
	K	0	C19	2.59357E-06	C36	-1.3645E-09	C53	-1.7814E-12
S20	C4	-0.00380713	C21	1.34672E-06	C37	2.55427E-12	C55	1.48598E-12
	C6	0.034310744	C22	-6.3335E-10	C39	-3.0724E-11	C56	-1.1411E-15
	C8	-0.00082075	C24	-3.2842E-08	C41	9.74292E-11	C58	1.71485E-14
	C10	-0.00096306	C26	-9.4354E-08	C43	5.80355E-11	C60	1.60064E-14
	C11	1.46478E-06	C28	5.63114E-08	C45	-1.3903E-10	C62	-1.6566E-13
	C13	2.57064E-05	C30	-1.5828E-10	C47	7.97383E-14	C64	1.4173E-13
	C15	-3.3719E-05	C32	-9.3186E-10	C49	-2.2316E-13	C66	5.32957E-14
			C17	-1.4847E-07	C34	-1.578E-10	C51	-3.1391E-14
	K	0	C19	-4.1463E-08	C36	-3.154E-10	C53	4.92021E-14
S21	C4	0.01628158	C21	3.75928E-07	C37	1.44753E-13	C55	-1.2229E-14
	C6	0.024536292	C22	8.73333E-10	C39	1.02001E-12	C56	-1.1929E-16
	C8	0.000287791	C24	-1.3318E-09	C41	4.04083E-12	C58	-1.9881E-16
	C10	-5.6467E-05	C26	-5.0191E-09	C43	2.15125E-12	C60	-1.1661E-16
	C11	-4.4889E-06	C28	-1.338E-09	C45	1.05501E-13	C62	-3.9789E-15
	C13	-7.4216E-06	C30	2.11331E-11	C47	-1.2171E-15	C64	1.92077E-15
	C15	-9.5063E-06	C32	3.73498E-11	C49	1.57629E-14	C66	-5.4374E-15
			C17	-1.7539E-07	C34	-2.5651E-10	C51	-3.1411E-14
	K	0	C19	-1.5271E-07	C36	-6.0608E-10	C53	2.14522E-13
S22	C4	0.016419443	C21	5.09788E-07	C37	1.26957E-13	C55	1.76045E-13
	C6	0.021115451	C22	7.02901E-10	C39	1.00917E-12	C56	-9.5762E-17
	C8	0.000323178	C24	-1.3689E-10	C41	3.91234E-12	C58	-2.6471E-16
	C10	-4.5525E-05	C26	-4.0137E-09	C43	-1.1163E-12	C60	-2.2728E-16
	C11	-4.138E-06	C28	1.70813E-10	C45	-4.4694E-12	C62	-3.086E-15
	C13	-9.223E-06	C30	2.82551E-11	C47	-7.7346E-16	C64	5.99803E-15
	C15	-9.9105E-06	C32	1.42902E-10	C49	-1.2051E-14	C66	-1.1247E-15
			C17	-2.5231E-09	C34	7.66238E-14	C51	-2.3328E-17
	K	0	C19	2.58369E-09	C36	3.37658E-15	C53	1.85177E-17
S23	C4	0.002289792	C21	1.24861E-09	C37	-1.5632E-16	C55	-4.0416E-18
	C6	0.000330451	C22	4.81491E-12	C39	2.15761E-15	C56	1.15938E-21
	C8	3.09058E-05	C24	-3.7371E-11	C41	-3.7026E-15	C58	-3.3248E-20
	C10	1.02245E-05	C26	1.56104E-11	C43	1.35291E-15	C60	7.75597E-20
	C11	-9.5057E-08	C28	7.8498E-12	C45	-3.329E-16	C62	-8.1537E-20
	C13	3.1048E-07	C30	1.56487E-13	C47	-4.2776E-18	C64	8.41917E-20
	C15	1.27367E-07	C32	-4.1734E-13	C49	1.73654E-17	C66	-2.3609E-20

【０１０９】

更に、以下の表１６には、本実施例における各面の傾きと偏心の大きさを示している。この表１６における「ＡＤＥ」、「ＹＤＥ」の値の表示の規則は、前述した通りであり、本実施例における各面の傾きも、先の実施例１とほぼ同じ量である。

【０１１０】

【表１６】

表１６

Surface	ADE (°)	YDE(mm)
S0	-2.000	0.0
S15	0.0	0.230
S17	0.0	-0.230
S23	35.000	0.0

【０１１１】

即ち、この表１６を見ると、前述した条件は満足していないことが分る。しかしながら、その分奥行きが小さく、奥行きを優先した実施例となっている。

【０１１２】

一方、この第４の実施例では、上記の表１６に示すように、Ｓ１５面を－０．２３ｍｍ偏心させ、Ｓ１７面を逆に０．２３ｍｍ偏心させている。ある面を偏心させた場合、以後の面ではその偏心量だけ光軸が移動する。従って、このＳ１５とＳ１７の偏心は、Ｓ１５とＳ１６で構成される１枚のレンズを光軸から－０．１９３ｍｍ偏心させることを意味している。この偏心量は微量であり、レンズのサイズを大きくするような悪影響は生じないが、この偏心によって、非対称な色収差の微調整を実現している。

【０１１３】

さらに、光路長の差｜Ｌ１－Ｌ２｜の値は、スクリーン画面の高さの０．６４倍であり、θｓが４５度であることから、上記［数１］の条件を満足している。

【０１１４】

また表１３及び表１５を見ると、この第４の実施例では、曲率「ｃ」とコーニック係数「ｋ」が零（０）となっていることがわかる。斜め入射による台形歪は、斜め入射の方向に極端に大きく発生し、これと垂直な方向に歪量は小さい。従って、斜め入射の方向とこれに垂直な方向とでは、大幅に異なる機能が必要であり、回転対称で全方向に機能する上記曲率「ｃ」やコーニック係数「ｋ」を利用しないことにより、図形歪を良好に補正することができる。

【０１１５】

なお、本実施例の有効範囲は、物面（比率：１６：９）上の範囲を像面（６０”＋over-scan：１４５２．８×８１７．２ｍｍ）上に拡大して投写しており、その図形歪を図１６に示す。この図１６の縦方向は上記図２の上下方向、即ち、Ｙ軸の方向である。また、この図１４の横方向はスクリーン上でＹ軸の垂直な方向（横方向）であり、図の長方形の中央が画面の中央である。そして、この図１４は、画面の縦方向を４分割、横方向を８分割した直線の曲がりの状態を表示すことによって、図形歪の様子を示している。

【０１１６】

さらに、この第４の実施例のスポットダイアグラムを図１７に示す。この図１７では、映像表示素子６１の表示画面上、Ｘ，Ｙ座標の値で、（８，４．５）、（０，４．５）、（４．８，２．７）、（８，０）、（０，０）、（４．８、－２．７）、（８、－４．５）、（０、－４．５）の８点から射出した光束のスポットダイアグラムを上から順に（図では、丸で囲んだ（１）～（８）の順に）示す。単位はｍｍである。各スポットダイアグラムの横方向はスクリーン上でのＸ方向、縦方向はスクリーン上でのＹ方向である。即ち、両者ともに、良好な性能を維持している。

【０１１７】

そして、上記によって得られた投射画像の対角寸法を「Ｌｏ」とし、自由曲面ミラー５の中心から投射画像までの距離を「Ｌｐ」とした場合（上記図１を参照）、Ｌｏ＝２０３２ｍｍ、Ｌｐ＝９９６×ｃｏｓ４５°≒７０４ｍｍであることから、これらの間の比率が２以上（Ｌｏ／Ｌｐ＞２）となり、比較的近い距離（Ｌｐ）でも、物面を十分大きな画面に拡大して投射することが出来ること、即ち、投射拡大率に優れていることが分る。

【０１１８】

次に、添付の図１８には、以上に詳述した投写光学ユニットを投写型映像表示装置に適用し、例えば、部屋の壁面やシート状のスクリーン等の上に画像を拡大投射した状態が示されており、更に、添付の図１９には、投写光学ユニットからスクリーンまでの投写距離を変えた場合の問題を示している。即ち、図１９からも明らかなように、自由曲面を用い、スクリーンに対して光軸を傾けて斜め投写する方式では、投写距離を設計した距離から大きく変化させると、図形歪が大きくなり、スポットサイズも大きくなって解像性能が劣化する。

【０１１９】

例えば、上記の図１９に示すように、スクリーン５の位置を、設計位置６５（設計された画面サイズ、例えば、８０インチ相当）から、投射画面を小さくする方向の位置６６（例えば、画面サイズ６０インチ相当）に置いた場合のスポット形状と歪の状態を添付の図２０に、他方、画面を大きくする方向の位置６７に（例えば、画面サイズ１００インチ相当）置いた場合のスポット形状とその歪の状態を図２１に示す。これら図２０及び図２１からも明らかなように、歪の大きさは画面縦幅の約２％以上にまで大きくなり、スポット形状は設計位置の場合の３倍以上に大きくなり解像性能が劣化する。

【０１２０】

なお、スポットの増大は、例えばパネルの位置を前後に移動させてピント合わせを行っても、画面全体スポット形状を良好にすることはできない。その理由は、光学系が回転対称でないため、パネルや回転対称のレンズの移動では、画面の一部のフォーカスを合わせると、他の部分のフォーカスが大きくずれることになるためである。また、自由曲面レンズである後方レンズ群のレンズ３１や３２のみを移動しただけでは、やはり、このスポット形状の補正はできない。これは、スクリーン位置の移動に伴う歪の補正には、回転対称レンズのパワーが必要になるためである。

【０１２１】

そこで、上記の実施例を基に、スクリーン位置の移動に対応して、レンズを移動させ、もって、スポット形状の歪や解像性能の改善に効果があるレンズを調査した結果、特に、前記後方レンズ群を構成する負のパワーを有するレンズ３３、３４（上記の図２又は図６を参照）と共に、自由曲面を有する透過レンズ３１と３２とを、その光軸方向に移動させることが有効であることを見出した。なお、前記自由曲面を有するミラー４の移動も効果的である。しかしながら、傾いて設置され、かつ、比較的サイズが大きい自由曲面のミラー４を移動させることは、装置の構造上からも、困難な点が多いため、特に、上記後方レンズ群３を構成するレンズ３１～３４を移動することが最も有効である。

【０１２２】

添付の図２２には、上記後方レンズ群３を構成するレンズ、即ち、自由曲面を有する透過レンズ３１と、やはり自由曲面を有する透過レンズ３２と、そして、負のパワーを有する回転対称な２枚の透過レンズ３３、３４）を移動させた状態を示している。なお、図２２（ａ）は、上記図１６において、投射画面を小さくする方向の位置６６（画面サイズ６０インチ相当）に置いた場合、図２２（ｂ）は、投射画面を設計位置６５（画面サイズ８０インチ相当）に位置する場合、そして、図２２（ｃ）は、投射画面を投射画面を大きくする方向の位置６７に移動した場合をそれぞれ示している。即ち、この実施例では、スクリーン位置の移動に対して、上記後方レンズ群３を構成する負のパワーを有するレンズとその近傍の回転対象なレンズを合せて一体としたレンズ群と、そして、自由曲面を有する２枚の透過レンズを１つのレンズ群とし、このレンズ群をその光軸方向に移動させてスクリーン位置に対して調整することにより、スクリーンを位置６６から６７までの間で、良好な性能を得られるようにしている。

【０１２３】

なお、上述したように、上記後方レンズ群３を構成するレンズ３１～３４を移動するための構造としては、例えば、添付の図２３（ａ）にも示すように、投写型映像表示装置１００の内部に、それぞれ、上記前方レンズ群２（回転対称のレンズ２１～２５）と後方レンズ群３（レンズ３１～３４）を個別の搭載台２１０、２２０に組み込み、一方の搭載台

２１０を装置の筐体１１０の底部１１１上に固定すると共に、他方の搭載台２２０は、例えば、レール上に滑動可能に取り付ける。また、この他方の搭載台２２０からは、例えば、ロッド状の部材２２１を上方に延長しており、上記筐体１１０の上面に形成したスリット部１１２から外部に突出させる。そして、この他方の搭載台（例えば、搭載台２２０）には、予め溝２２１、２２２、２２３を形成しておくと共に、当該搭載台２２０を上記搭載台２１０に対して（この例では、図に矢印で示すように、レンズ群の光軸方向に対して直角方向に）移動可能に装置内に設置する。

【０１２４】

なお、上記後方レンズ群３を構成するレンズ３１～３４は、上記の図２３（ｂ）にも示すように、レンズ３３と３４とを纏めて一体とし、即ち、レンズ３１、レンズ３２、そして、レンズ３３及び３４からなる３群に分けられており、そして、そのそれぞれの位置を、スクリーンに投射して得られる画面のサイズ（６０インチ、８０インチ、１００インチ）に対応して移動する。即ち、上記の溝２２１、２２２、２２３は、これら３群のレンズに対応して、即ち、各レンズ群に対して所望の傾斜角度で形成されている。かかる構成によれば、上記移動可能な搭載台２２０から筐体外部に突出したロッド部材２２１を、予め筐体１１０の表面上に「６０」インチ、「８０」インチ、「１００」インチなどの印を付けておいた位置に移動することにより、上記３群のレンズ、即ち、レンズ３１、レンズ３２、そして、レンズ３３及び３４が、それぞれ、溝２２１、２２２、２２３に沿って移動することにより、所望に位置に配置されることとなる。即ち、かかる構成によれば、投写型映像表示装置の外部から、上記ロッド状部材２２１の先端を図の矢印方向に移動することにより、投射画面の大きさを、スポット形状の歪や解像性能の劣化を伴うことなく、変更することが可能となる。

【０１２５】

または、上述した構造に代えて、図示はしないが、やはり上記のような溝をその外周に形成した円筒を利用することによっても、上記と同様の機能を達成することも出来る。なお、その場合、特に、後方レンズ群３において自由曲面を有する２枚の透過レンズ３１、３２は、光軸方向の相対位置の変更にもかかわらず、回転を伴う必要がない。このことから、例えば、上記筒状部材を互いに独立に回転可能に、即ち、先端側と後端側に分離し、その先端側を回転しないような構造とすることが好ましい。更には、例えば、電動モータなどを含む駆動手段を用いて、後方レンズ群３（レンズ３１～３４）をそれぞれ移動する構造を採用することも可能であろう。即ち、これによれば、映像を投射するスクリーンの位置（即ち、装置からスクリーンまでの距離）の変更に対応して、スポット形状の歪や解像性能の改善する効果が得られる。

【０１２６】

続いて、上記に示した実施例のレンズデータを、以下の表１７～２１及び図２４～２６を参照しながら、以下に示す。

【０１２７】

なお、ここでも、自由曲面の式は、上記の［数１］と同様である。また、以下の表１７～２０の数値は、物面（比率１６：９）上の範囲の映像を像面（６０”＋over-scan：１８４１．９×１０３６．１ｍｍ）上に拡大投写する場合の一例を示したものである。また、この場合の投写光学ユニットにおける光学素子のレンズ面が、図２４に示されている。なお、この実施例が上記の実施例と異なるのは、上記図４においてＳ９とＳ１０で示されるレンズ面が、この図２１では、これらが一体になっており、そのため、Ｓ０～Ｓ２２の面で構成されている。

【０１２８】

まず、表１７において「Ｒｄ」は各面の曲率半径であり、図中で面の左側に曲率の中心がある場合には正の値で、逆の場合は負の値で表わされている。また、この表１７において「ＴＨ」は面間距離であり、そのレンズ面の頂点から次のレンズ面の頂点までの距離を示す。あるレンズ面に対して、次のレンズ面が左側に位置するときには面間距離は正の値で、右側に位置する場合は負の値で表されている。更に、この表１７においてＳ５、Ｓ６

、Ｓ１６、Ｓ１７（上記図４を参照）は回転対称な非球面であり、表１７では面の番号の横に「＊」を付けて示している。なお、これら４つ面の非球面の係数を以下の表１８に示している。

【０１２９】

【表１７】

表１７

Surface	Rd	TH	nd	νd
S0	Infinity	7.600		
S1	Infinity	22.200	1.51827	48.0
S2	Infinity	7.343		
S3	62.278	4.500	1.85306	17.2
S4	-266.980	19.016		
S5 *	-51.942	5.000	1.49245	42.9
S6 *	-47.349	0.100		
S7	32.165	11.700	1.48876	52.8
S8	-32.506	2.246	1.85306	17.2
S9	33.772	10.500	1.48876	52.8
S10	-42.116	18.784		
S11	Infinity	6.916		
S12	198.090	5.500	1.85306	17.2
S13	-59.931	41.959		
S14	-20.939	3.200	1.74702	33.2
S15	134.847	4.782		
S16 *	-27.918	6.000	1.49245	42.9
S17 *	-31.695	6.437		
S18 #	Infinity	6.000	1.49245	42.9
S19 #	Infinity	11.138		
S20 #	Infinity	6.000	1.49245	42.9
S21 #	Infinity	91.557		
S22 #	Infinity	-996.000	REFL	

【０１３０】

また、上記の表１７においてＳ１８からＳ２１は自由曲面レンズの各屈折面であり、Ｓ２２は自由曲面ミラーの反射面であって、面の番号の横に「#」を付けて示している。これら５つの自由曲面の形状を表す係数の値を表１８に示す。

【０１３１】

【表１８】

表１８

Surface	非球面係数							
5	K	-19.19	C	1.6E-10	F	1.19E-17	J	1.28E-24
	A	-1.3E-05	D&	-8.9E-13	G	1.59E-19		
	B	7.24E-08	E	-3.5E-15	H&	-8.8E-22		
6	K	-14.7411	C	1.79E-10	F	2.48E-17	J	3.16E-25
	A	-6.9E-06	D&	-1.1E-12	G	-3.2E-20		
	B	6.14E-08	E	-1.8E-15	H&	-1.4E-22		
16	K	-2.80795	C	-3.6E-10	F	-6.5E-17	J	4.91E-24
	A	1.18E-05	D&	2.15E-12	G	-8.8E-19		
	B	-2.2E-07	E	2.24E-14	H&	6.62E-22		
17	K	-3.04559	C	-1.3E-11	F	-6.7E-18	J	1.47E-25
	A	7.14E-06	D&	8.97E-13	G	-2.7E-20		
	B	-1.5E-07	E	8.7E-17	H&	-3.1E-23		

【０１３２】

次に、以下の表１９においては、係数の名称と値を左右に並べて枠の組で表示しており、右側が係数の値であり、左側が名称で括弧内のカンマで区切った２組の数値は式２に示した「ｍ」と「ｎ」の値を示している。

【０１３３】

【表１９】

表１９

Surface	自由曲面係数							
18			C(4,1)	1.66E-06	C(2,5)	-6.4E-09	C(4,5)	2.8E-12
	K	0	C(2,3)	2.53E-06	C(0,7)	7.43E-09	C(2,7)	5.2E-11
	C(2,0)	-0.01616	C(0,5)	1.98E-06	C(8,0)	-4.6E-11	C(0,9)	-2E-11
	C(0,2)	-0.01788	C(6,0)	4.65E-08	C(6,2)	-2.1E-10	C(10,0)	-1.7E-13
	C(2,1)	-0.00075	C(4,2)	-5.3E-09	C(4,4)	-9.1E-10	C(8,2)	4.71E-13
	C(0,3)	-0.00079	C(2,4)	2.61E-08	C(2,6)	-3E-10	C(6,4)	2.11E-12
	C(4,0)	9.37E-06	C(0,6)	-4.1E-08	C(0,8)	1.55E-10	C(4,6)	2.48E-12
	C(2,2)	2.32E-05	C(6,1)	-5.2E-09	C(8,1)	1.38E-12	C(2,8)	1.11E-12
	C(0,4)	3.49E-05	C(4,3)	-1.6E-08	C(6,3)	5.41E-11	C(0,10)	-3.6E-13
19			C(4,1)	3.72E-07	C(2,5)	1.86E-09	C(4,5)	-8.4E-12
	K	0	C(2,3)	7.05E-07	C(0,7)	6.3E-09	C(2,7)	1.61E-11
	C(2,0)	-0.01514	C(0,5)	5.2E-07	C(8,0)	2.16E-12	C(0,9)	-6.2E-12
	C(0,2)	-0.01501	C(6,0)	3.39E-08	C(6,2)	-2.8E-12	C(10,0)	-1.2E-13
	C(2,1)	-0.00072	C(4,2)	-5E-08	C(4,4)	-2.8E-10	C(8,2)	5.85E-14
	C(0,3)	-0.00078	C(2,4)	-5.5E-08	C(2,6)	1.8E-10	C(6,4)	7.47E-13
	C(4,0)	4.19E-06	C(0,6)	-1.1E-07	C(0,8)	2.33E-10	C(4,6)	4.42E-13
	C(2,2)	2.77E-05	C(6,1)	-9.1E-10	C(8,1)	-1.6E-12	C(2,8)	7.55E-15
	C(0,4)	3.81E-05	C(4,3)	-5.8E-09	C(6,3)	2.17E-11	C(0,10)	2.57E-13
20			C(4,1)	-8.8E-07	C(2,5)	2.22E-09	C(4,5)	-2.3E-12
	K	0	C(2,3)	-6.1E-07	C(0,7)	-1.9E-09	C(2,7)	1.21E-12
	C(2,0)	0.027017	C(0,5)	-2E-07	C(8,0)	1.23E-12	C(0,9)	1.01E-13
	C(0,2)	0.013975	C(6,0)	7.2E-10	C(6,2)	2.59E-11	C(10,0)	-1.4E-16
	C(2,1)	0.00078	C(4,2)	-2E-08	C(4,4)	6.17E-11	C(8,2)	-2.1E-14
	C(0,3)	0.000502	C(2,4)	-8.2E-09	C(2,6)	1.19E-10	C(6,4)	-1.7E-14
	C(4,0)	-6.8E-06	C(0,6)	-3.4E-08	C(0,8)	7.66E-12	C(4,6)	-1.1E-13
	C(2,2)	-1.9E-06	C(6,1)	4.75E-10	C(8,1)	4.11E-14	C(2,8)	-5.5E-14
	C(0,4)	-2.1E-05	C(4,3)	1.45E-09	C(6,3)	-8.3E-13	C(0,10)	3.29E-14
21			C(4,1)	-1.3E-06	C(2,5)	3.4E-09	C(4,5)	-2.6E-12
	K	0	C(2,3)	-9.9E-07	C(0,7)	-1.7E-09	C(2,7)	-9.2E-13
	C(2,0)	0.028429	C(0,5)	-6.1E-07	C(8,0)	2.33E-12	C(0,9)	1.91E-12
	C(0,2)	0.011865	C(6,0)	8.35E-10	C(6,2)	2.38E-11	C(10,0)	-5.5E-16
	C(2,1)	0.001007	C(4,2)	-1.8E-08	C(4,4)	5.95E-11	C(8,2)	-2.2E-14
	C(0,3)	0.000596	C(2,4)	1.32E-08	C(2,6)	6.51E-11	C(6,4)	-2.8E-14
	C(4,0)	-7.9E-06	C(0,6)	-6.9E-09	C(0,8)	-5.8E-11	C(4,6)	-8.9E-14
	C(2,2)	-2.8E-06	C(6,1)	9.14E-10	C(8,1)	-1.1E-13	C(2,8)	-4.5E-14
	C(0,4)	-2.8E-05	C(4,3)	2.2E-09	C(6,3)	-1.5E-12	C(0,10)	1.23E-13
22			C(4,1)	-1.55E-08	C(2,5)	-3.17E-12	C(4,5)	-8.31E-17
	K	0	C(2,3)	1.79E-09	C(0,7)	1.00E-12	C(2,7)	-8.62E-16
	C(2,0)	0.003857	C(0,5)	5.04E-09	C(8,0)	-6.30E-15	C(0,9)	2.81E-16
	C(0,2)	0.001542	C(6,0)	5.14E-11	C(6,2)	5.88E-14	C(10,0)	2.50E-19
	C(2,1)	6.83E-05	C(4,2)	-3.38E-10	C(4,4)	-1.90E-14	C(8,2)	-3.80E-18
	C(0,3)	3.28E-05	C(2,4)	-1.19E-10	C(2,6)	-6.92E-14	C(6,4)	7.75E-18
	C(4,0)	-3.7E-07	C(0,6)	4.08E-11	C(0,8)	2.52E-14	C(4,6)	-4.39E-18
	C(2,2)	7.66E-07	C(6,1)	2.63E-12	C(8,1)	-2.66E-16	C(2,8)	-1.82E-18
	C(0,4)	4.96E-07	C(4,3)	-4.13E-12	C(6,3)	8.19E-16	C(0,10)	3.67E-19

【０１３４】

更に、この実施例における、各面のローカル座標系の傾き又は偏心の様子を以下の表２０に示す。なお、この表２０において、「ＡＤＥ」は図の断面と平行な面内での傾きの大

きさで、傾きの方向は図の断面内で反時計回りに回転する方向を正とし、単位は度である。また、「ＹＤＥ」は偏心の大きさであり、偏心は図の断面内でかつ光軸に垂直な方向で設定され、図の断面において下側への偏心を正とし、単位はｍｍである。

【０１３５】

【表２０】

表２０

Surface	ADE (°)	YDE(mm)
S3	3.251	1.647
S22	33.000	0.0

【０１３６】

この表２０に示した傾き又は偏心では、表示された面番号を含むそれ以降の面は、全て、表示された面の傾いた光軸の上に配置される。但し、Ｓ２２面の傾きは２２面のみの光軸の傾きを示しており、その後の２３面は２２面の傾き量の２倍傾いた光軸の上に配置される。

【０１３７】

表２１は、スクリーン位置の移動に対応して移動するレンズ群について、それらの面間距離の変化を示している。

【０１３８】

【表２１】

表２１

Surface	TH		
	Sc65	Sc67	Sc66
S13	41.959	41.935	41.991
S17	6.437	7.841	4.000
S19	11.138	10.169	12.785
S21	91.557	91.145	92.314
S22	-996.000	-1259.800	-732.335

【０１３９】

なお、この表９のＳｃ６５、Ｓｃ６７、Ｓｃ６６に対応する欄の値が、スクリーン位置６５、６７、６６でのレンズ間隔を表示している。

【０１４０】

また、添付の図２５は、上記スクリーンが、それぞれ、上記図１９において６６、６５、６７の位置にある場合の歪の様子を示しており、また、添付の図２６は、その場合のスポット形状の様子をそれぞれ示している。

【０１４１】

即ち、図２５（ａ）～（ｃ）では、物面（比率１６：９）上の範囲を、それぞれ、６０インチの像面、８０インチの像面、１００インチの像面上に拡大して投写した場合の図形歪を示す。この図２４の縦方向は上記図１の上下方向、即ち、Ｙ軸の方向である。また、この図２２の横方向はスクリーン上でＹ軸の垂直な方向であり、図の長方形の中央が画面の中央である。そして、この図２４は、画面の縦方向を４分割、横方向を８分割した直線の曲がりの状態を表示すことによって、図形歪の様子を示している。

【０１４２】

一方、図２６では、スクリーンをそれぞれの位置６６、６５、６７（上記図１９を参照）に配置した場合に得られたスポットダイアグラムを示す。なお、この図では、映像表示素子１の表示画面上、Ｘ，Ｙ座標の値で、（８，４．５）、（０，４．５）、（４．８，２．７）、（８，０）、（０，０）、（４．８、－２．７）、（８、－４．５）、（０、－４．５）の８点から射出した光束のスポットダイアグラムを上から順に（図では、丸で

囲んだ（１）～（８）の順に）示しており、また、その横方向には、それぞれの位置６６、６５、６７でのスクリーン位置（Ｓｃ６６、Ｓｃ６５、Ｓｃ６７）を示している。なお、単位はｍｍであるり、各スポットダイアグラムの横方向はスクリーン上でのＸ方向、縦方向はスクリーン上でのＹ方向である。即ち、これらの図からも明らかなように、その何れの場合においても、両者ともに良好な性能を維持していることが分る。

【０１４３】

そして、上記によって得られた投射画像の対角寸法を「Ｌｏ」とし、自由曲面ミラー５の中心から投射画像までの距離を「Ｌｐ」とした場合（上記図１を参照）、Ｌｏ＝２０３２ｍｍ、Ｌｐ＝９９６×ｃｏｓ４５°≒７０４ｍｍであることから、これらの間の比率が２以上（Ｌｏ／Ｌｐ＞２）となり、比較的近い距離（Ｌｐ）でも、物面を十分大きな画面に拡大して投射することが出来ること、即ち、投射拡大率に優れていることが分る。

【０１４４】

次に、添付の図２７には、本発明の他の実施形態になる投写型映像表示装置が示されている。即ち、図からも明らかなように、この他の実施形態になる投写型映像表示装置１００’では、上記図１又は図５に示した投写型映像表示装置の投写光学ユニットの構成に加え、その自由曲面の反射鏡４とスクリーン５との間の光路に、更に、平面の反射鏡２１を配置して投写光学ユニットを構成している。なお、この図の例では、この平面の反射鏡２１は、上記自由曲面の反射鏡４に対応して装置筐体１１０の上面に形成された開口部を覆うための蓋をも兼ね、その上方で開閉自在に設けられている。

【０１４５】

かかる投写光学ユニットの構成では、添付の図２８にも示すように、画像表示素子１からプリズム１０を介して射出した光は、まず、レンズ光学系を構成する前方レンズ群２に入射される。その後、この前方レンズ群２から射出した光は、やはり少なくとも一方の面が回転対称でない（回転非対称の）自由曲面の形状を有する複数（本例では２枚）のレンズを含めた複数のレンズから構成される後方レンズ群３を通過する。そして、この後方レンズ群３から射出した光は、回転対称でない自由曲面形状の反射面を有する反射鏡（以下、自由曲面ミラーと言う）４を含む反射光学系で拡大反射された後、更に、上記平面の反射鏡２１により反射されて所定のスクリーン５（例えば、部屋の壁面やシート状のスクリーン等）上に投写されることとなる。即ち、この図からも明らかなように、上述した実施例（例えば、図２や図４）とは反対の方向に投写する。このことからも、この他の実施形態になる投写型映像表示装置１００’の投写光学ユニットの構成では、自由曲面ミラー４からスクリーン５までの光路を上記平面反射鏡２１により折り返すことから、スクリーン５までの距離をより小さくすることが可能となり、広角化を可能とするのに好適である。

【０１４６】

また、この投写光学ユニットの構成では、図２８において破線で示すように、上記平面反射鏡２７は、その傾斜角度を微小な角度で調整可能となるように構成されている。即ち、これによれば、やはり図中に破線及び矢印で示すように、この平面反射鏡２７の傾斜角度を変えることにより、スクリーン５上での投写画像の位置を上下に変更することが可能となり、特に、投写型映像表示装置においては、好適な機能を提供することが可能となる。なお、この平面反射鏡２７は、当該投写型映像表示装置の使用状況に応じてユーザがその傾斜角度を調整することが出来、或いは、ここでは図示しないが、例えば、電動モータなどを含む駆動機構によって筐体１１０上面の開口部を覆おう位置から移動し（立ち上がり）、そして、ユーザによって設定された角度に傾斜して配置されるように構成することも可能であろう。

【０１４７】

なお、以上に述べた本発明の実施例になる投写型映像表示装置では、画像表示素子１からの映像（画像）は、上記の投写光学ユニットから出射して自由曲面ミラー４で反射され、又は、更に平面反射鏡２７により反射されてスクリーン５上に投写される。そのため、当該装置１００、１００’の位置を、映像（画像）を投写するスクリーン５に対して正確に位置決めする必要がある。即ち、上記図５に示した画面中央の光線が上記スクリーン５

の面に対して垂直になるよう、その配置を調整することが、特に、その全体において歪みや収差を最小限に抑え、良好な投写画面を得るために重要である。

【０１４８】

そこで、本発明の実施例になる投写型映像表示装置では、装置の位置決め機構をその一部に備えており、その具体的な例を、以下に説明する。

【０１４９】

添付の図２９は、上記位置決め機構を備えた投写型映像表示装置１００が示されており、特に、図２９（ａ）は、位置決め機構を備えた投写型映像表示装置１００の上面からの斜視図を、図２９（ｂ）は、当該装置の底面からの斜視図を、そして、図２９（ｃ）は、上記図２９（ｂ）におけるｃ－ｃ拡大断面をそれぞれ示している。

【０１５０】

即ち、図２９（ｂ）にも示すように、投写型映像表示装置１００の筐体１１０の底面には、光の投射方向（図の右方向）の縁部に隣接して、その中央部には、例えば、ゴム等の弾性体を略円錐形状に形成してなる中心ストッパ１１３が取り付けられ、他方、上記縁部とは反対側の縁部に隣接して、その両端付近には、例えば、回動ボールからなる一対の移動部材１１４、１１４が設けられている。

【０１５１】

なお、上記一対の移動部材１１４、１１４の各々は、図２９（ｃ）にも示すように、筐体１１０の底面に形成した受孔１１５内にボール１１６を回転可能に保持しており、更に、当該筐体１１０の内部には、その矢印方向の移動によって上記ボール１１６の回転を停止する拘束部材（又は、押圧部材）１１７を備えている。即ち、図の拘束部材（又は、押圧部材）１１７をユーザが矢印方向に押下することにより（但し、図２９（ｃ）は、上下を逆転して示す）、ボール１１６を受孔１１５の内壁面に押し付けてその回動を停止する。

【０１５２】

上述した位置決め機構の使用方法の一例を図２９（ａ）に示す。まず、拘束部材（又は、押圧部材）１１７を上方に移動した状態（即ち、ボール１１６を回転可能にする）で、投写型映像表示装置１００を、その筐体１１０の底面を下にして、例えば、机等の上に平行に配置する。そして、図に矢印で示すように、映像（画像）をスクリーン５上に投写しながら、その側面を押す等により、当該装置１００（１００’）を上記ストッパ１１３を中心として回転移動する。そして、投写型映像表示装置１００がスクリーン５に対して所望の角度位置になった時点で、装置筐体１１０の両側面に設けられた一対の移動部材１１４、１１４を押し下げる。即ち、上述の位置決め機構を備えた投写型映像表示装置１００によれば、以上に述べた操作により、簡単に、スクリーン５に対して正確に位置決めすることが可能となり、更には、上記した平面反射鏡２１や後方レンズ群３の移動機構を適宜設定することによれば、スクリーン５上に、その全体において歪みや収差を最小限に抑えた良好な投写画面を得ることが可能になる。

【０１５３】

以上述べたように、本発明によれば、上述した従来技術のように使用するレンズを偏心させる必要がないことから、口径の大きな付加光学系を必要とすることなく、しかも広角角化を可能とすると共に、スクリーンまでの位置が変更しても歪みを最小限に抑えることが可能であり、かつ、その製造も比較的容易な投写型映像表示装置が提供される。そして、かかる投写型映像表示装置によれば、その全体において歪みや収差を最小限に抑えた良好な投写画面を得ることが出来、使い勝手にも優れた投写型映像表示装置装置を実現することが可能となる。

【図面の簡単な説明】

【０１５４】

【図１】本発明の一実施の形態になる投写型映像表示装置装置の全体構成を示す斜視図である。

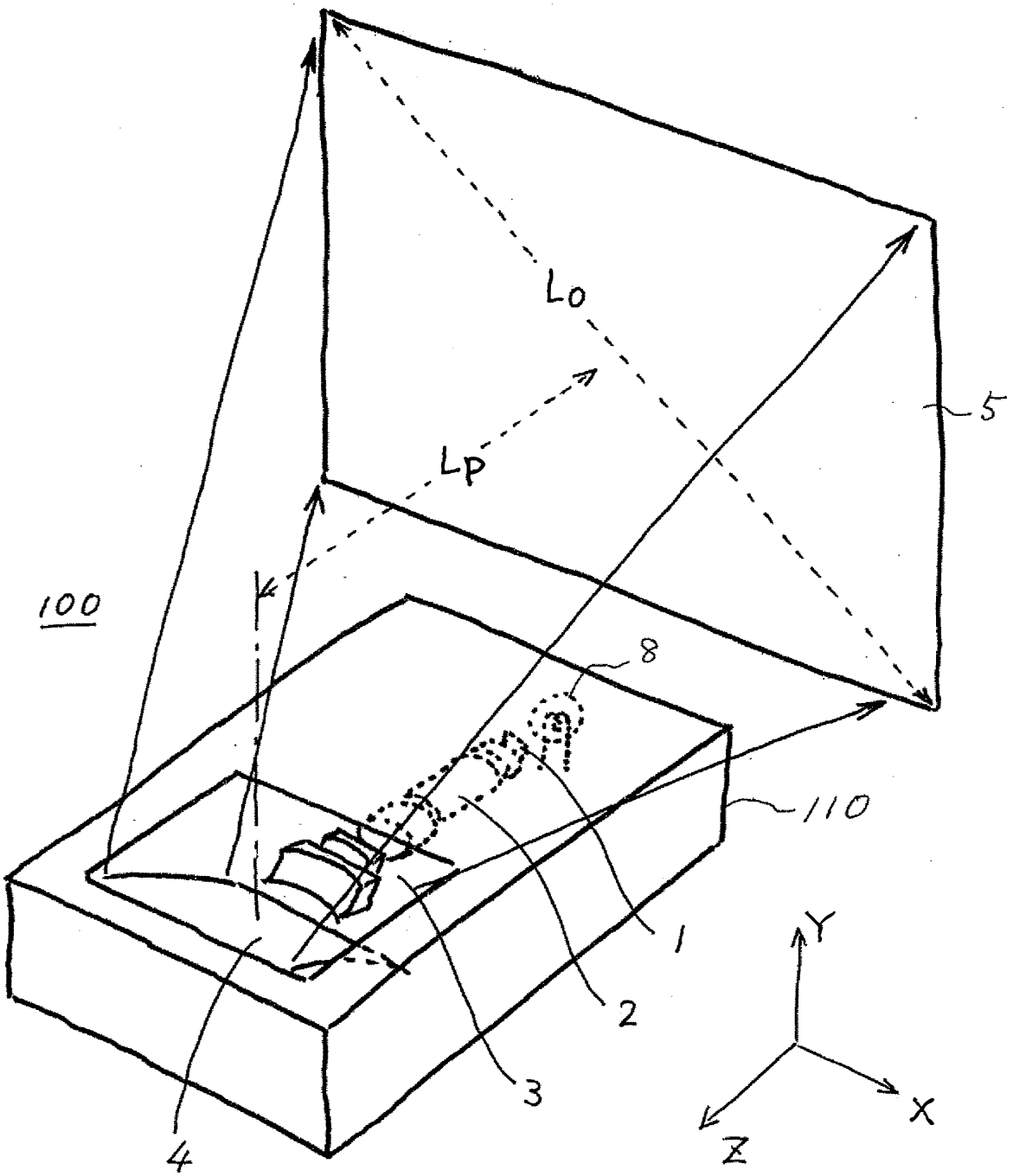
【図２】上記投写型映像表示装置装置の投写光学ユニットの基本構成を示す断面図で

ある。
【図３】上記光学ユニットのレンズ配置の一例を示す斜視図である。
【図４】上記光学ユニットのレンズ面を説明するための垂直方向及び水平方向の断面図である。
【図５】本発明の他の実施形態になる投写型映像表示装置装置の全体構成を示す斜視図である。
【図６】上記他の実施形態になる投写型映像表示装置装置における光学ユニットのレンズ配置の一例を示す斜視図である。
【図７】上記光学ユニットのレンズ面を説明するための垂直方向の断面図である。
【図８】上記本発明の投写型映像表示装置装置における光路を示すＹＺ断面図である。
【図９】上記本発明の投写型映像表示装置装置における光路を示すＸＺ断面図である。
【図１０】本発明の実施例１になる光学ユニットの歪性能を示す図である。
【図１１】本発明の実施例１になる光学ユニットのスポット性能を示す図である。
【図１２】本発明の実施例２になる光学ユニットの歪性能を示す図である。
【図１３】本発明の実施例２になる光学ユニットのスポット性能を示す図である。
【図１４】本発明の実施例３になる光学ユニットの歪性能を示す図である。
【図１５】本発明の実施例３になる光学ユニットのスポット性能を示す図である。
【図１６】本発明の実施例４になる光学ユニットの歪性能を示す図である。
【図１７】本発明の実施例４になる光学ユニットのスポット性能を示す図である。
【図１８】上記の投写光学ユニットを投写型映像表示装置に適用してスクリーン上に画像を拡大投射した状態を示す図である。
【図１９】上記の投写光学ユニットを適用した投写型映像表示装置において、投写距離変化させた場合の状態を示す図である。
【図２０】上記の投写光学ユニットを適用した投写型映像表示装置において、投写距離変化させた場合の歪性能とスポット性能を示す図である。
【図２１】上記の投写光学ユニットを適用した投写型映像表示装置において、投写距離変化させた場合の歪性能とスポット性能を示す図である。
【図２２】上記の投写光学ユニットにおいて後方レンズ群を移動させた状態を示す図である。
【図２３】上記投写型映像表示装置において、投写光学ユニットにおける後方レンズ群を移動させるための構造の一例を示す、一部断面を含む斜視図である。
【図２４】上記の投写光学ユニットにおけるレンズ面を説明するための水平方向の断面図である。
【図２５】上記の投写光学ユニットにおいて後方レンズ群を移動させた場合における歪性能を示す図である。
【図２６】上記の投写光学ユニットにおいて後方レンズ群を移動させた場合におけるスポット性能を示す図である。
【図２７】本発明の更に他の実施形態になる投写型映像表示装置装置の全体構成を示す斜視図である。
【図２８】上記更に他の実施形態になる投写型映像表示装置装置における投写光学ユニットの基本構成を示す断面図である。
【図２９】本発明の投写型映像表示装置装置の一部に取り付けられた位置決め機構の構造と使用方法を説明するための図である。
【符号の説明】
【０１５５】
１…映像発生源、２…前方レンズ群、３…後方レンズの後、４…自由曲面ミラー、５…スクリーン、６…自由曲面ミラーの原点座標の法線、７…スクリーンの法線、１００、１００’…投写型映像表示装置装置、１１０…筐体、２７…平面反射鏡、１１３…ストッパ

、１１４…移動部材

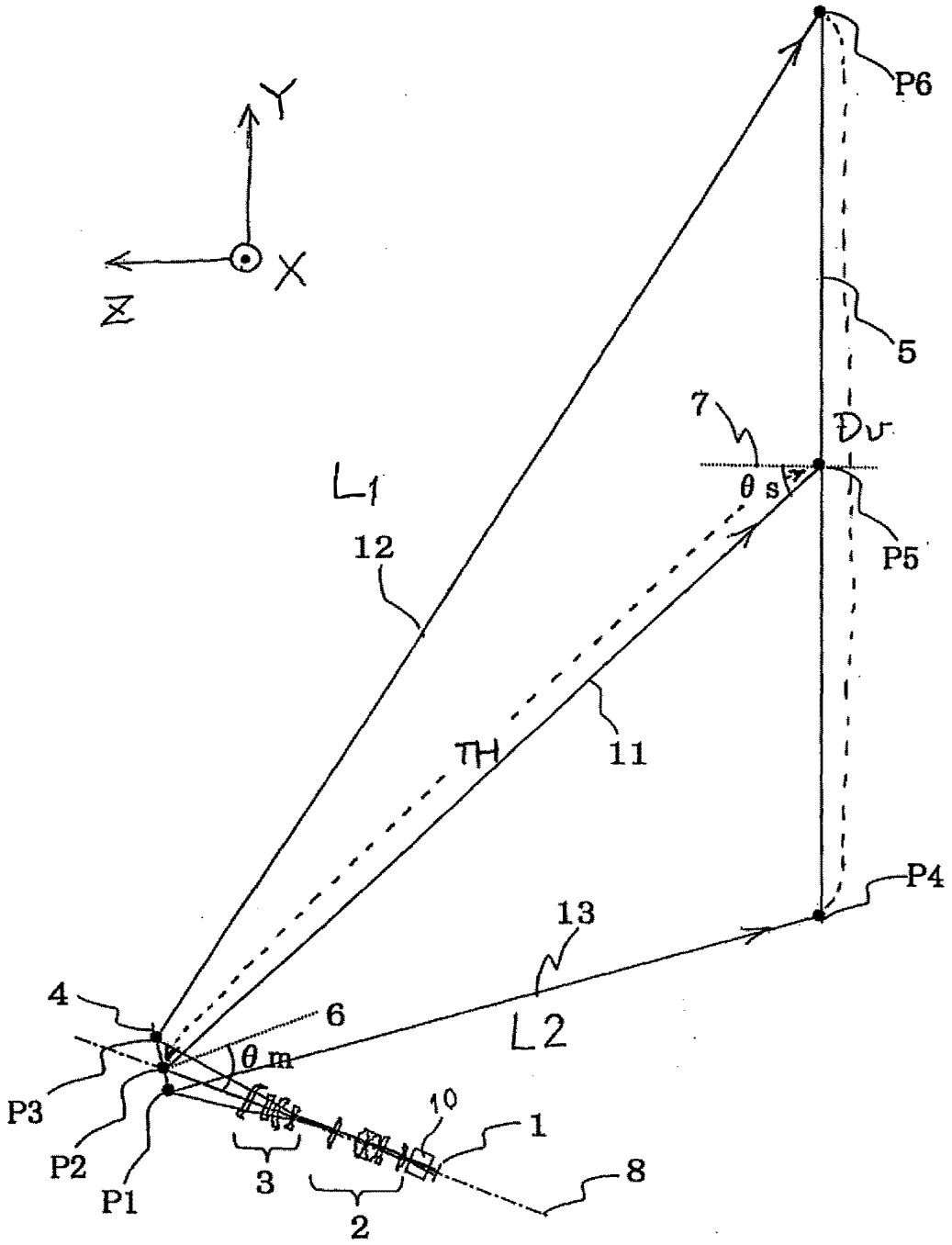
【書類名】図面
【図１】

図１



【図２】

図２



【図３】

図３

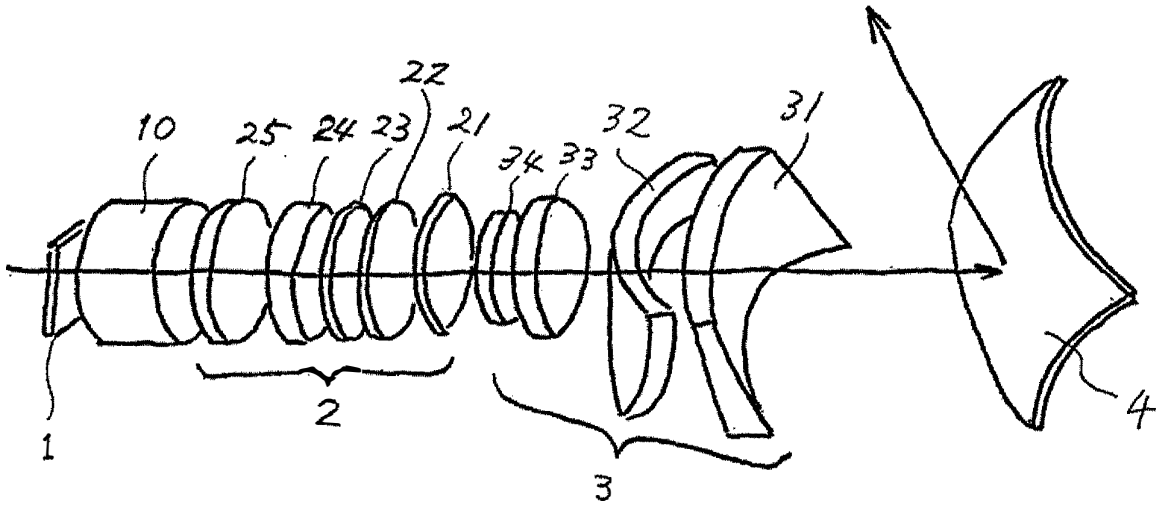
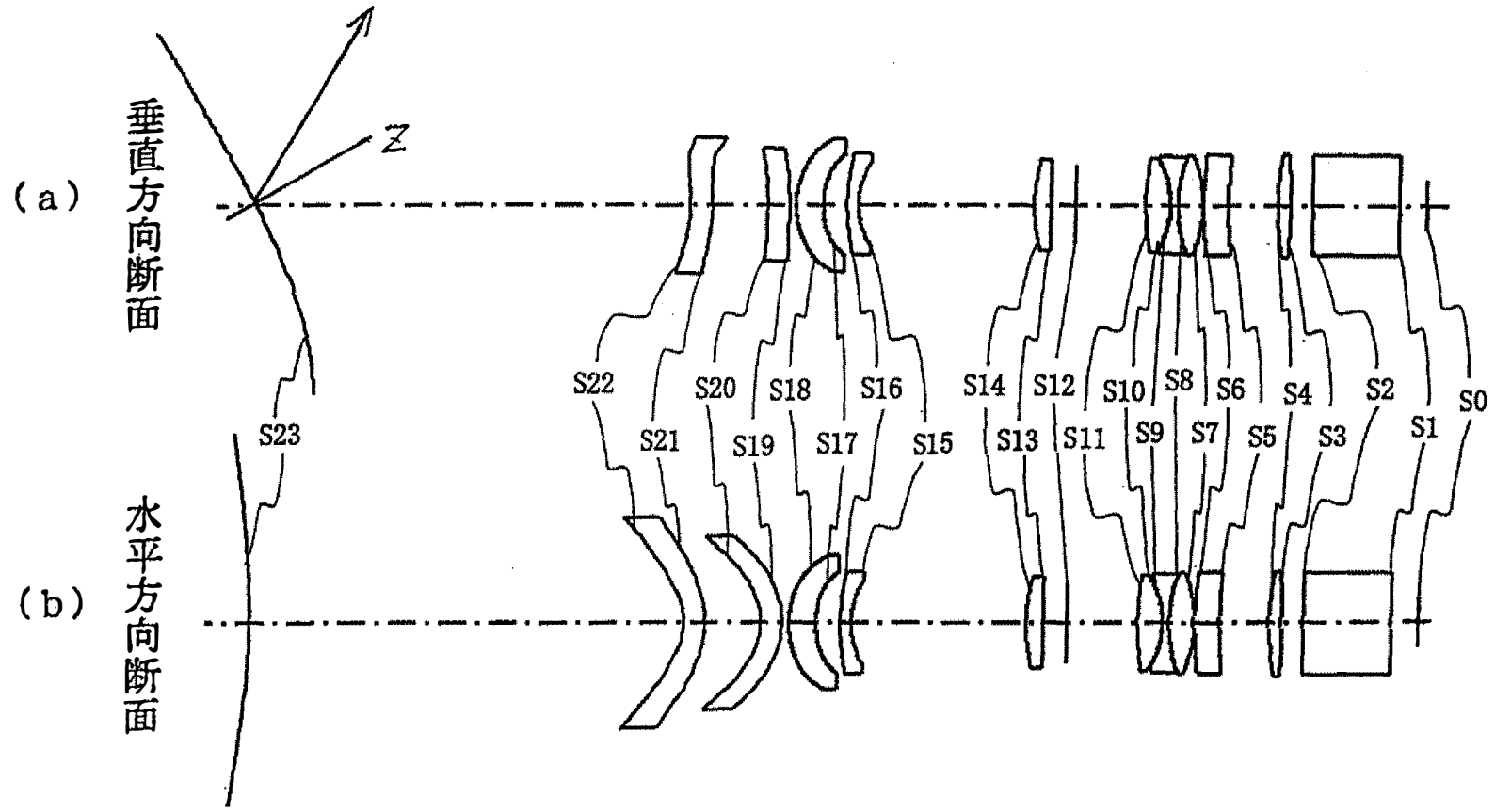


図４


（a）
垂直方向断面
Z
S23
S22
S21
S20
S19
S18
S17
S16
S15
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
S0
（b）
水平方向断面

【図４】

【図５】

図５

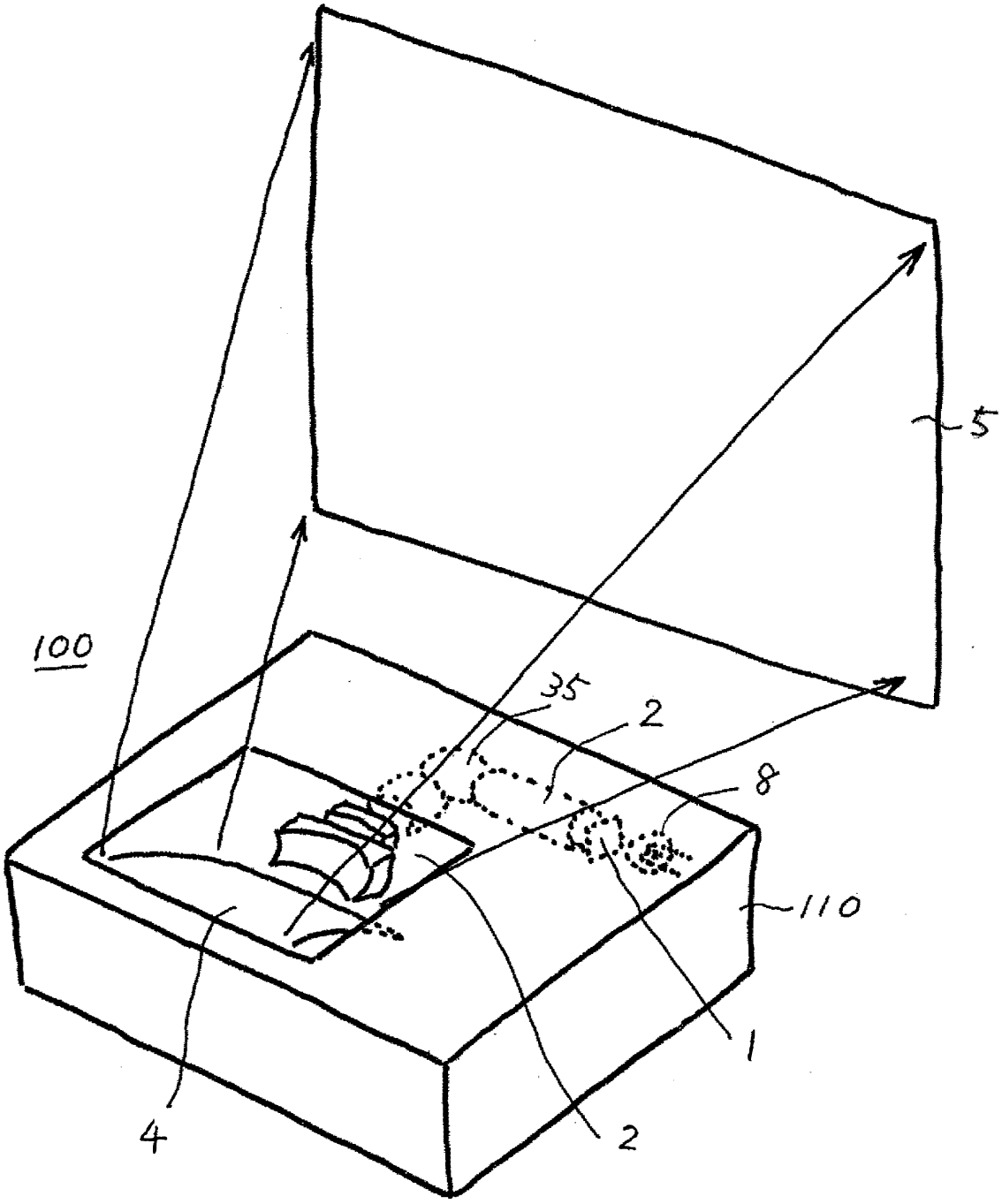
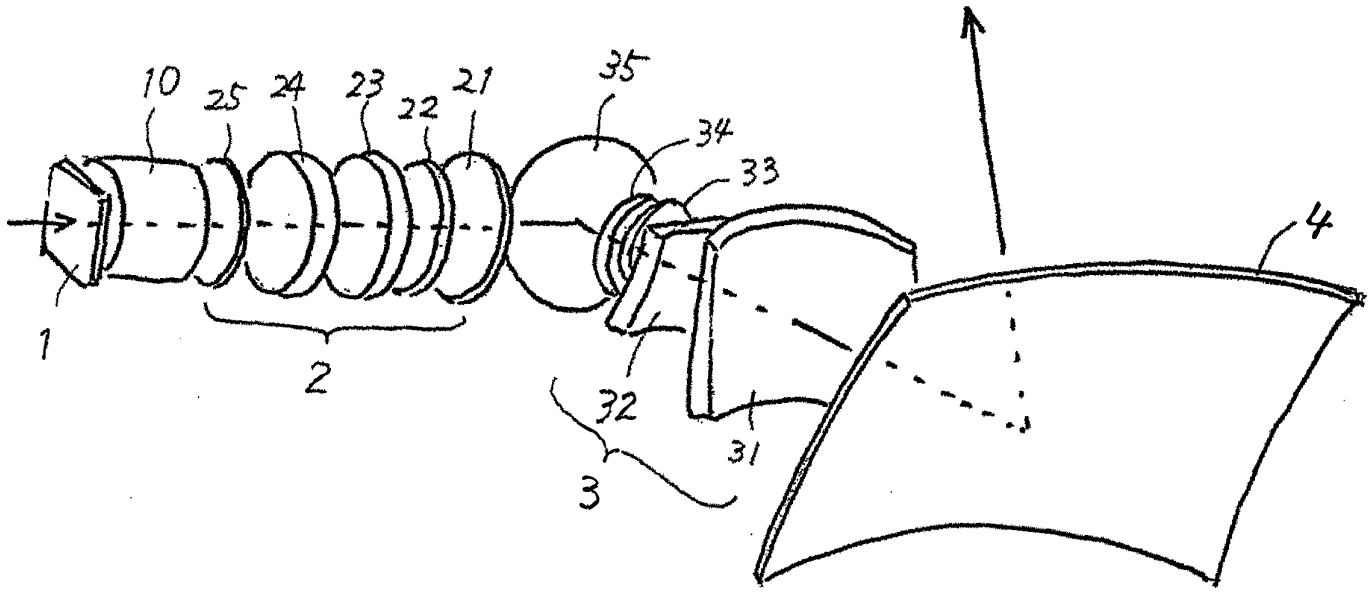
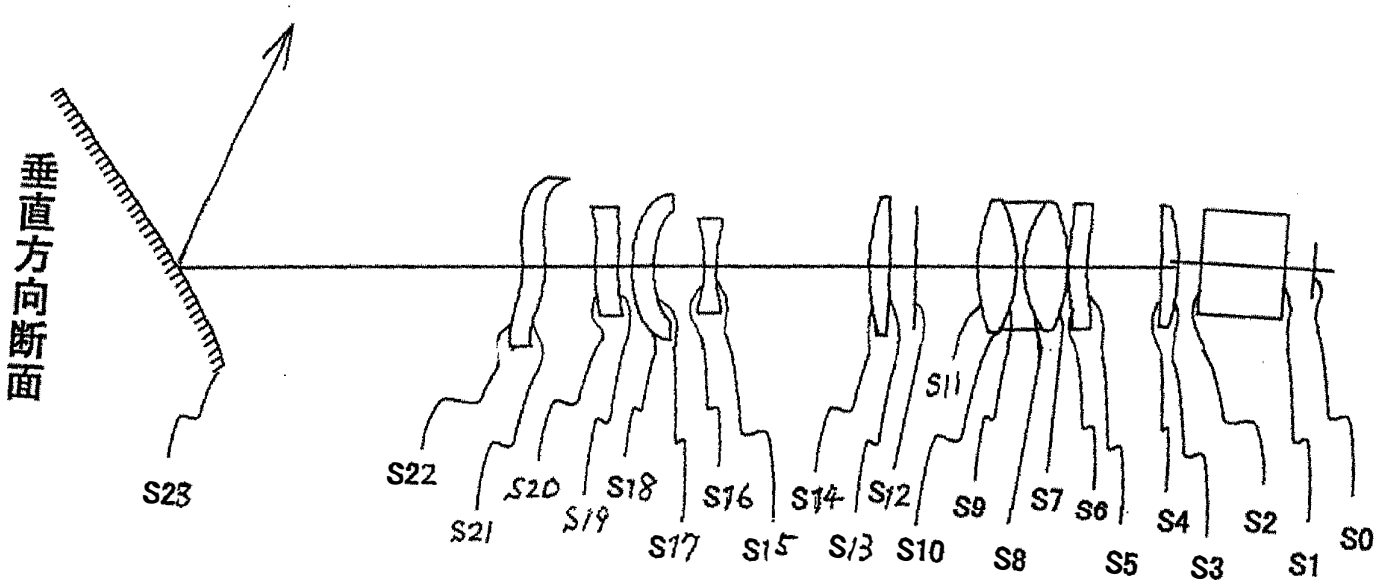


図6



【図6】

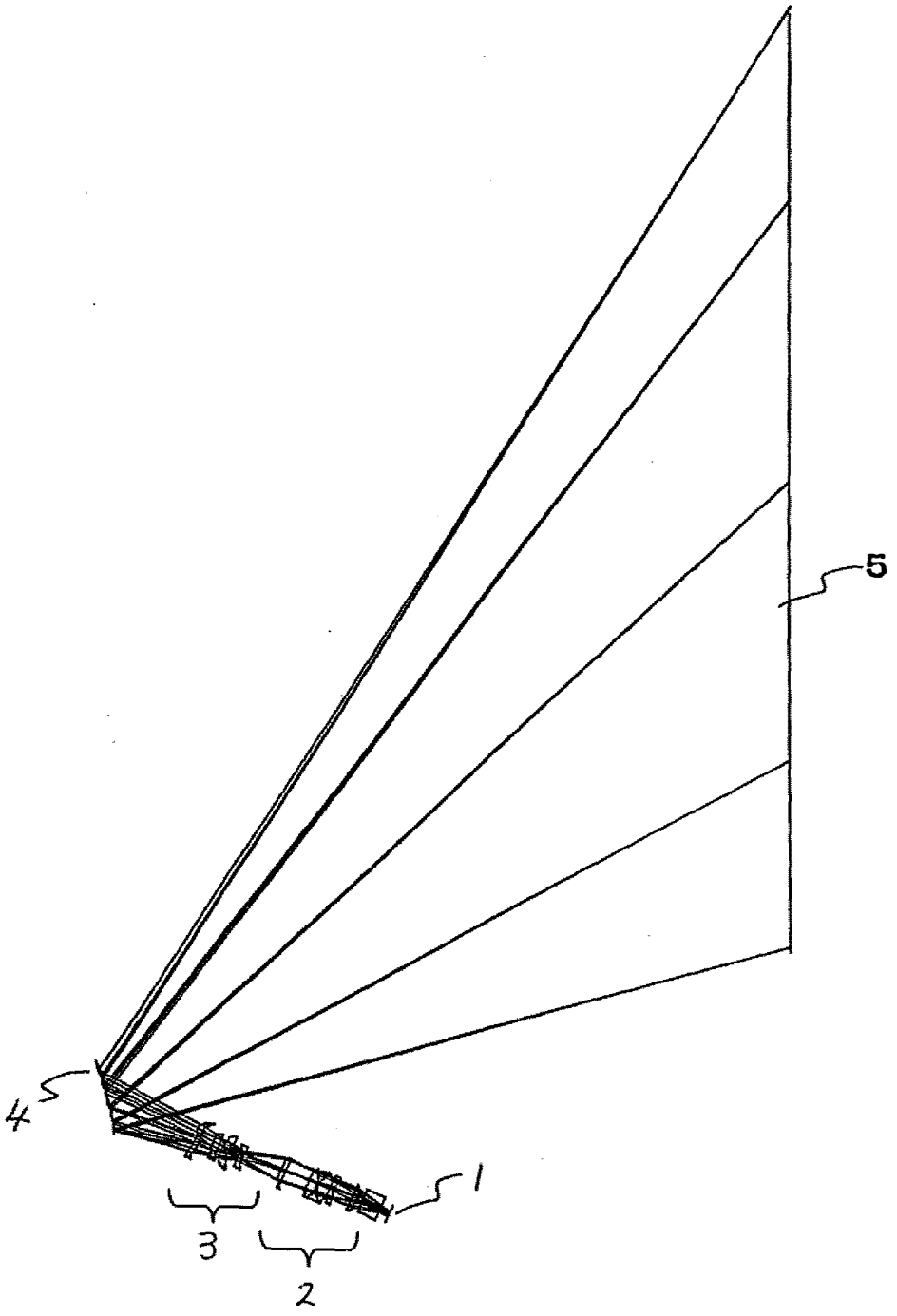
図 7


垂直方向断面
S23
S22
S21
S20
S19
S18
S17
S16
S15
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
S0

【図７】

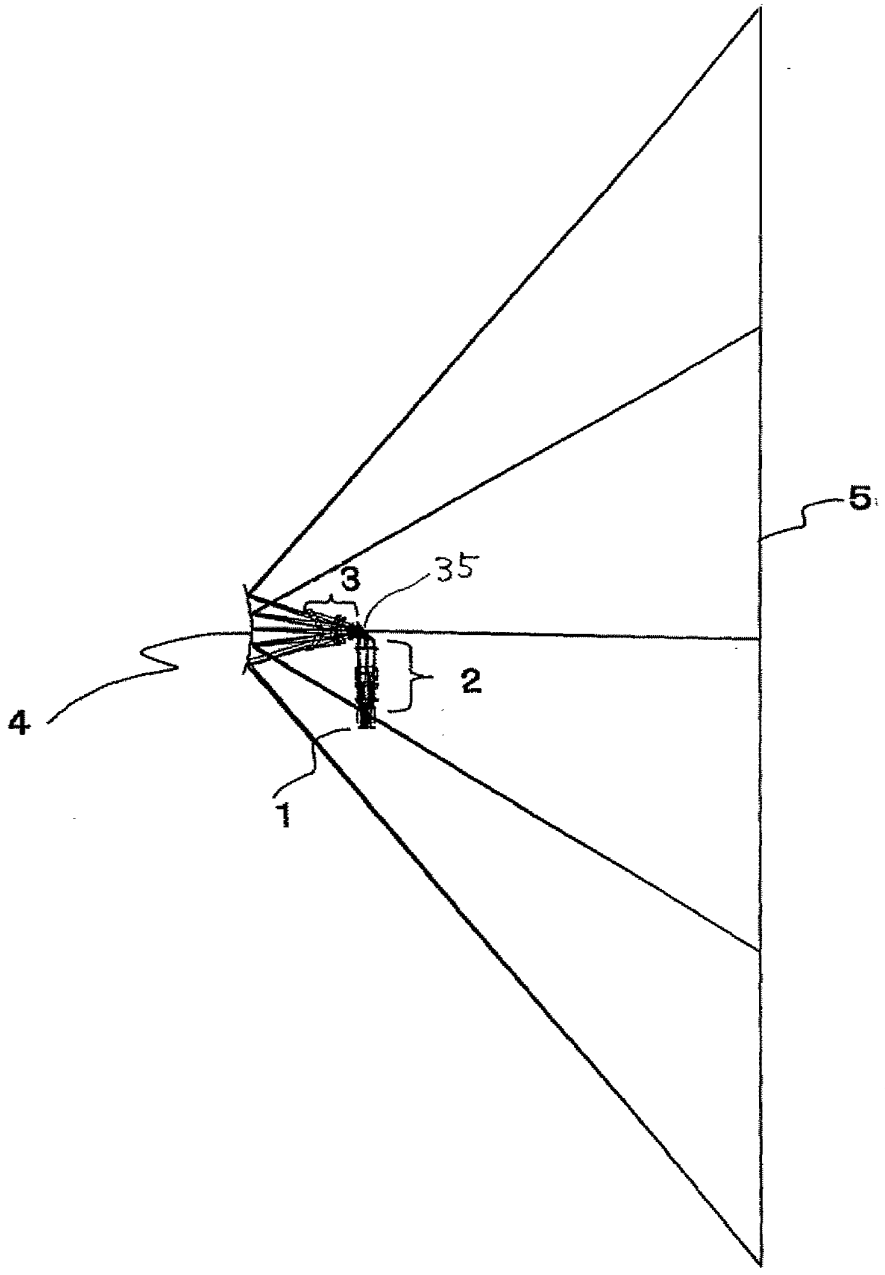
【図８】

図８



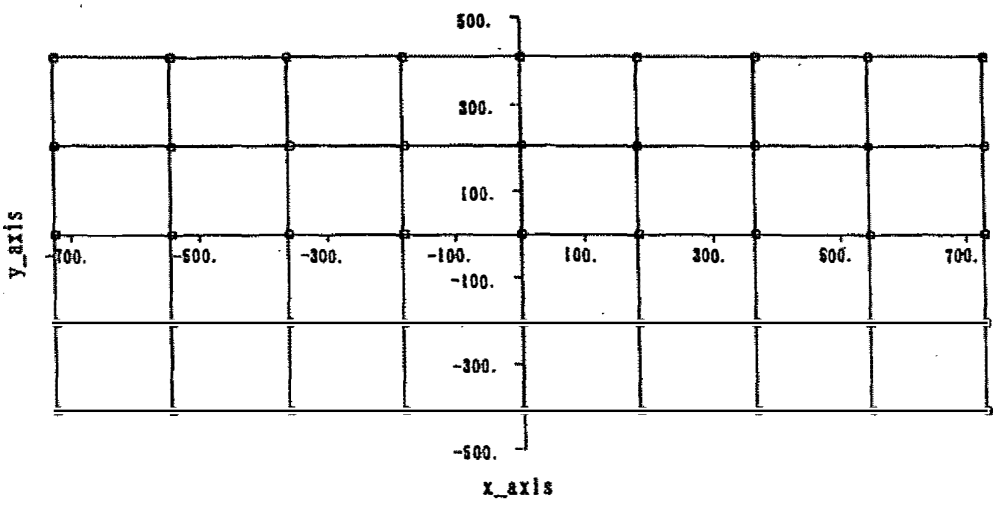
【図９】

図９



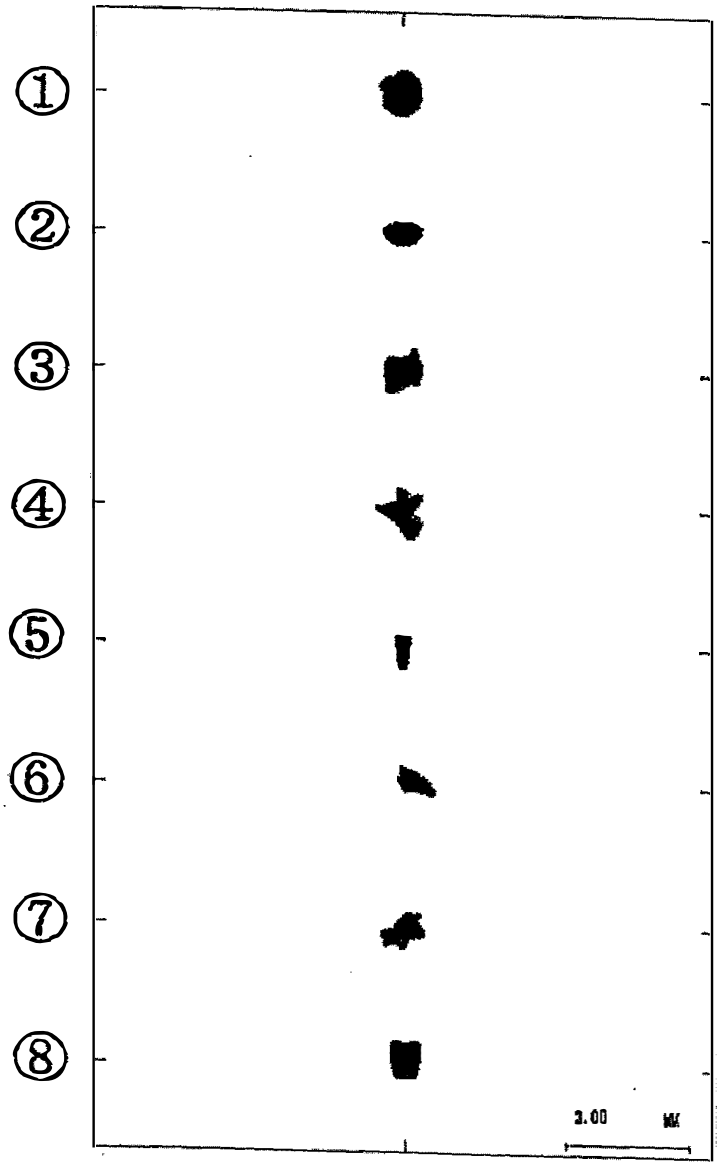
【図１０】

図１０


500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
y_axis
x_axis

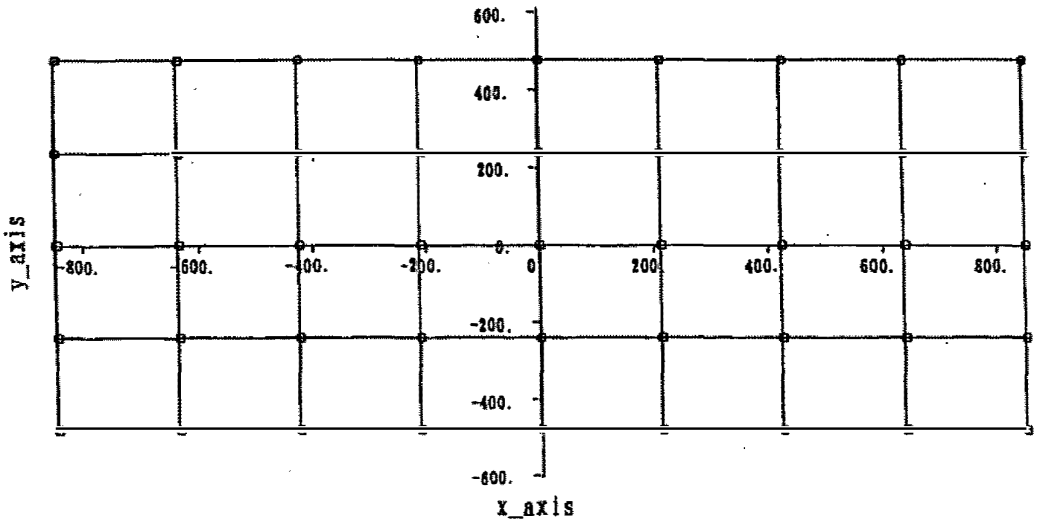
【■１１】

図１１



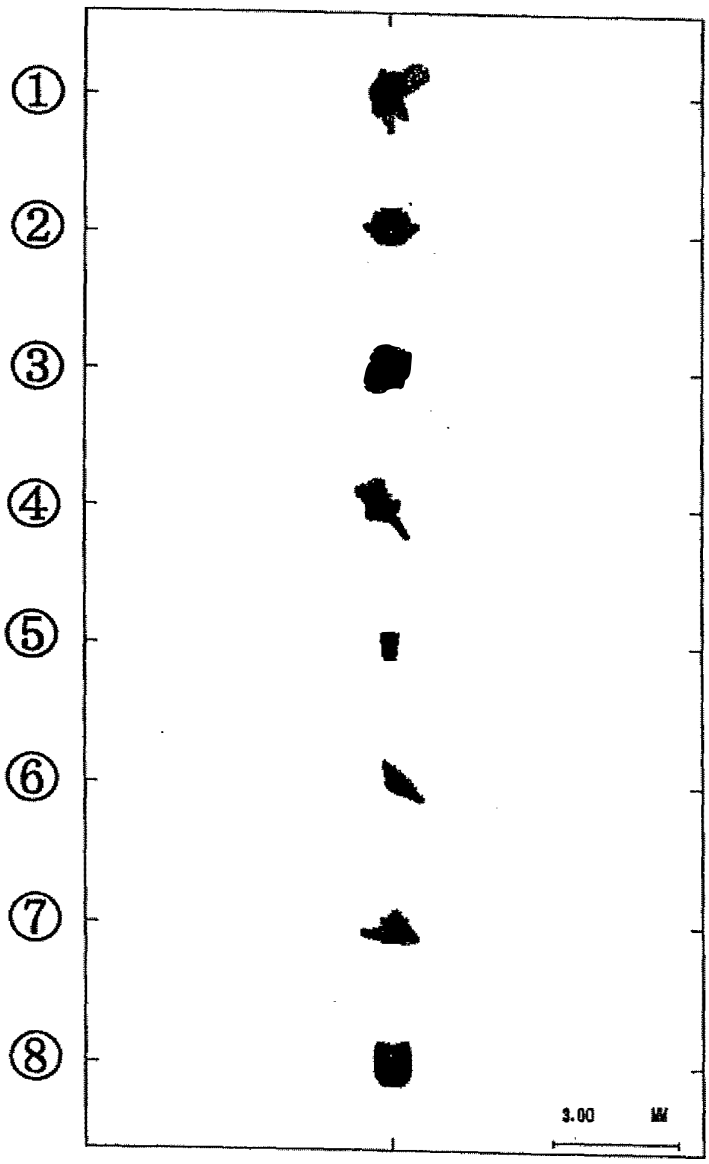
【図１２】

図１２


600.
400.
200.
0.
-200.
-400.
-600.
-800.
-600.
-400.
-200.
0
200
400.
600.
800.
y_axis
x_axis

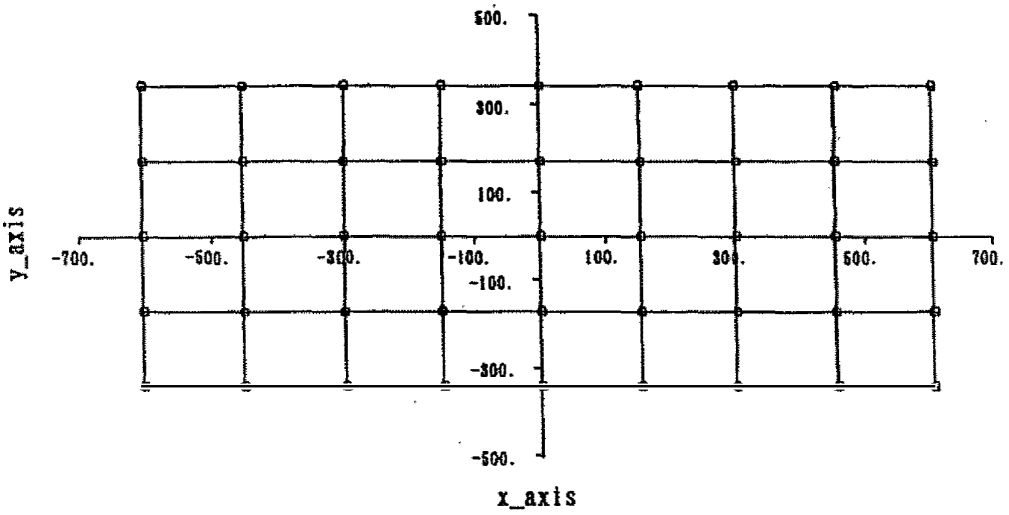
【図１３】

図１３



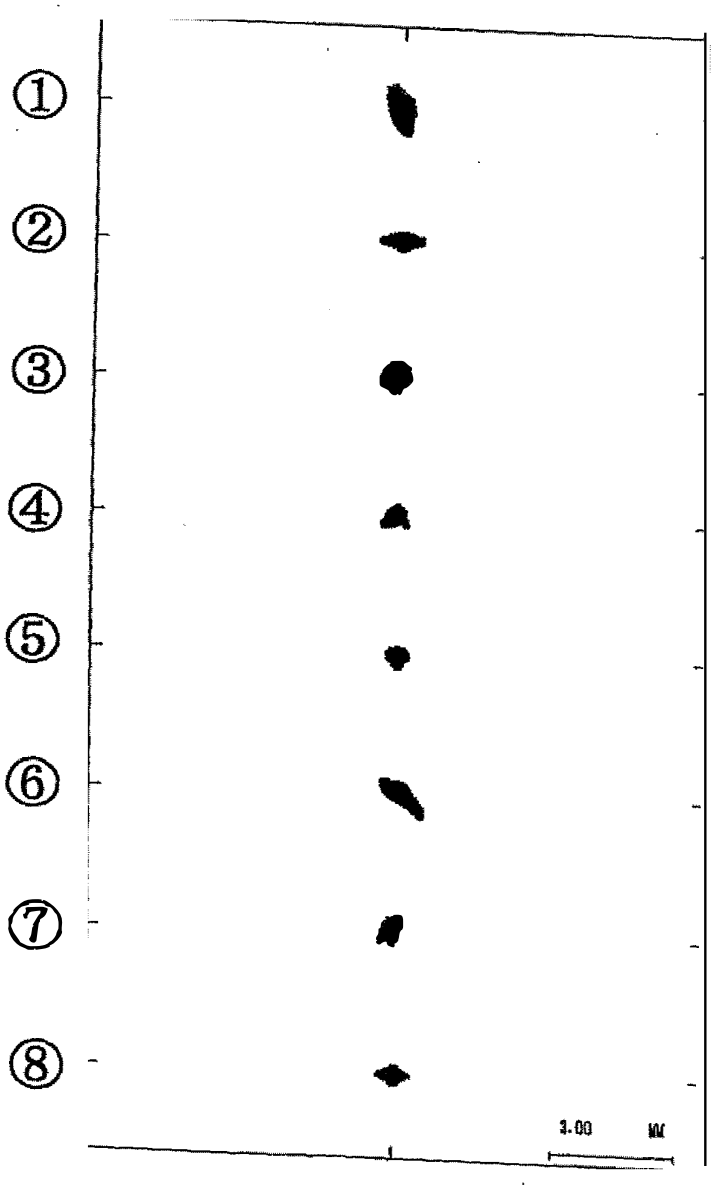
【図１４】

図１４


500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
y_axis
x_axis

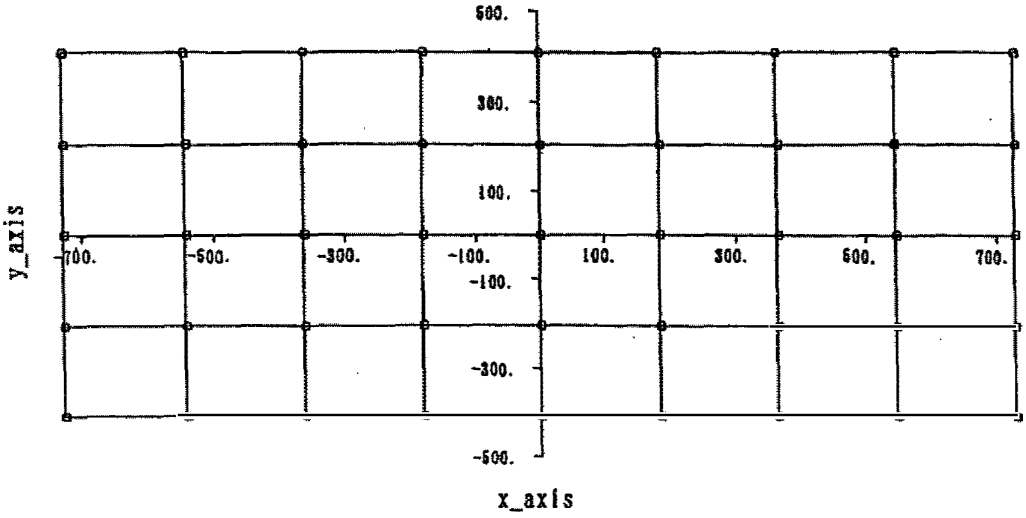
【図１５】

図１５



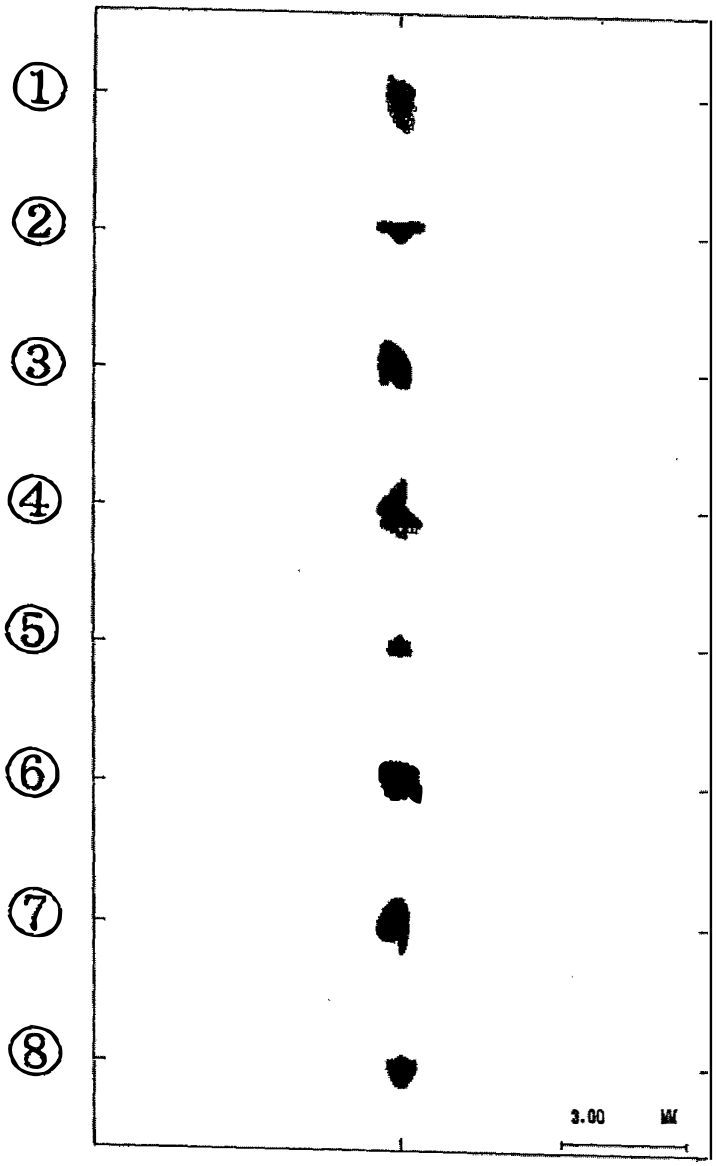
【図１６】

図１６


500.
300.
100.
-700.
-500.
-300.
-100.
100.
300.
600.
700.
-100.
-300.
-500.
y_axis
x_axis

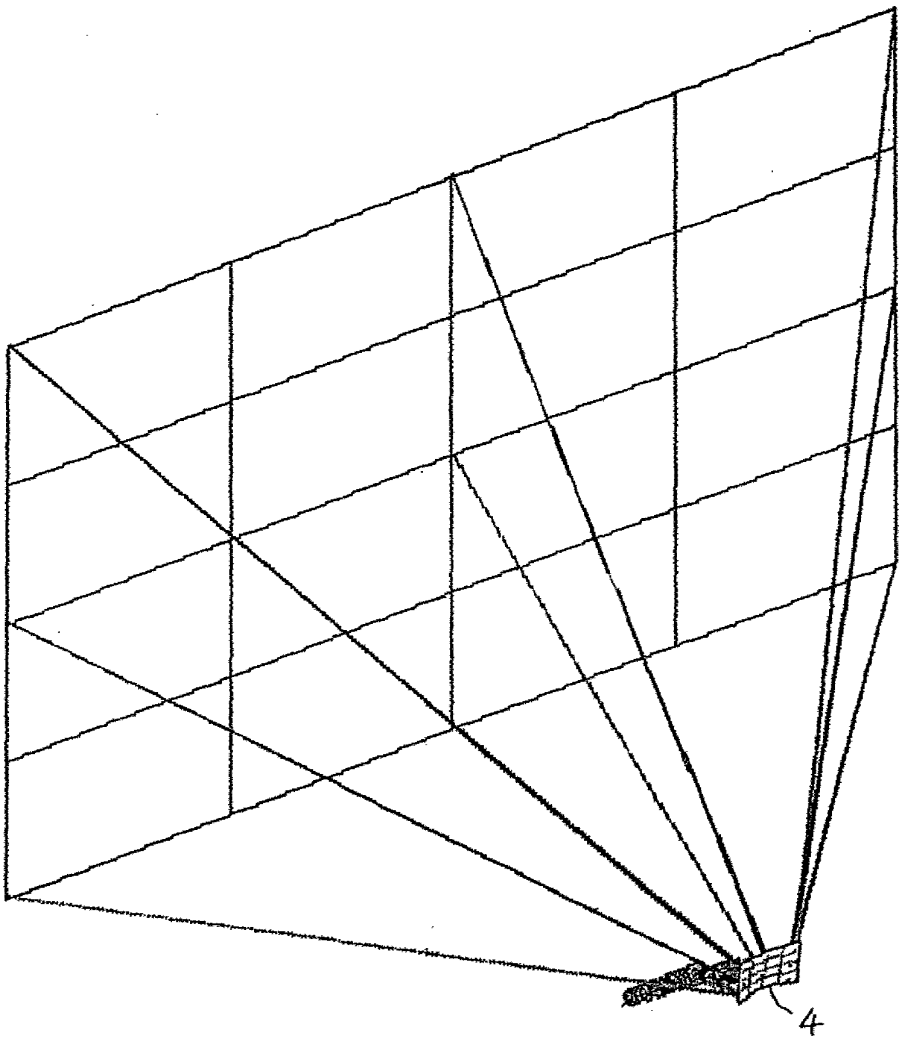
【図１７】

図１７



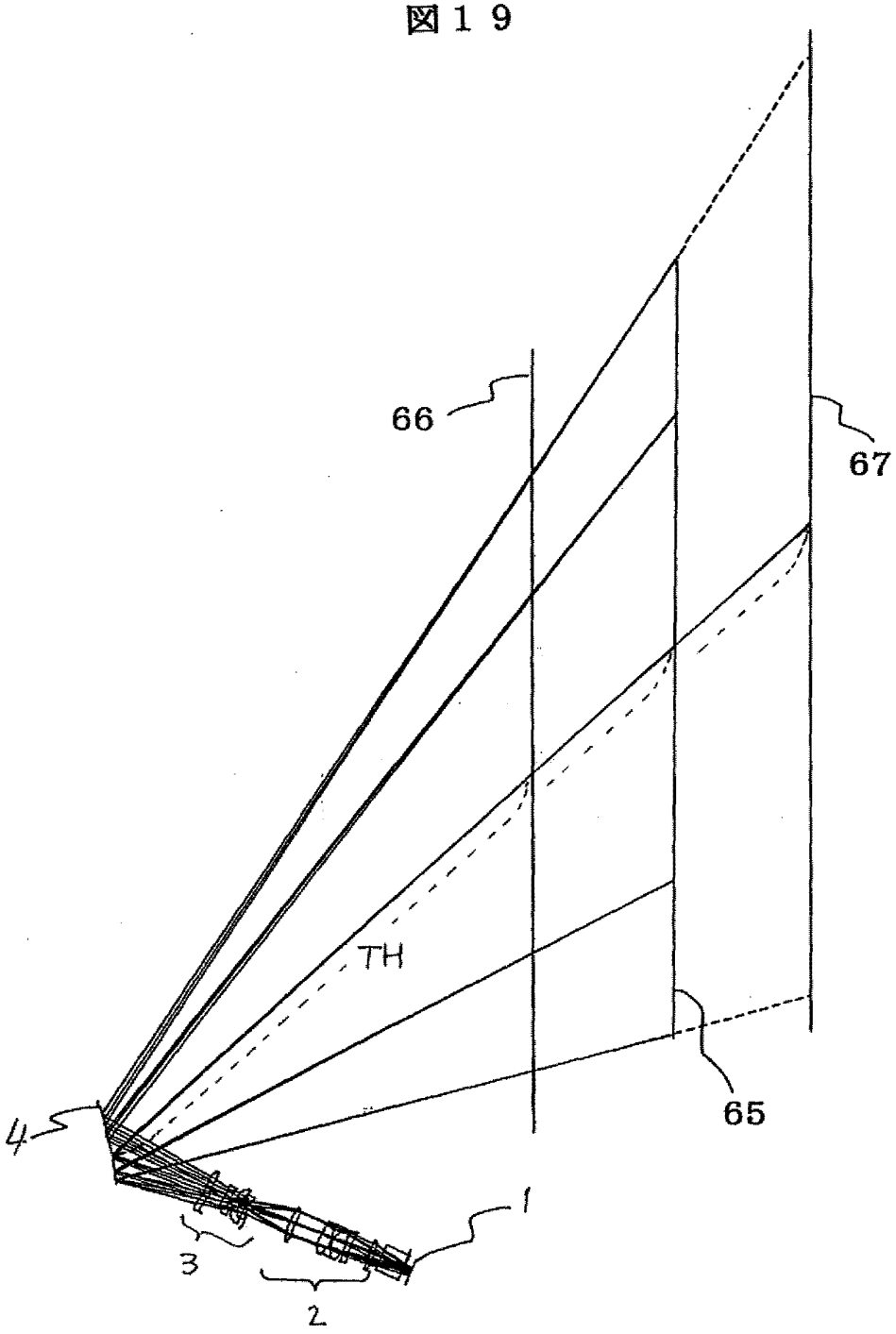
【図１８】

図１８



【図１９】

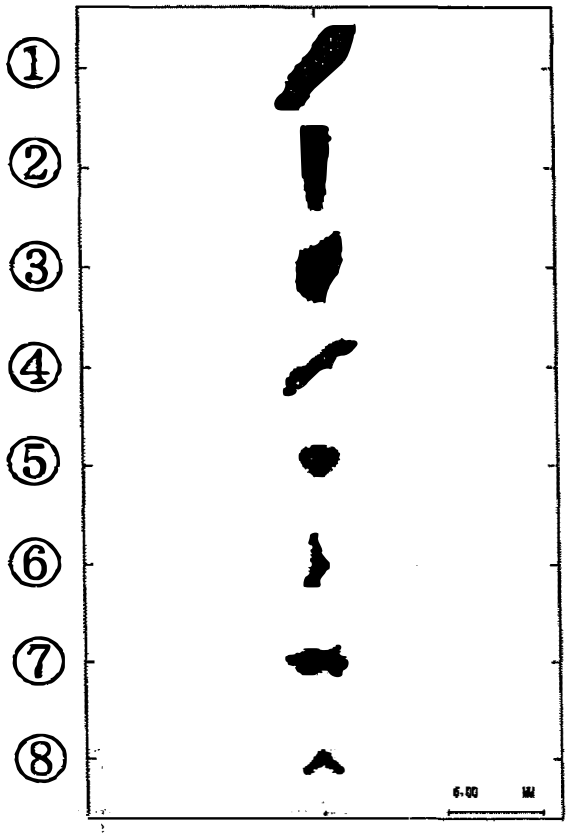
図１９



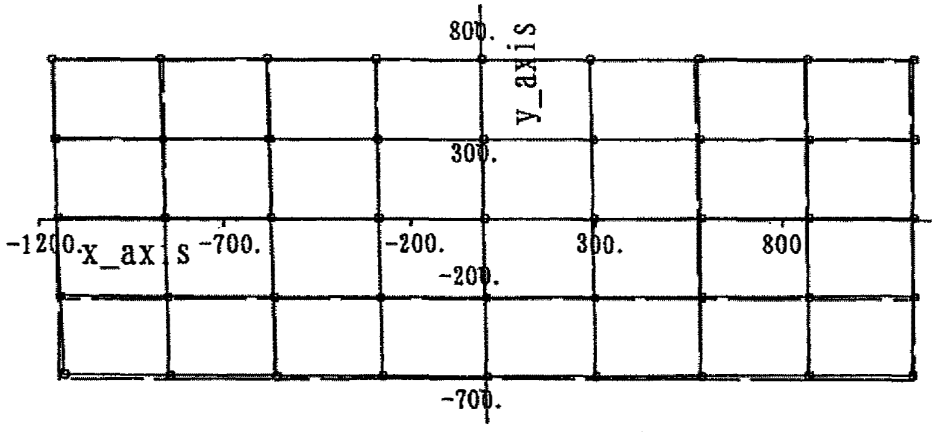
【図２０】

図２０

(a)



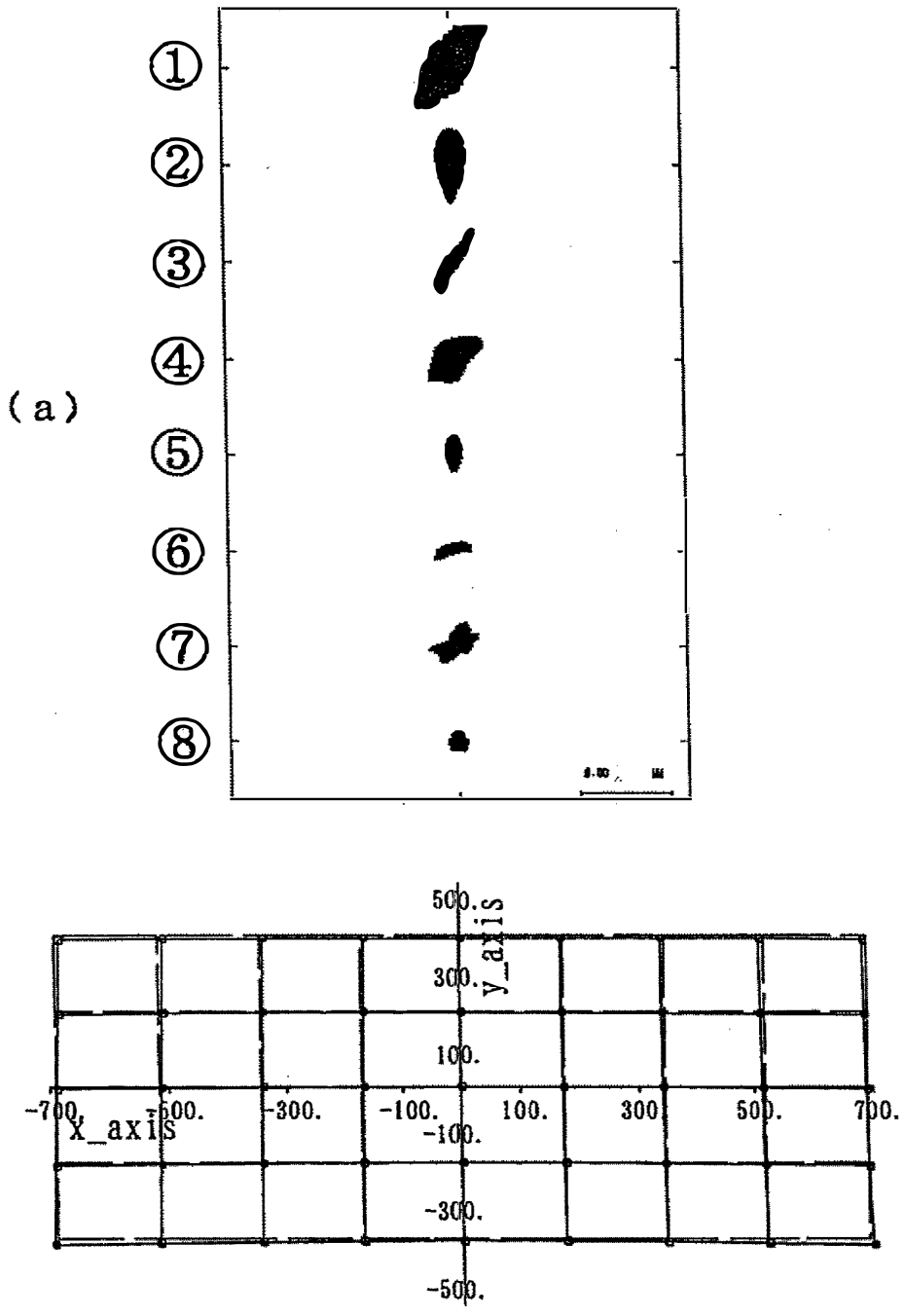
(b)



Sc67

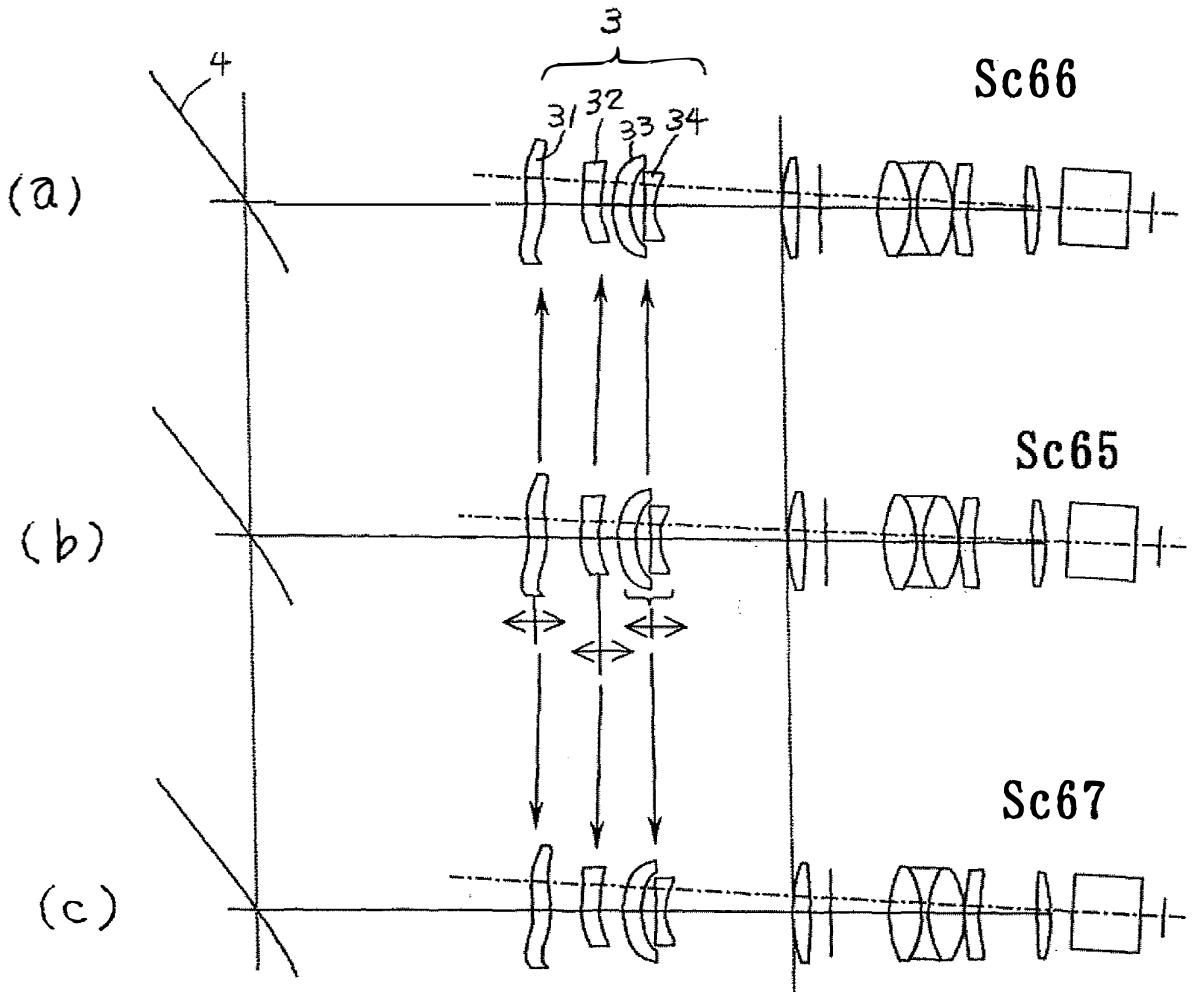
【図２１】

図２１


(a)
①
②
③
④
⑤
⑥
⑦
⑧
(b)
500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300
500.
700.
y_axis
X_axis
Sc66

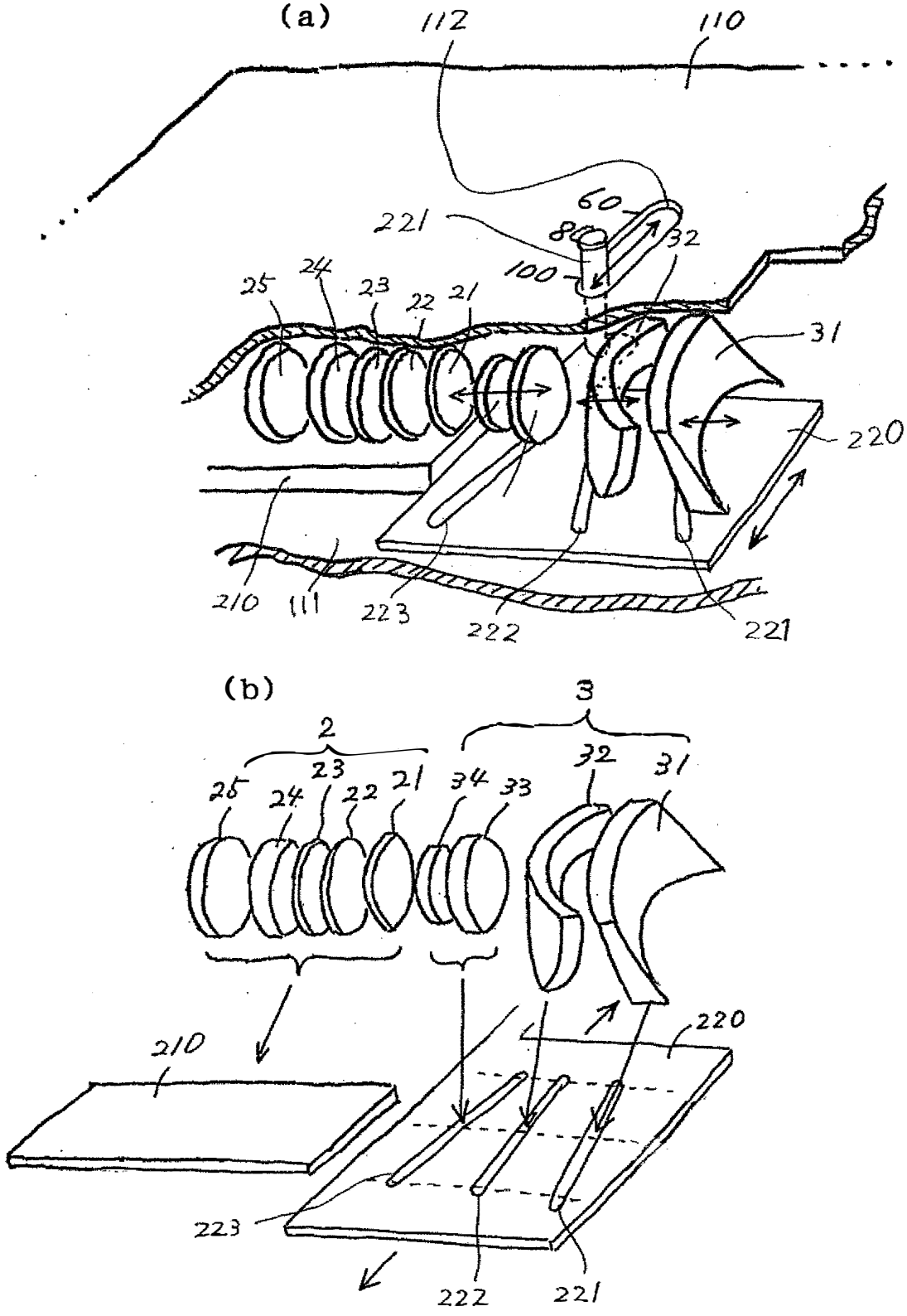
【図２２】

図２２



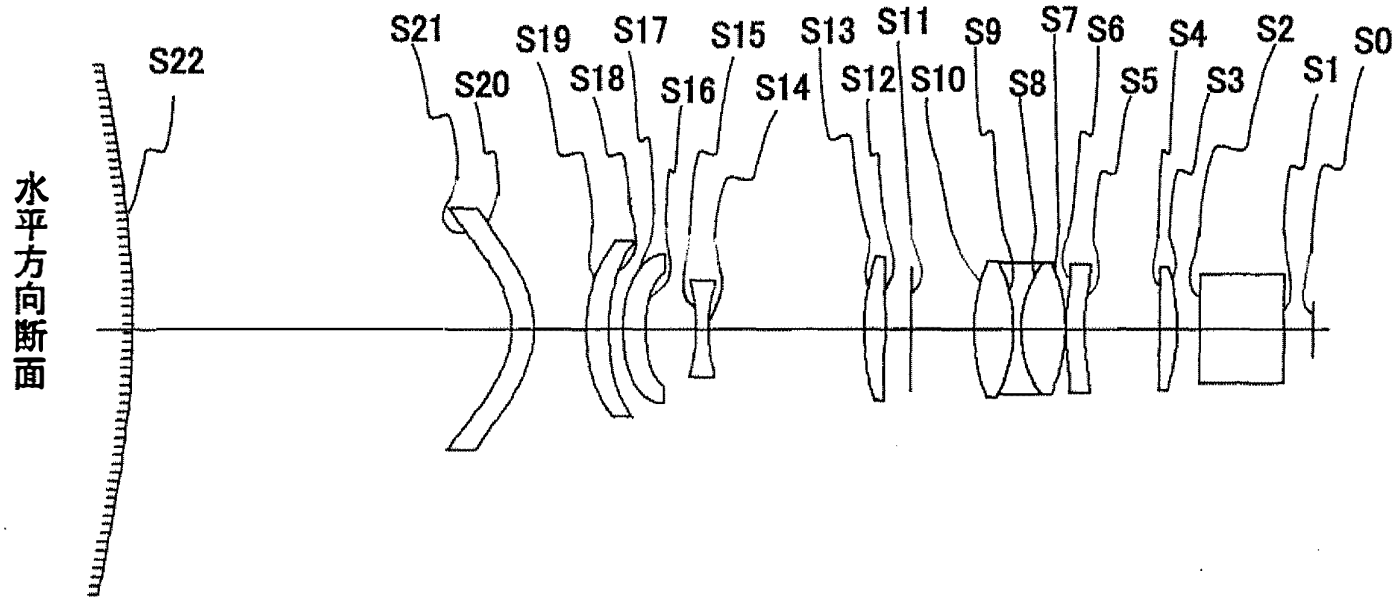
【図２３】

図２３


(a)
112
110
60
80
221
100
32
25
24
23
22
21
31
220
210
111
223
222
221
(b)
3
2
23
25
24
22
21
34
33
32
31
220
210
223
222
221

【図２４】

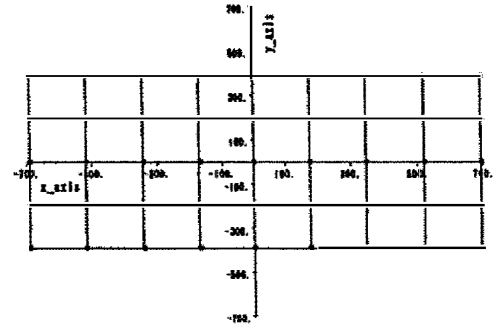
図２４


水平方向断面
S22
S21
S20
S19
S18
S17
S16
S15
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
S0

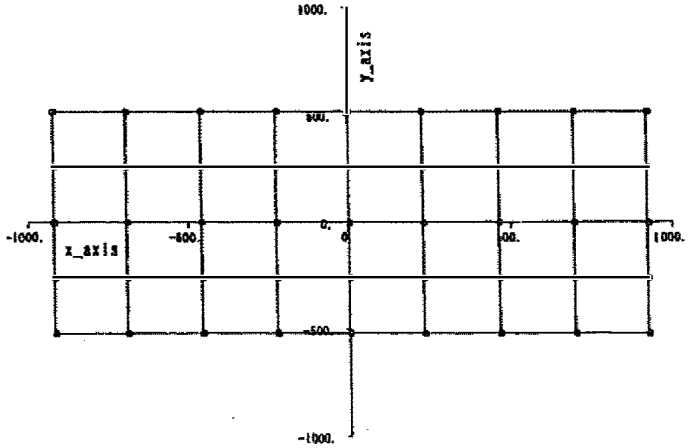
【図２５】

図２５

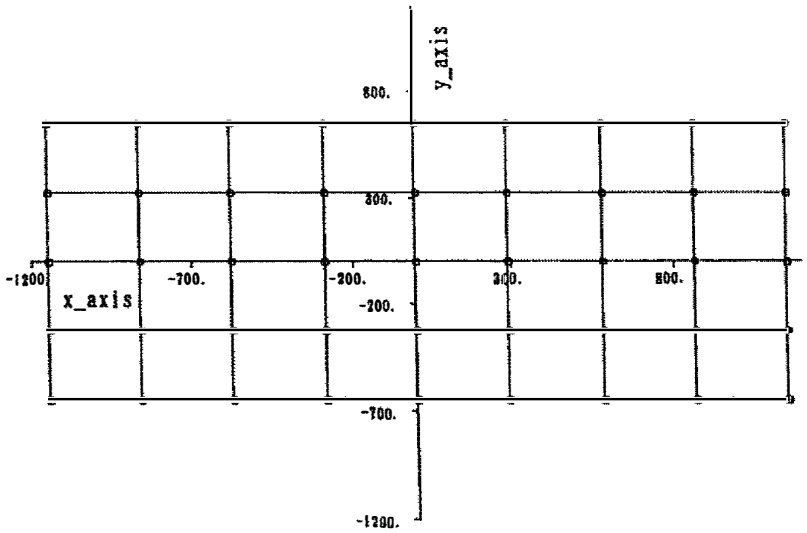
（ａ）


y_axis
x_axis

（ｂ）

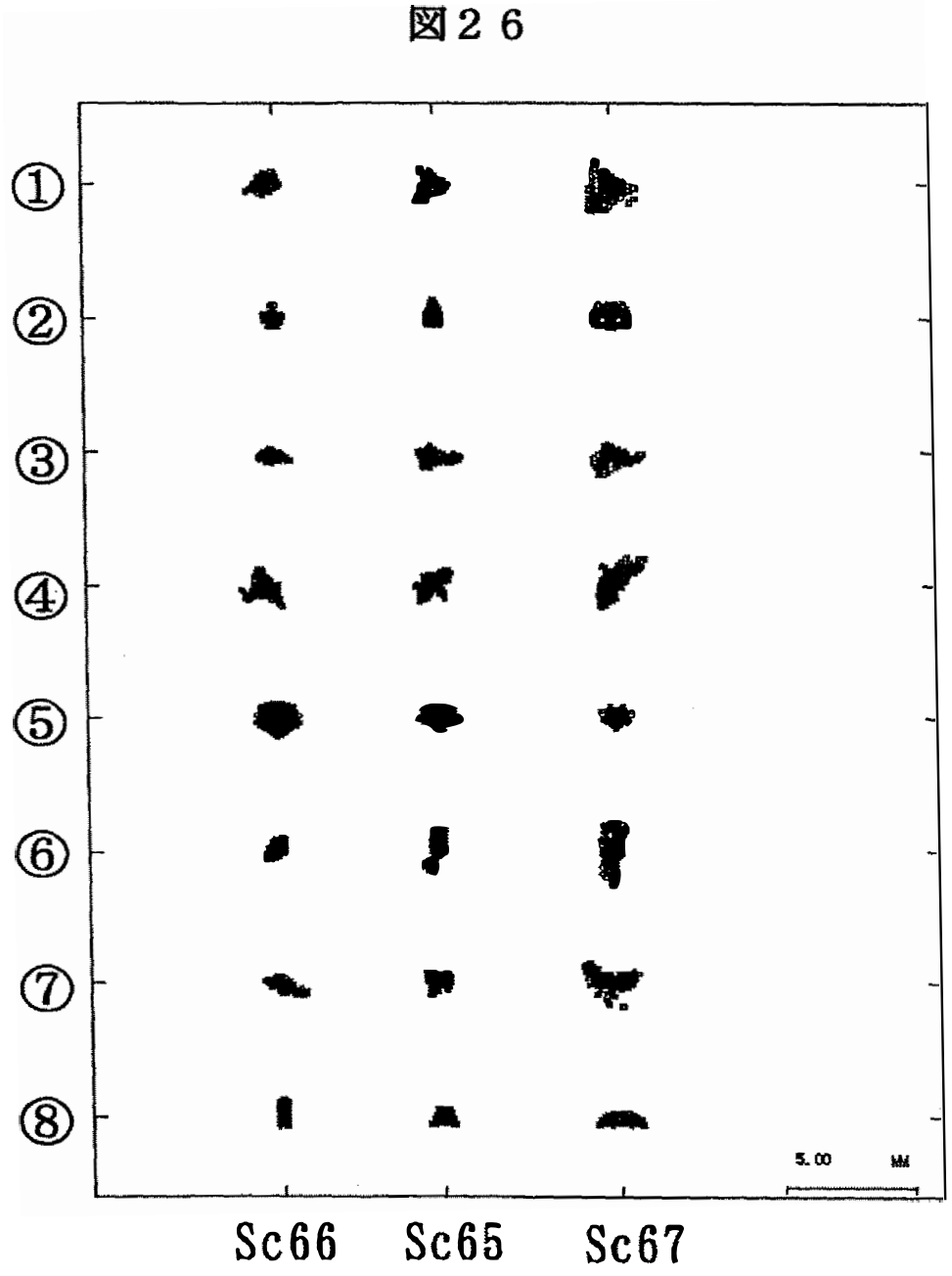

1000.
y_axis
500.
0.
-500.
-1000.
x_axis

（ｃ）


y_axis
800.
400.
-200.
-700.
-1200.
x_axis

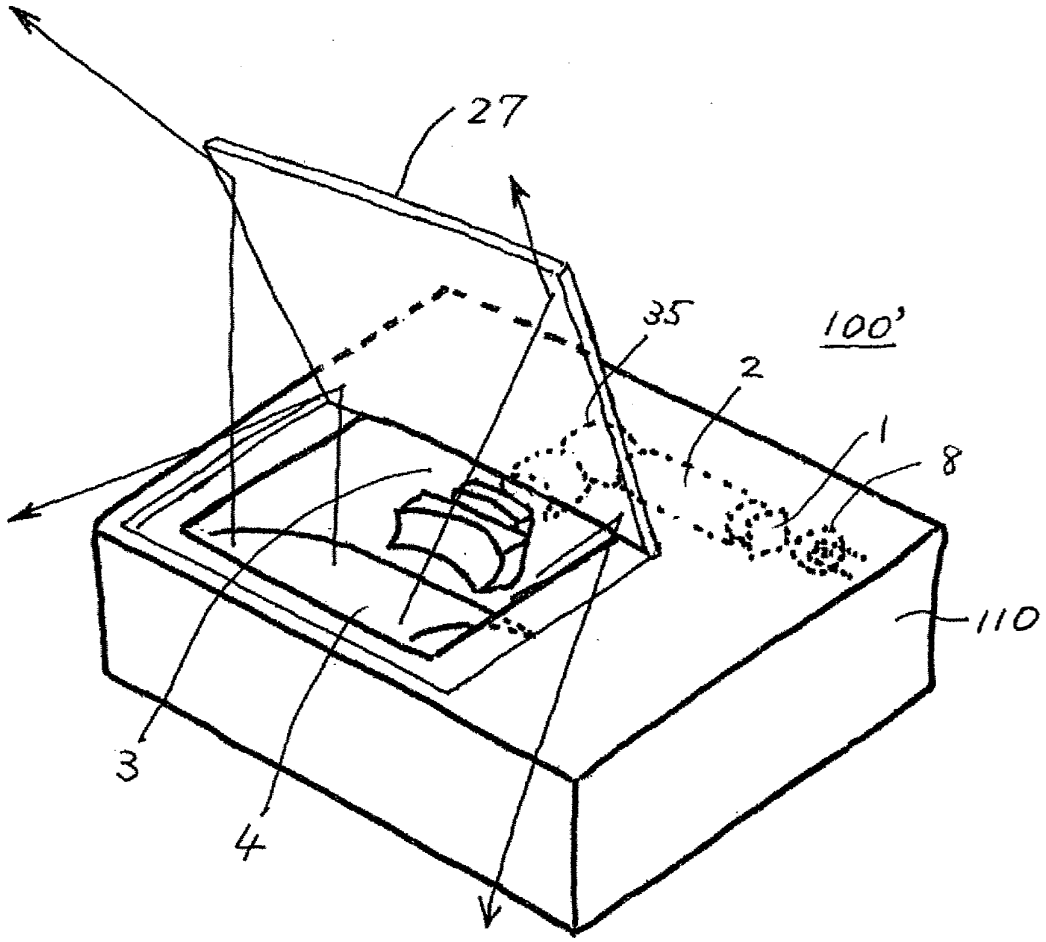
【図２６】

図２６



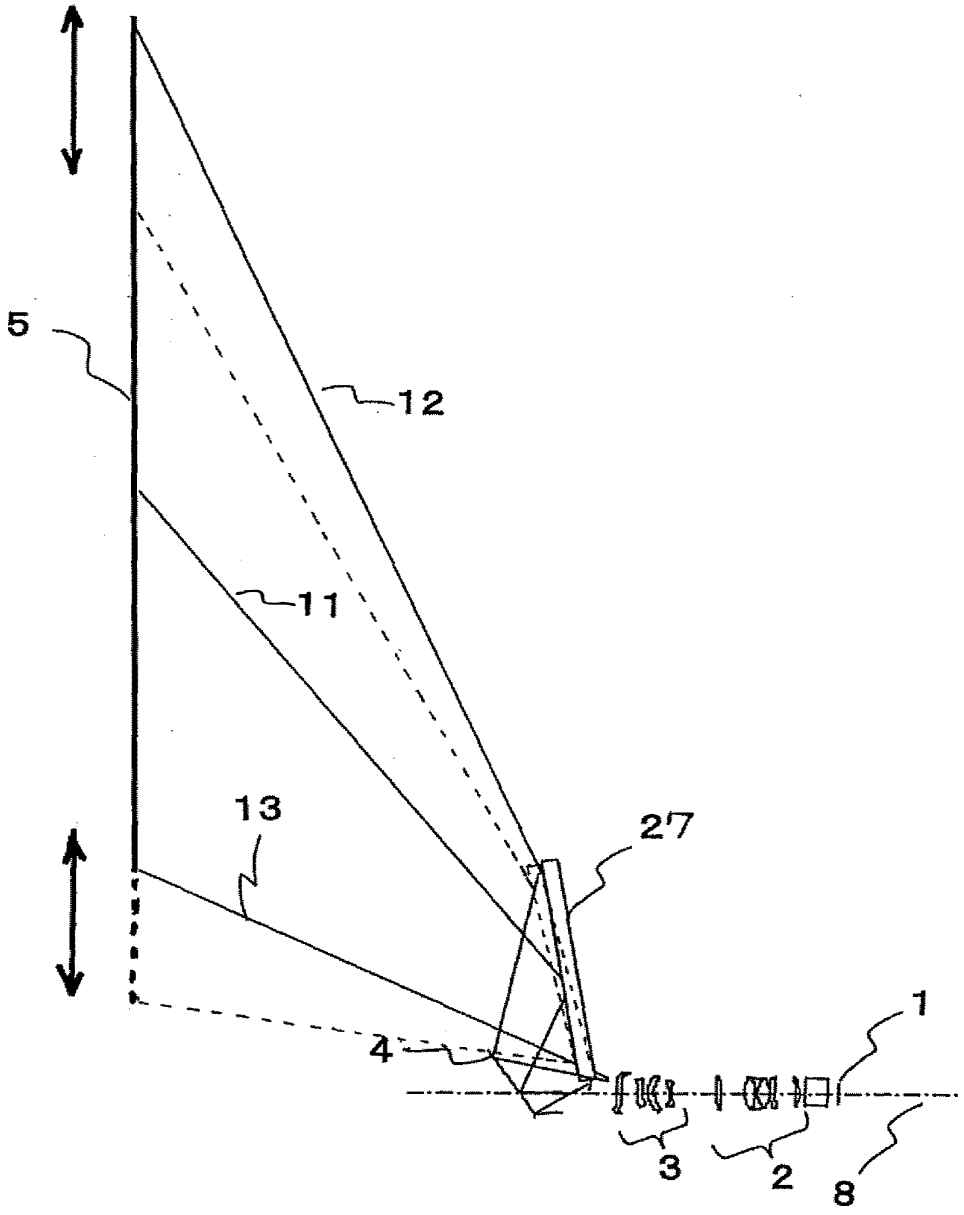
【図２７】

図２７



【図２８】

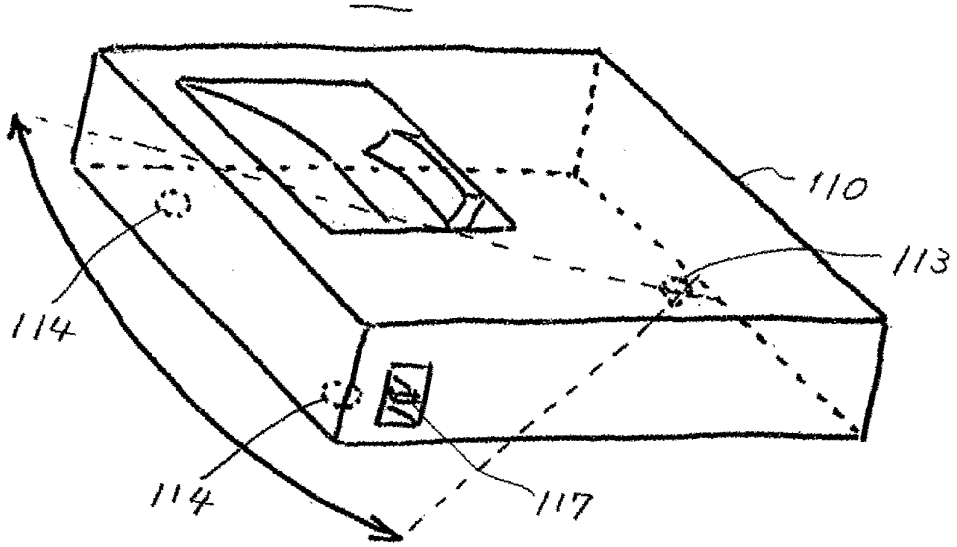
図２８



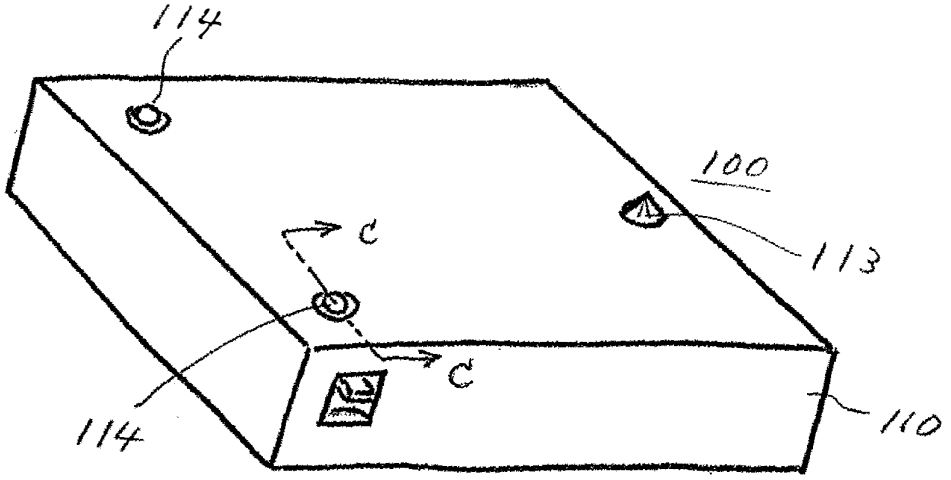
【図２９】

図２９

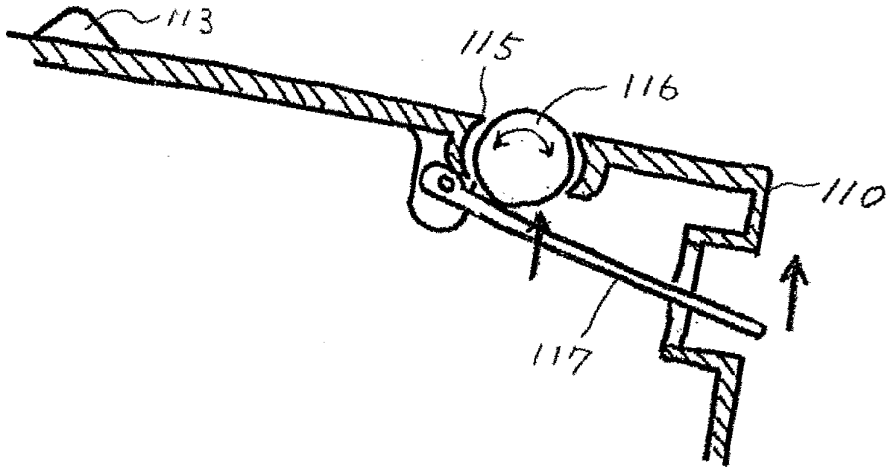
(a)


100
110
113
114
114
117

(b)


114
100
C
113
C
114
110

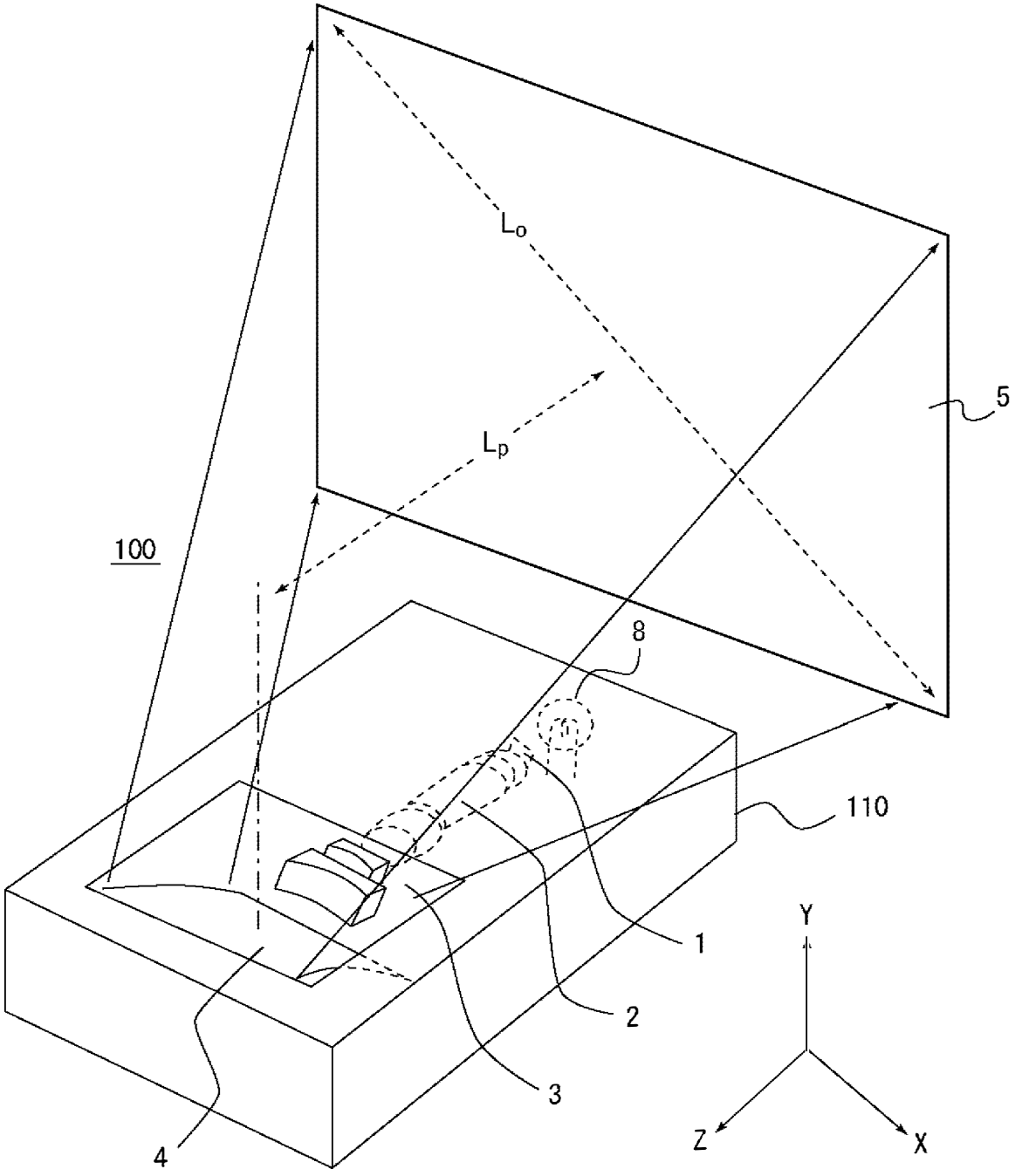
(c)


113
115
116
110
117

【書類名】要約書
【要約】
【課題】　広角角化を可能とし、投写面（スクリーン）までの位置が変更しても歪みを最小限に抑え、かつ、その製造も容易な投写型映像表示装置を提供する。
【解決手段】　映像表示素子１に表示された映像を拡大して投写面に投写する投写型映像表示装置、複数の投写用レンズを含んで構成されるレンズ光学系２、３と、レンズ光学系からの出射光を反射してスクリーン５上に傾斜して投写する反射系を構成する反射ミラー５とを備えており、レンズ光学系を構成する後方レンズ群３は回転非対称の自由曲面の形状を有する複数のレンズ３１、３２を備えており、かつ、反射ミラー５は、その一部が反射方向に凸形状の回転非対称の凸面反射ミラーから構成された投写光学ユニットを備えている。
【選択図】　図１

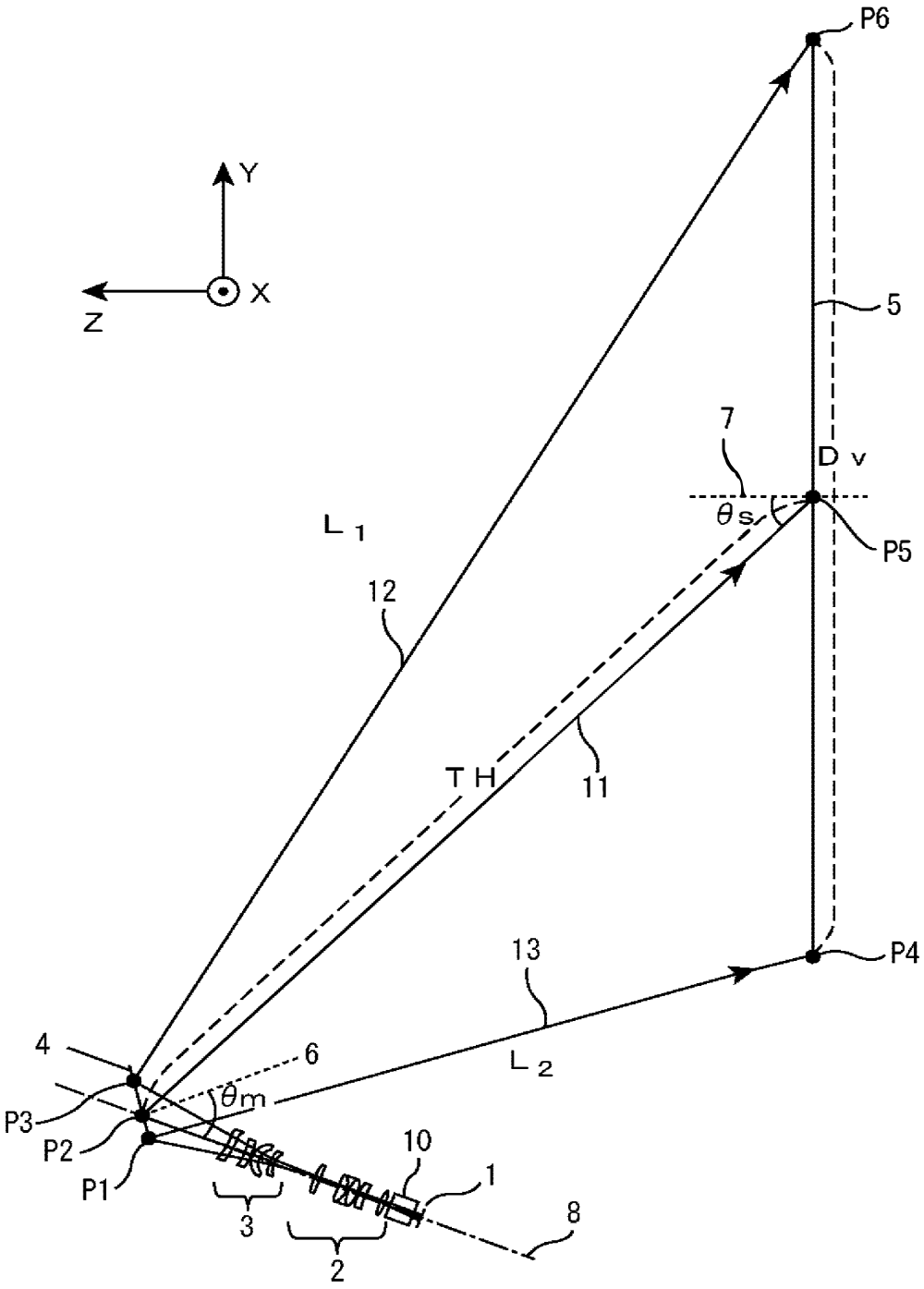
【書類名】　手続補正書
【整理番号】　NT06P0160
【提出日】　平成18年 7月 6日
【あて先】　特許庁長官　殿
【事件の表示】
　【出願番号】　特願2006-166434
【補正をする者】
　【識別番号】　000005108
　【氏名又は名称】　株式会社日立製作所
【代理人】
　【識別番号】　110000350
　【氏名又は名称】　特許業務法人　日東国際特許事務所
　【代表者】　作田　康夫
　【電話番号】　03-3537-1621
【手続補正1】
　【補正対象書類名】　図面
　【補正対象項目名】　全図
　【補正方法】　変更
　【補正の内容】
　　【書類名】図面
　　【図１】

図　1



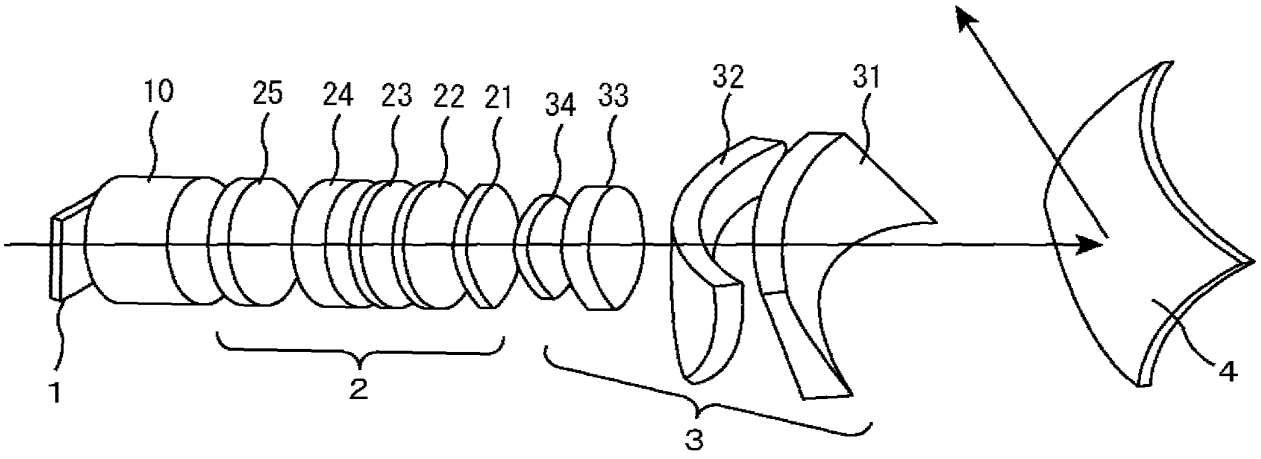
【図２】

図　2



【図３】

図　３



【図４】

図　4

【図５】

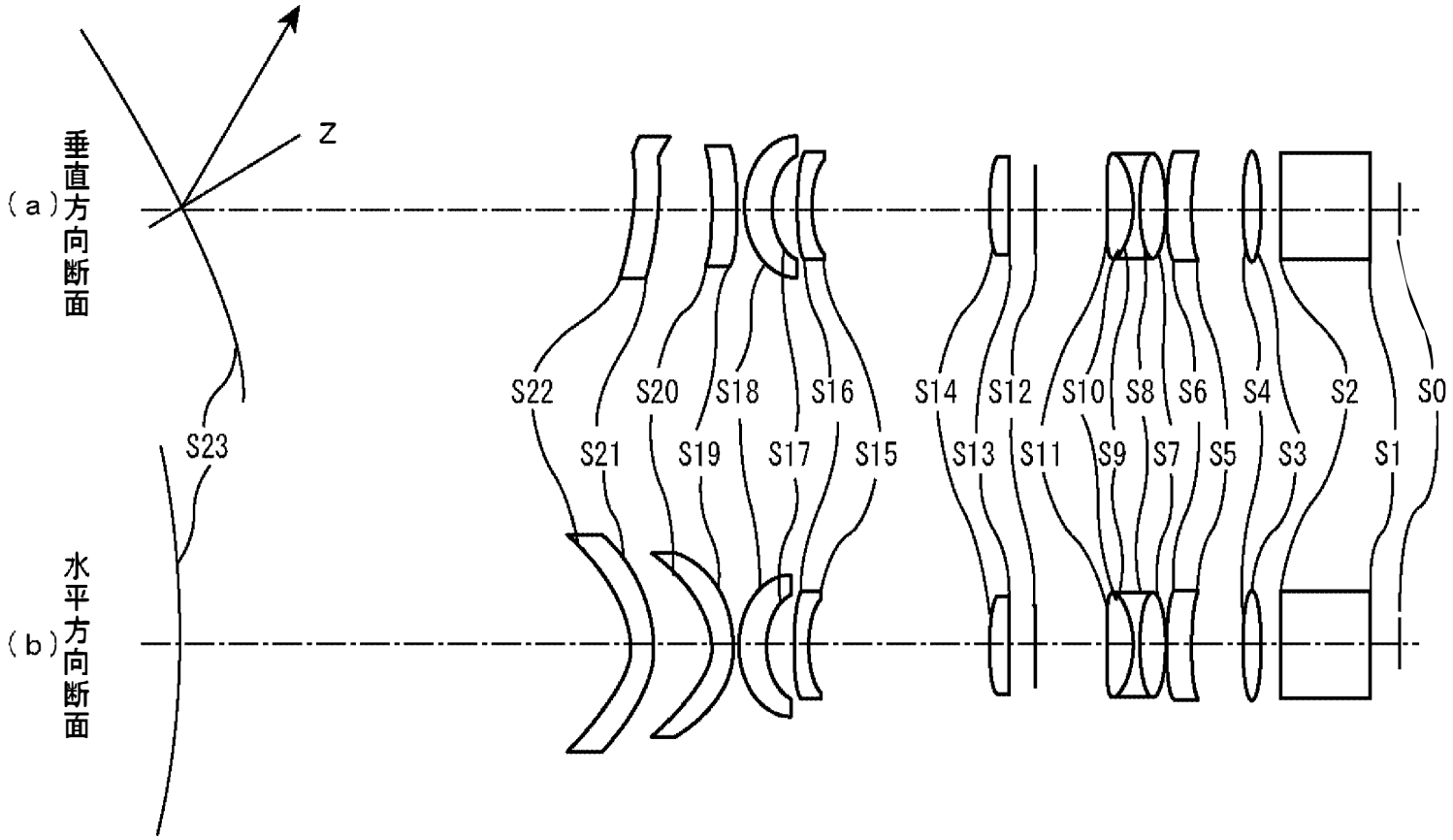
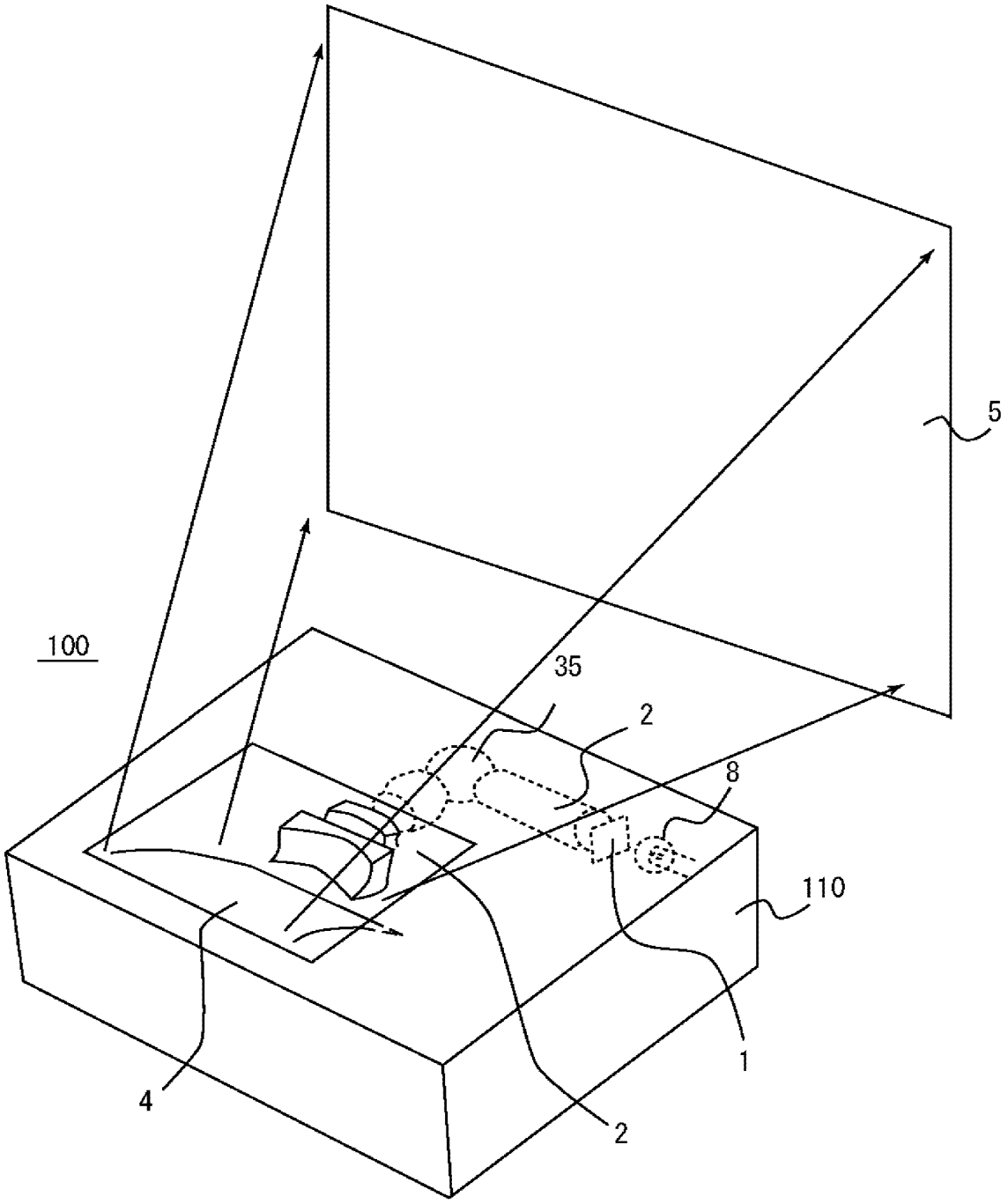

（ａ）垂直方向断面
（ｂ）水平方向断面
Z
S0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
S21
S22
S23

図　5



【図６】

図 6

【図７】

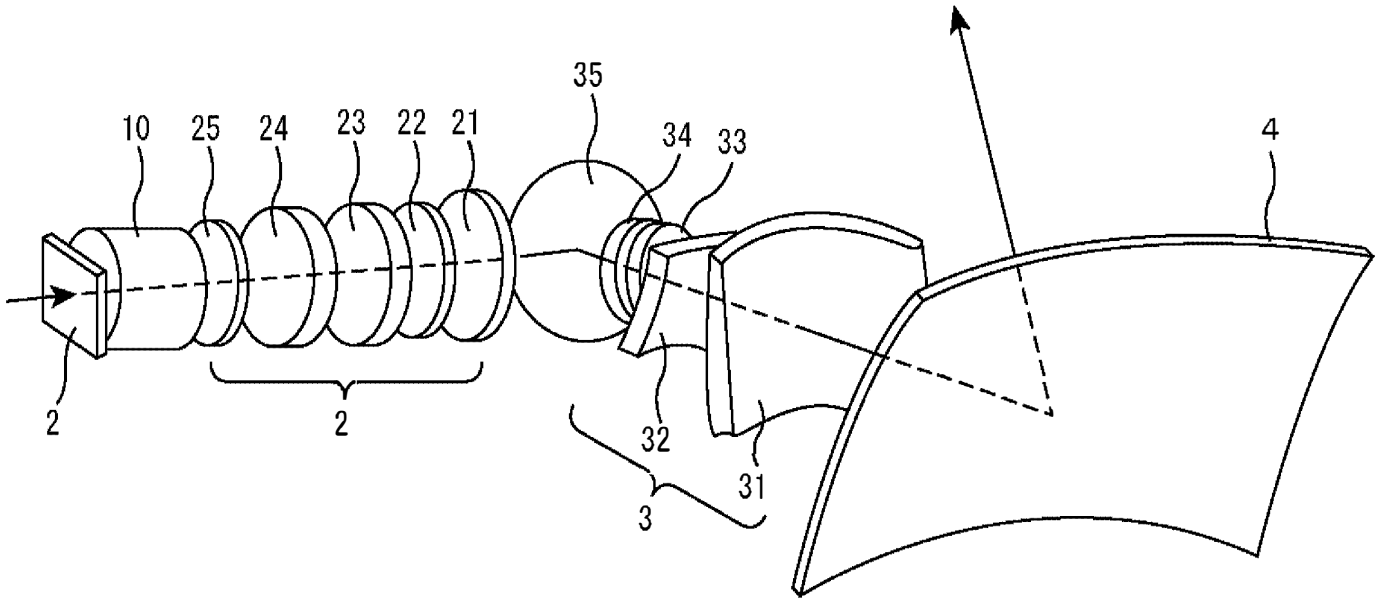


図　7

【図８】

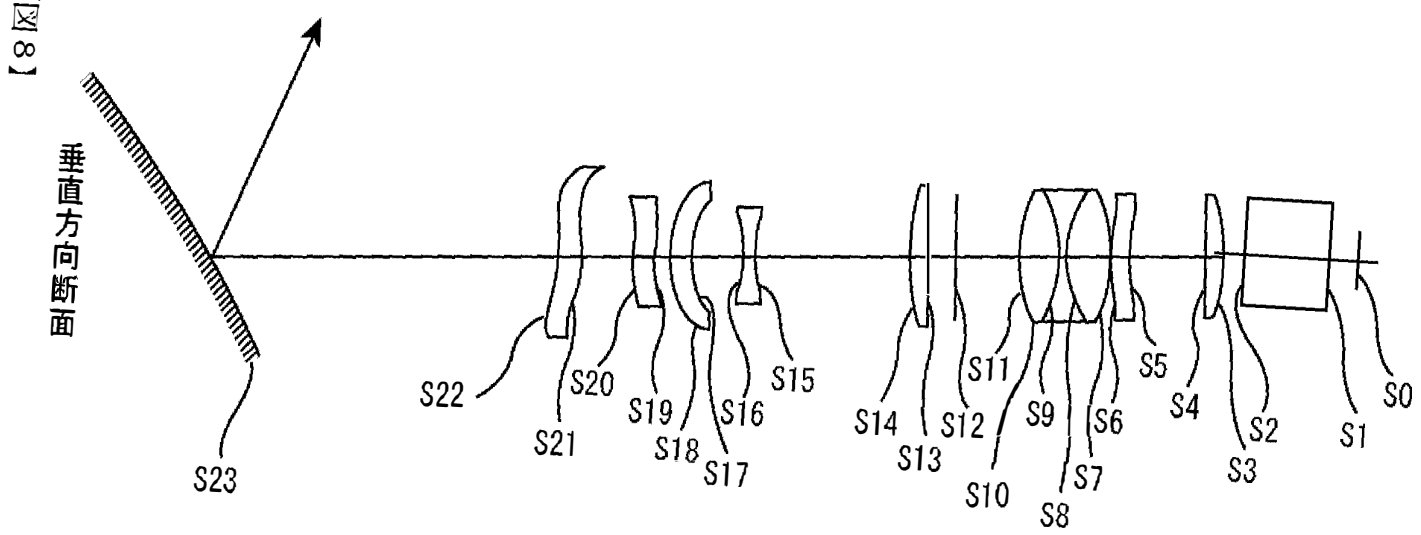
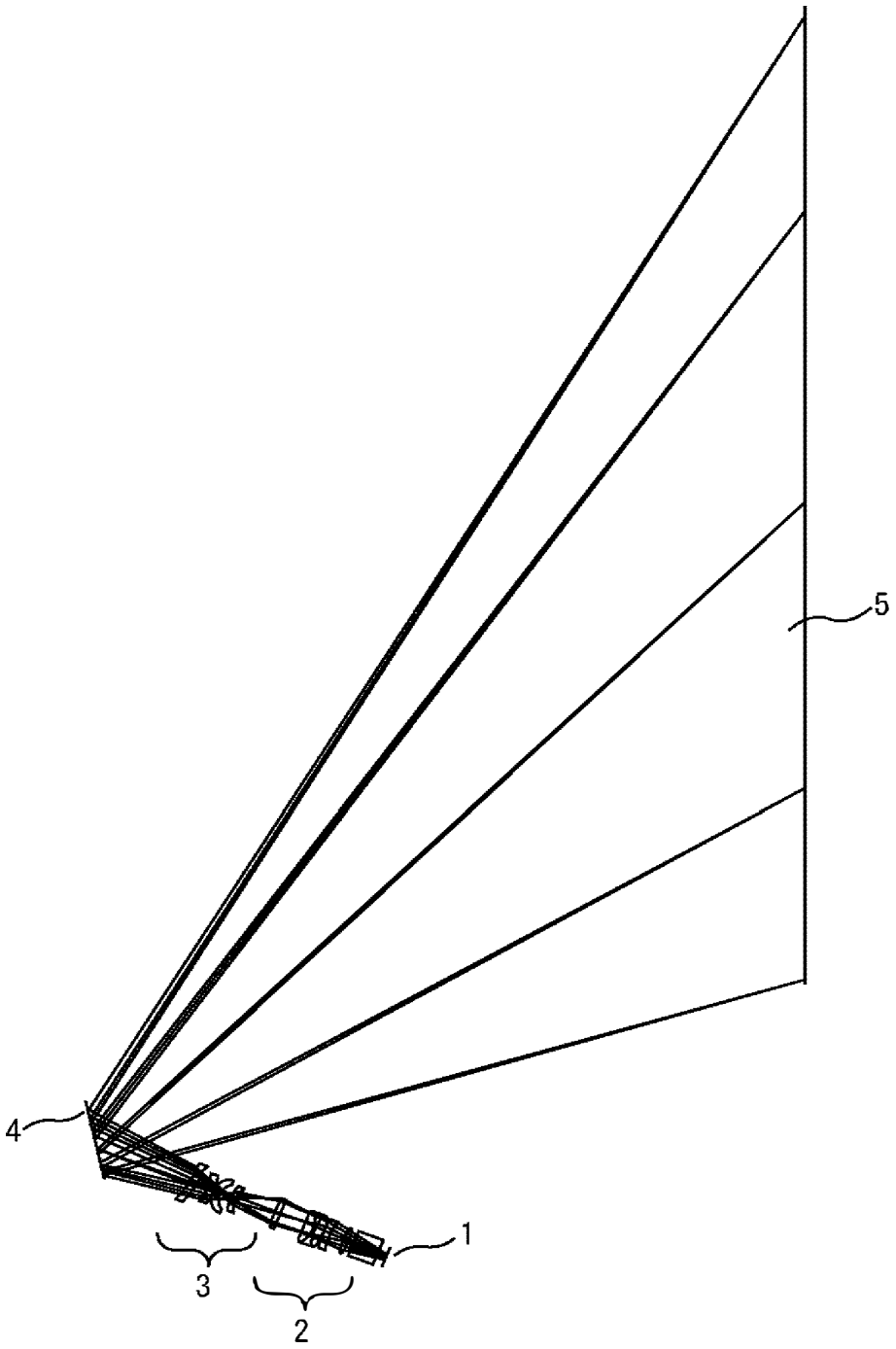
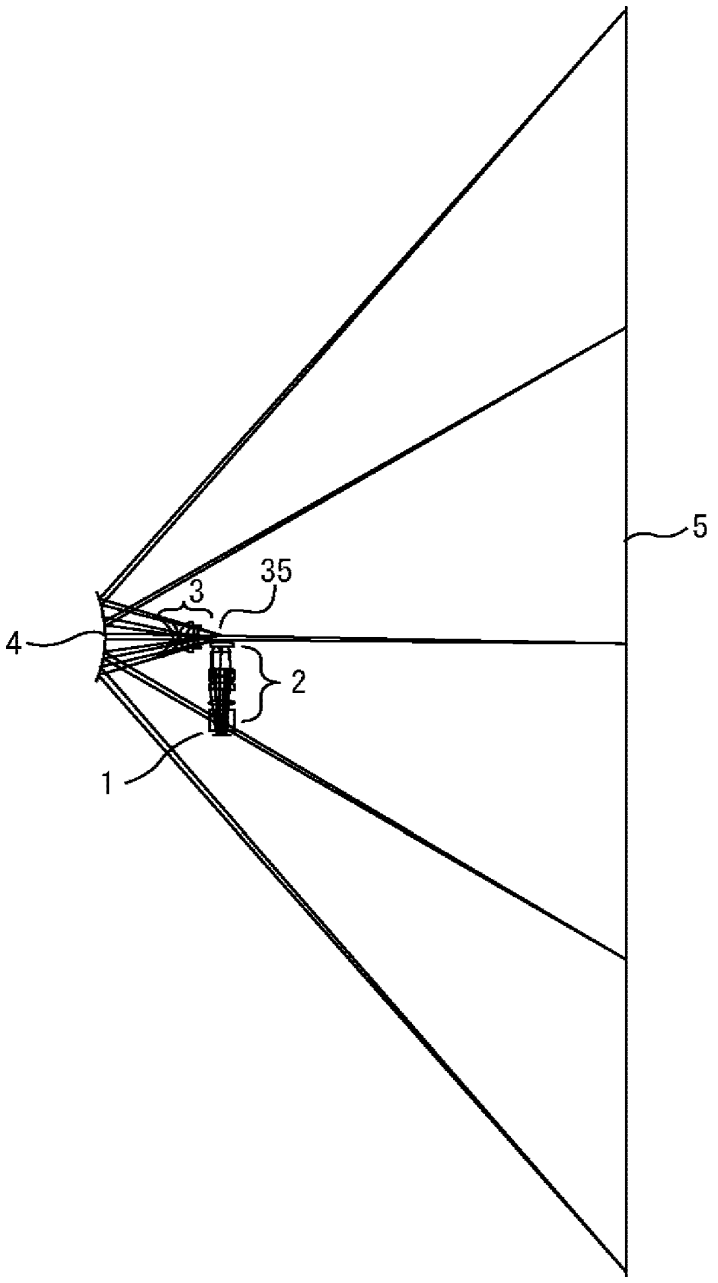

垂直方向断面
S23
S22
S21
S20
S19
S18
S17
S16
S15
S14
S13
S12
S11
S10
S9
S8
S7
S6
S5
S4
S3
S2
S1
S0

図　８



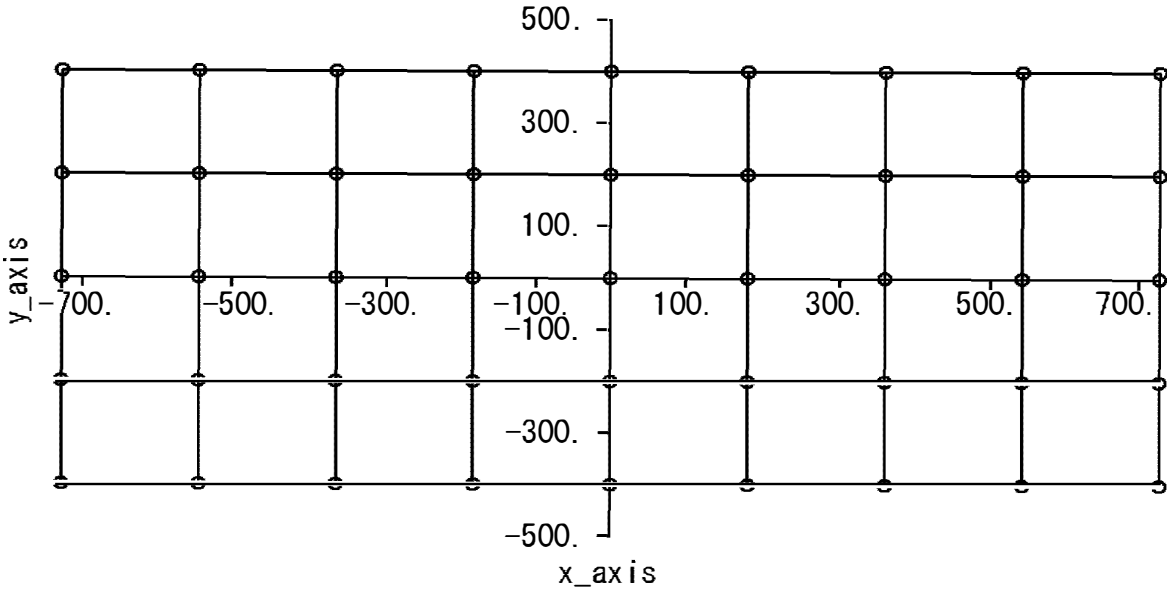
【図９】

図　９



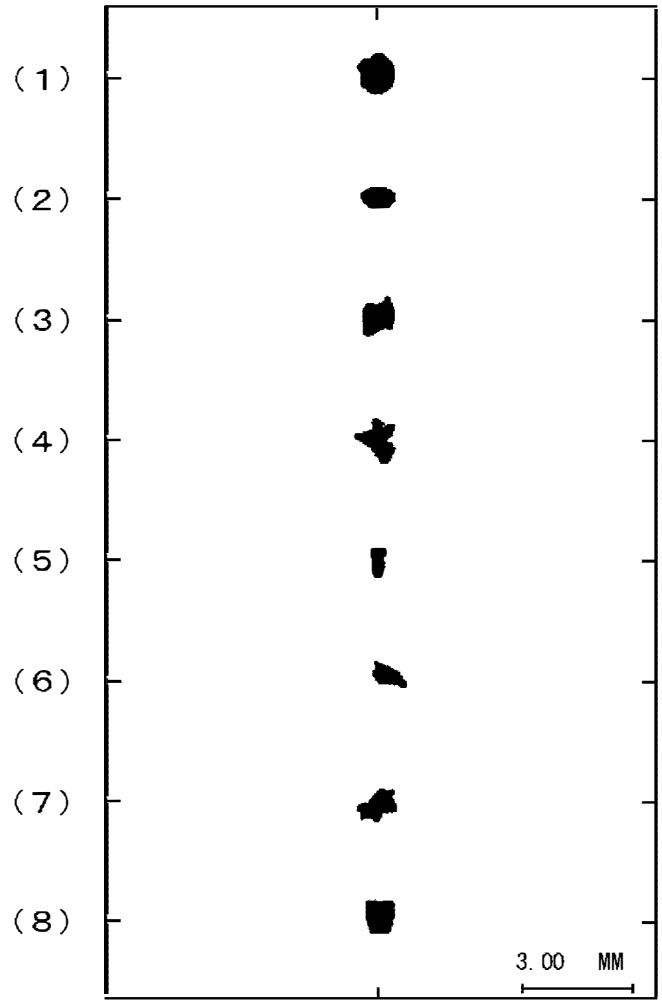
【図１０】

図　１０


500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
y_axis
x_axis

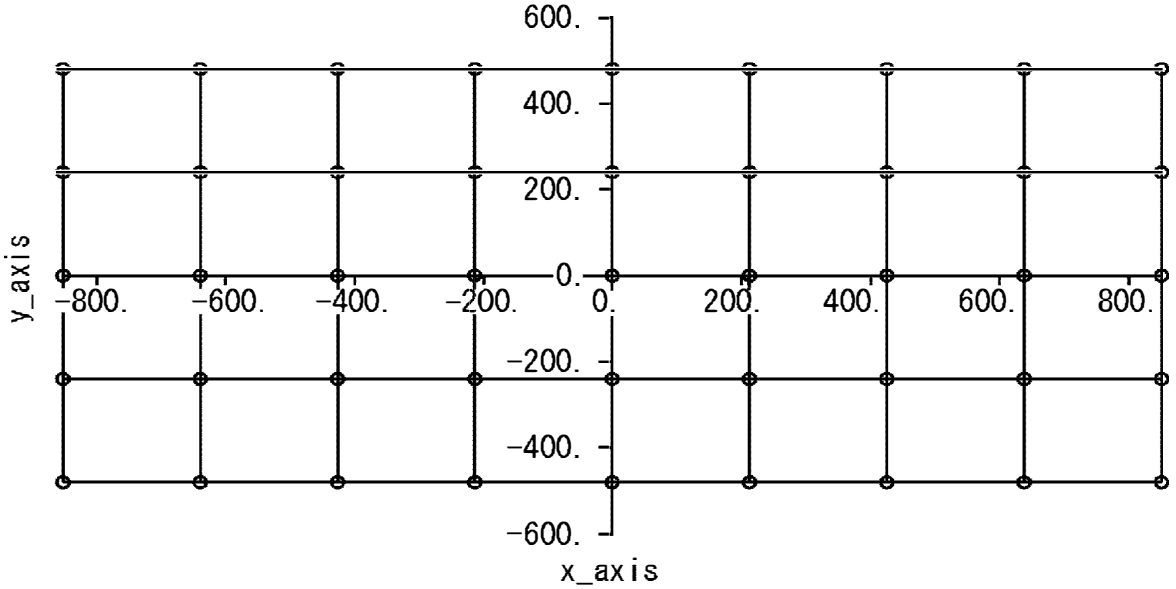
【図１１】

図　１１


(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
3.00 MM

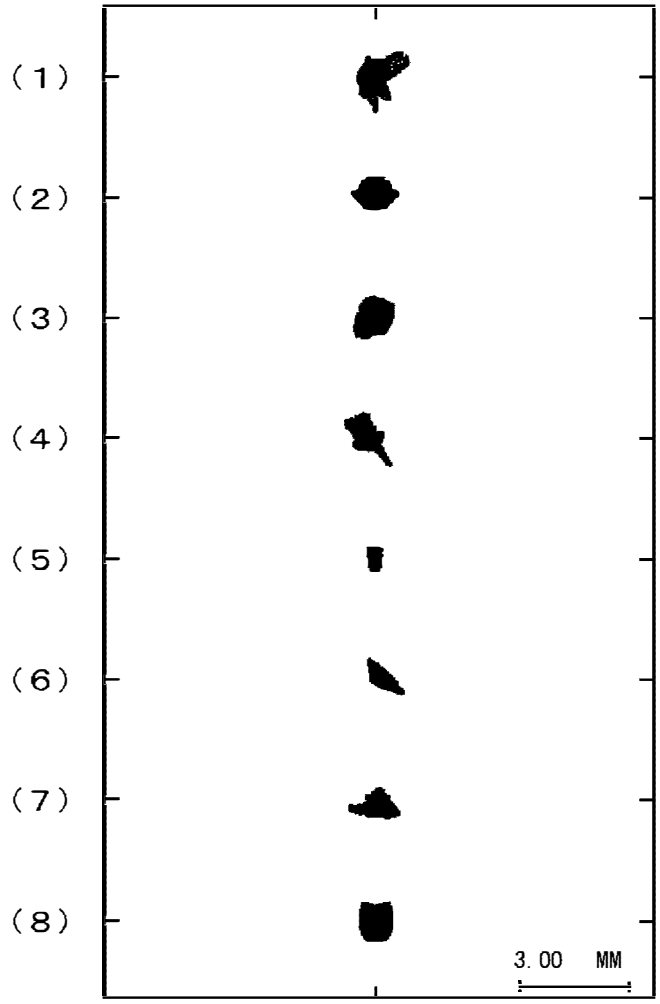
【図１２】

図　１２


600.
400.
200.
0.
-200.
-400.
-600.
-800.
-600.
-400.
-200.
0.
200.
400.
600.
800.
y_axis
x_axis

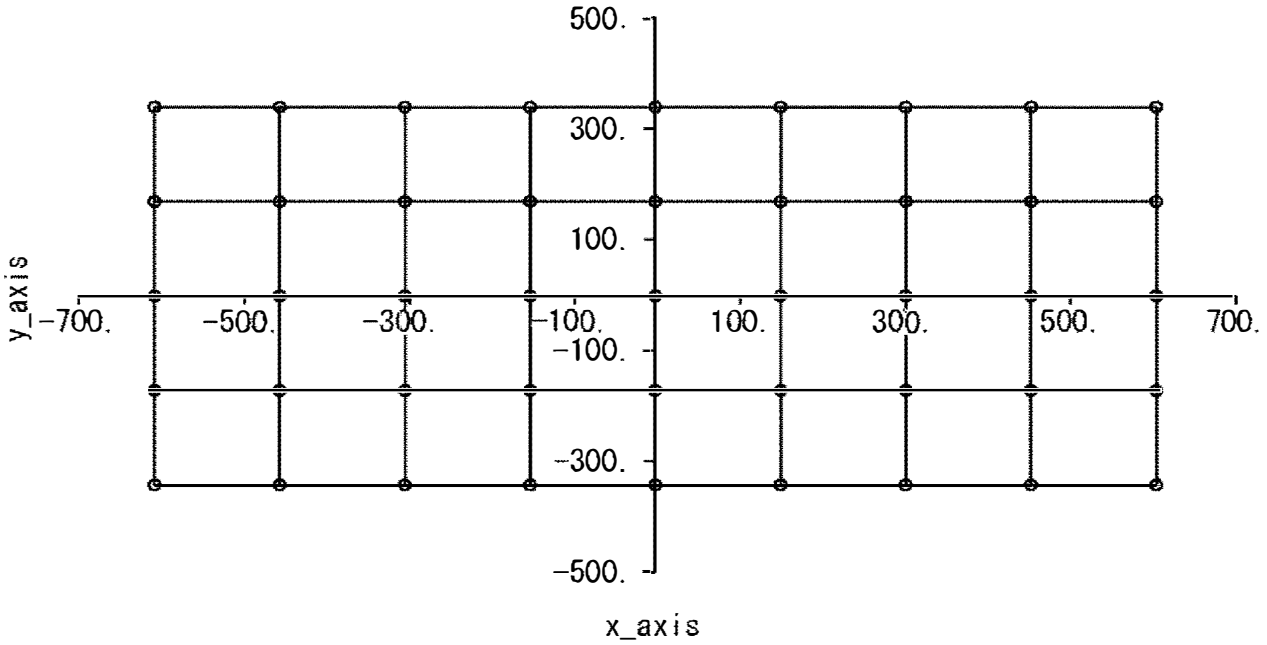
【図１３】

図　１３



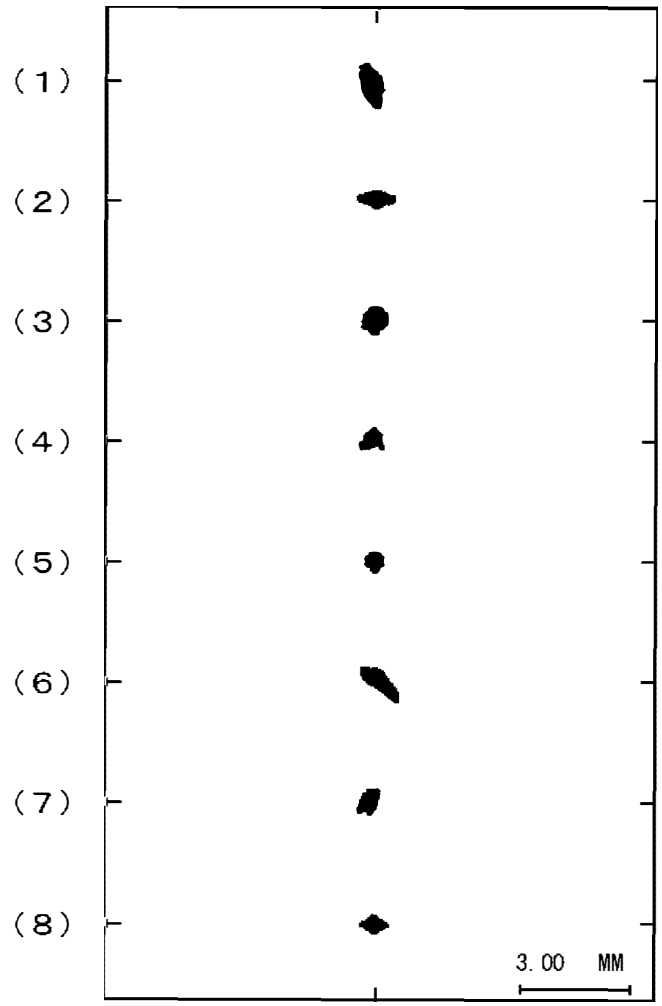
【図１４】

図　１４


500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
y_axis
x_axis

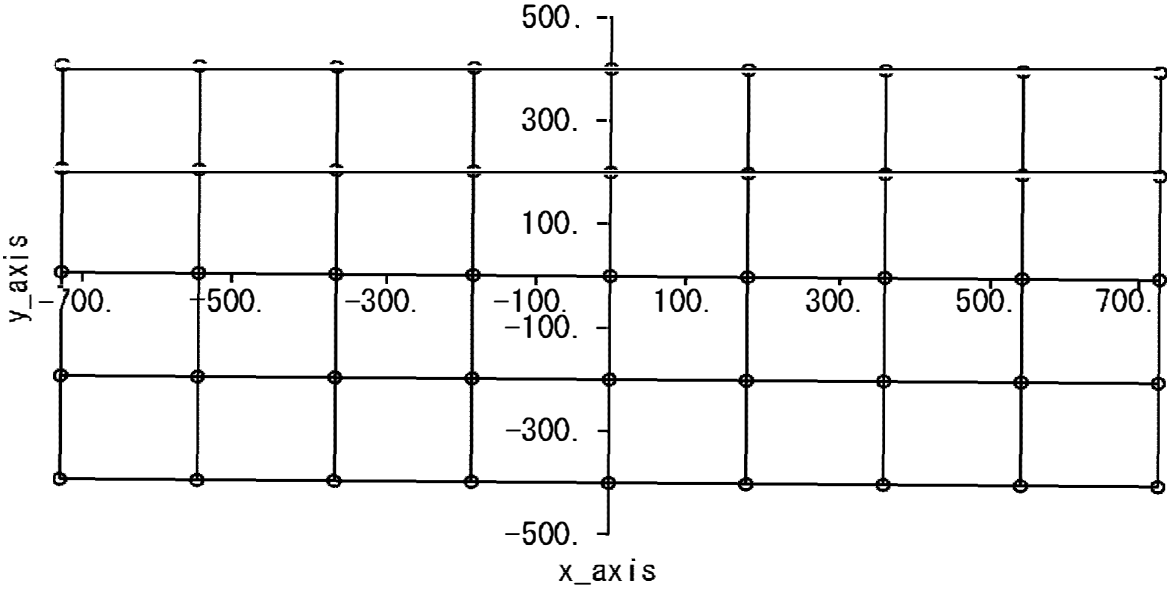
【図１５】

図　１５


(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
3.00 MM

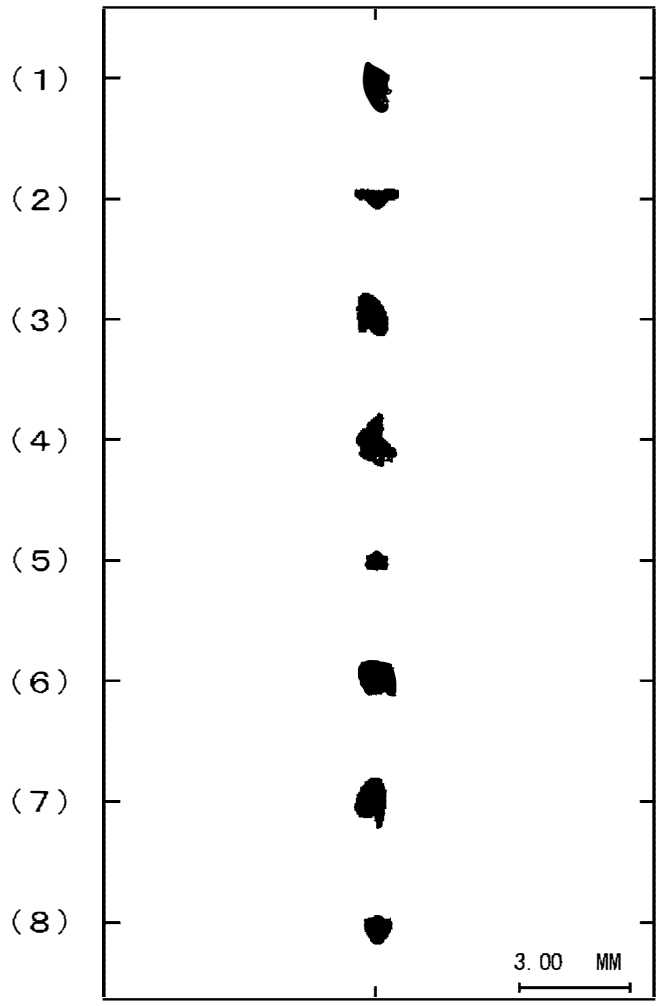
【図１６】

図　１６


500.
300.
100.
-100.
-300.
-500.
-700.
-500.
-300.
-100.
100.
300.
500.
700.
y_axis
x_axis

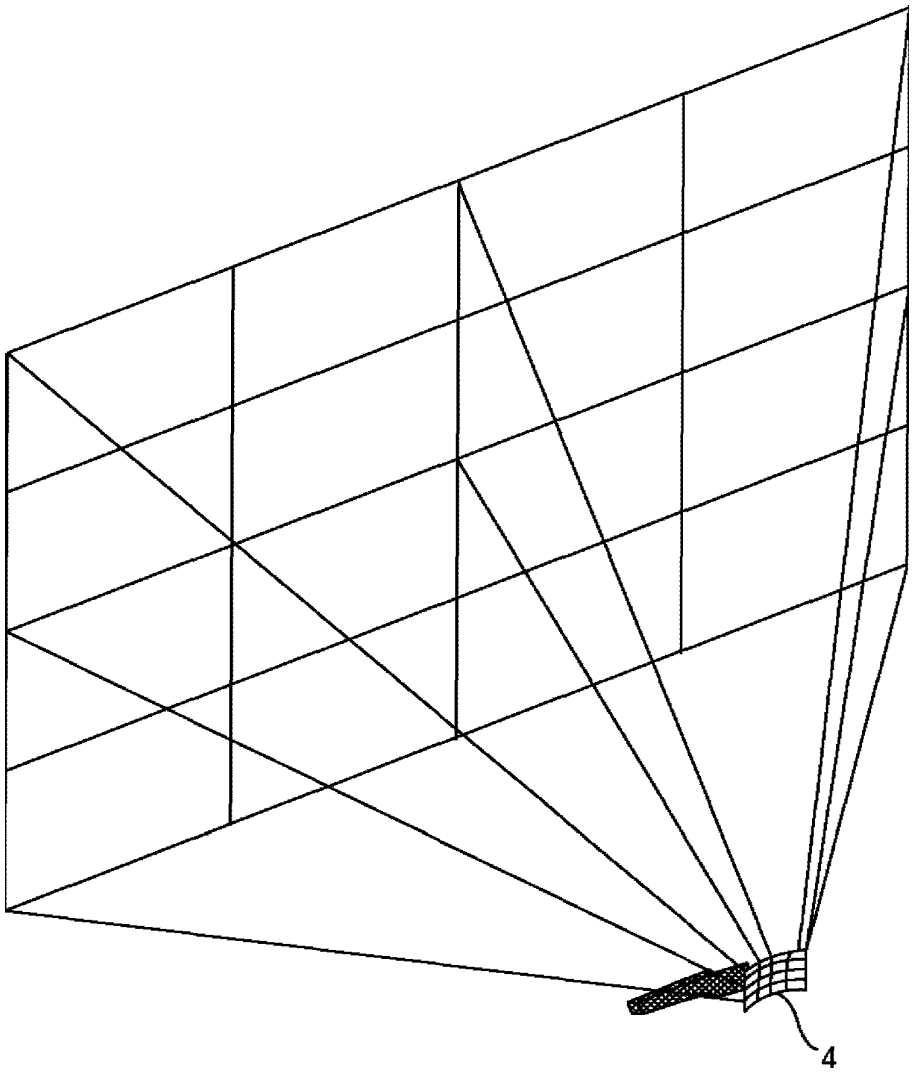
【図１７】

図　１７



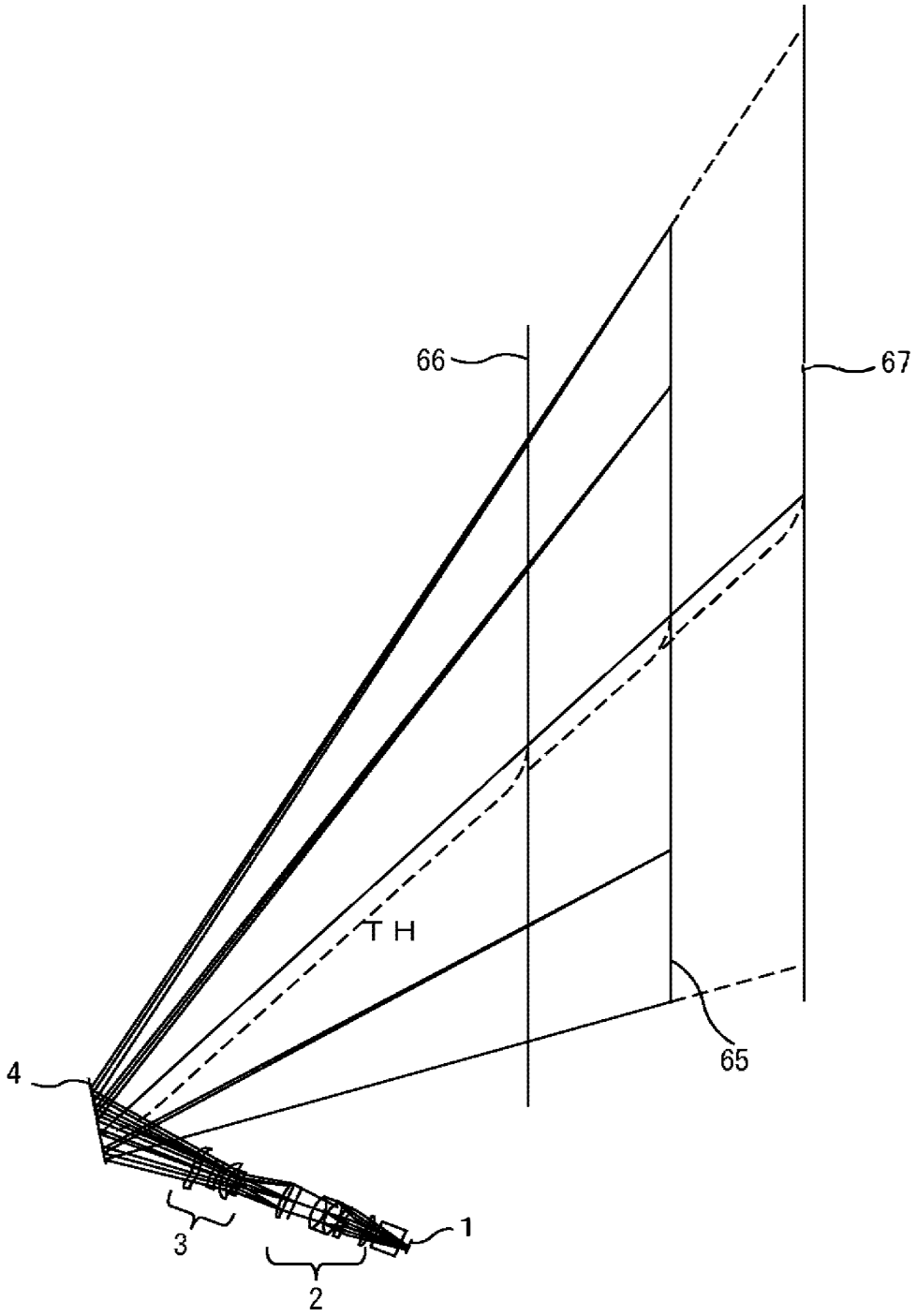
【図１８】

図　１８



【図１９】

図　１９



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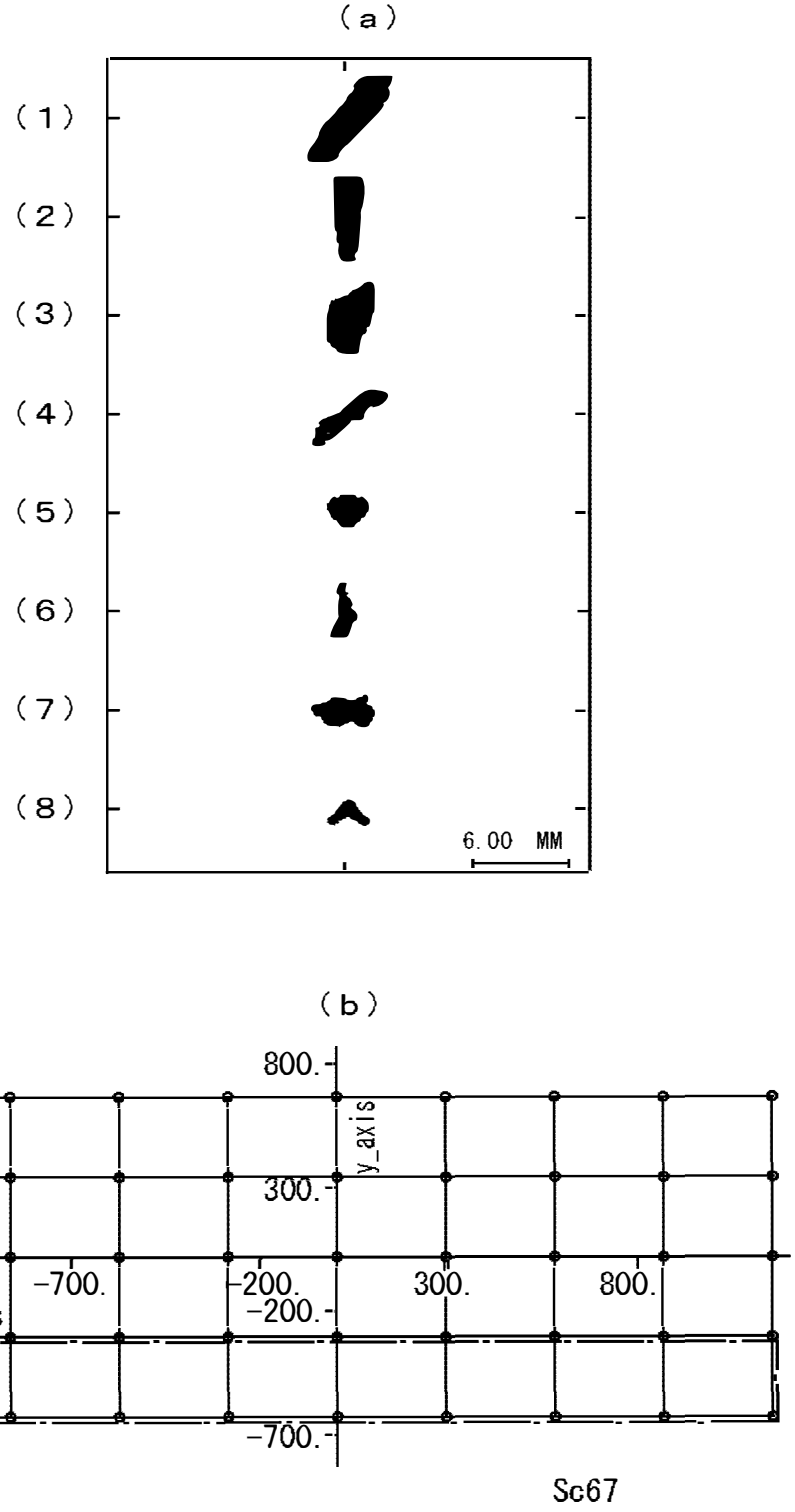
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（8）
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-1200.
-700.
-200.
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x_axis
-200.
-700.
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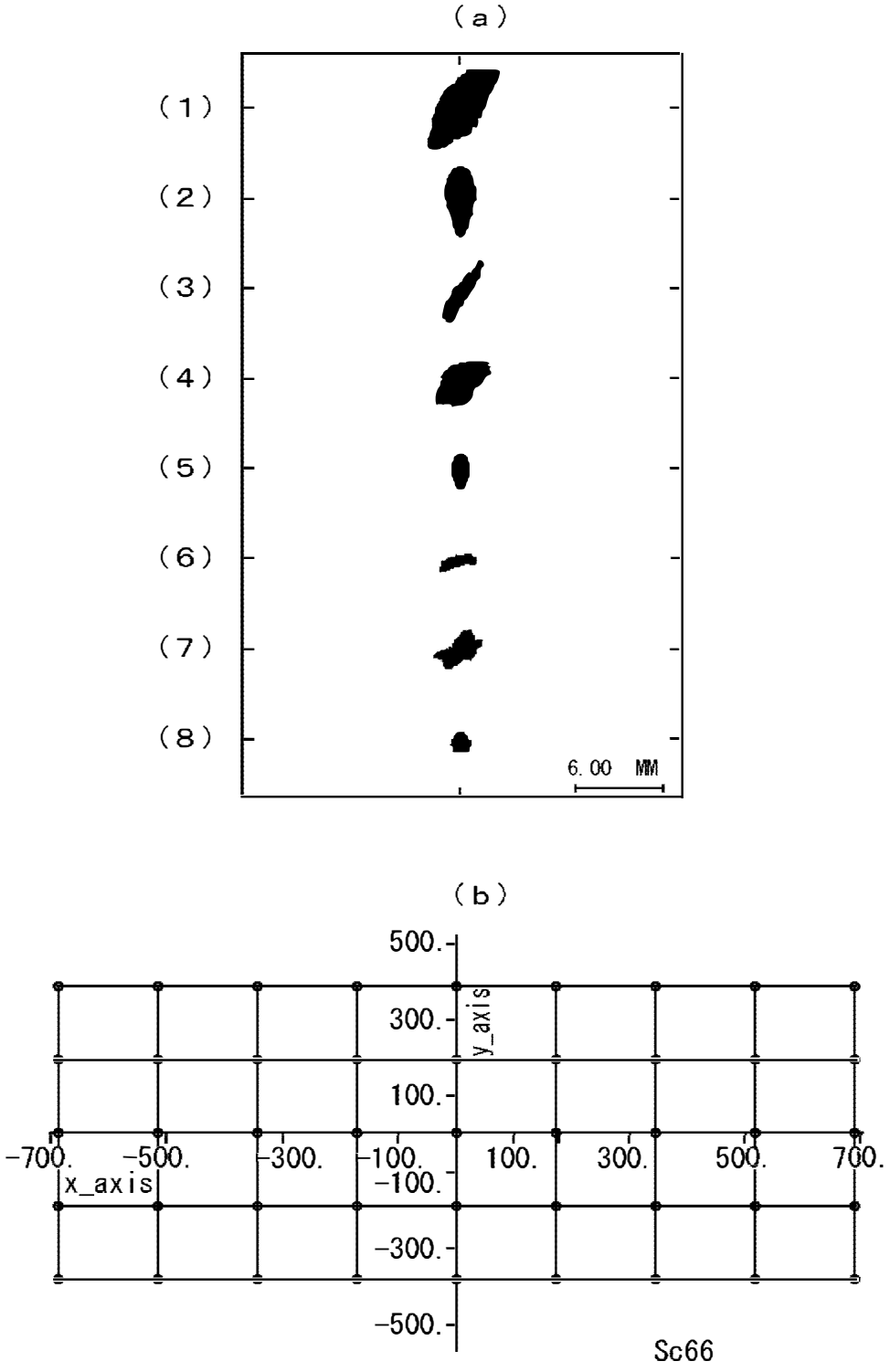
図　２１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【図２２】

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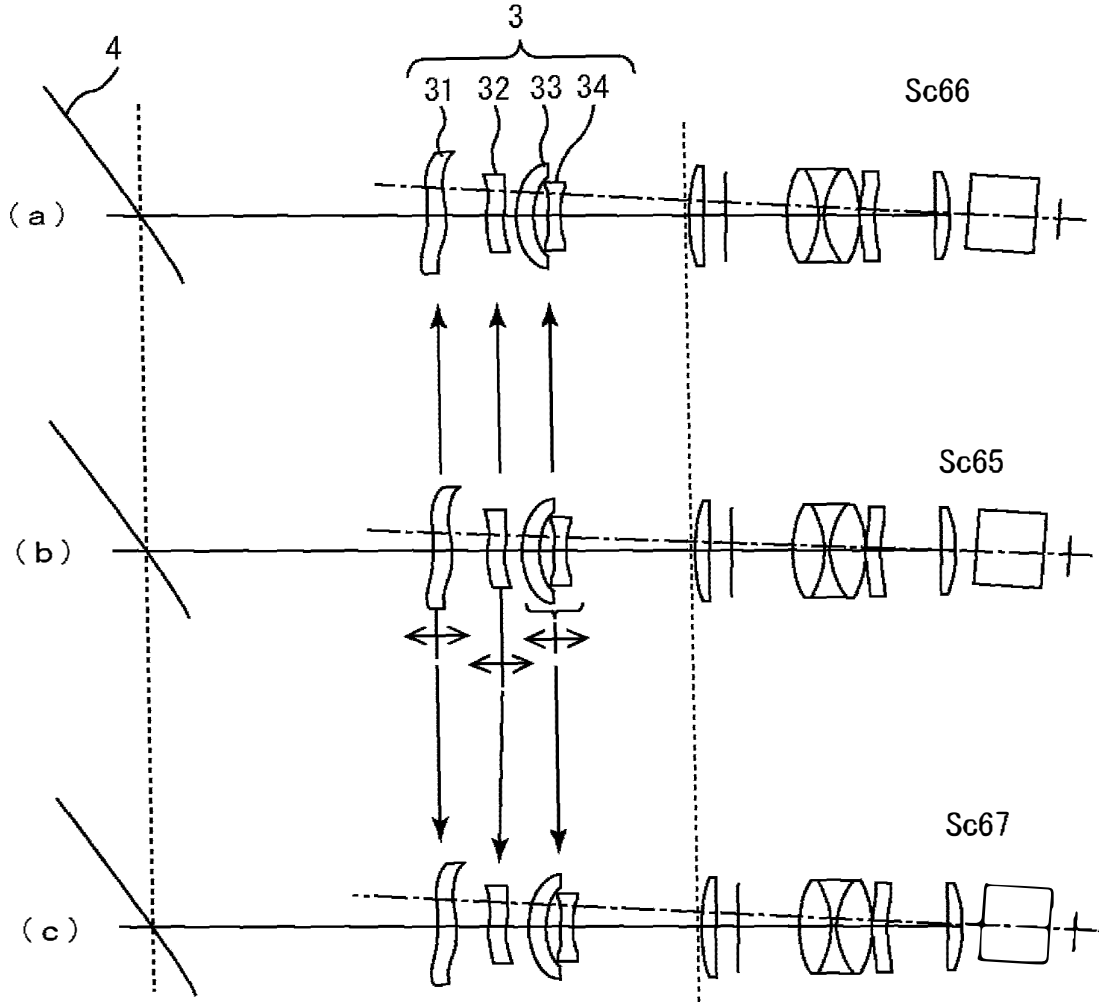

【図２３】

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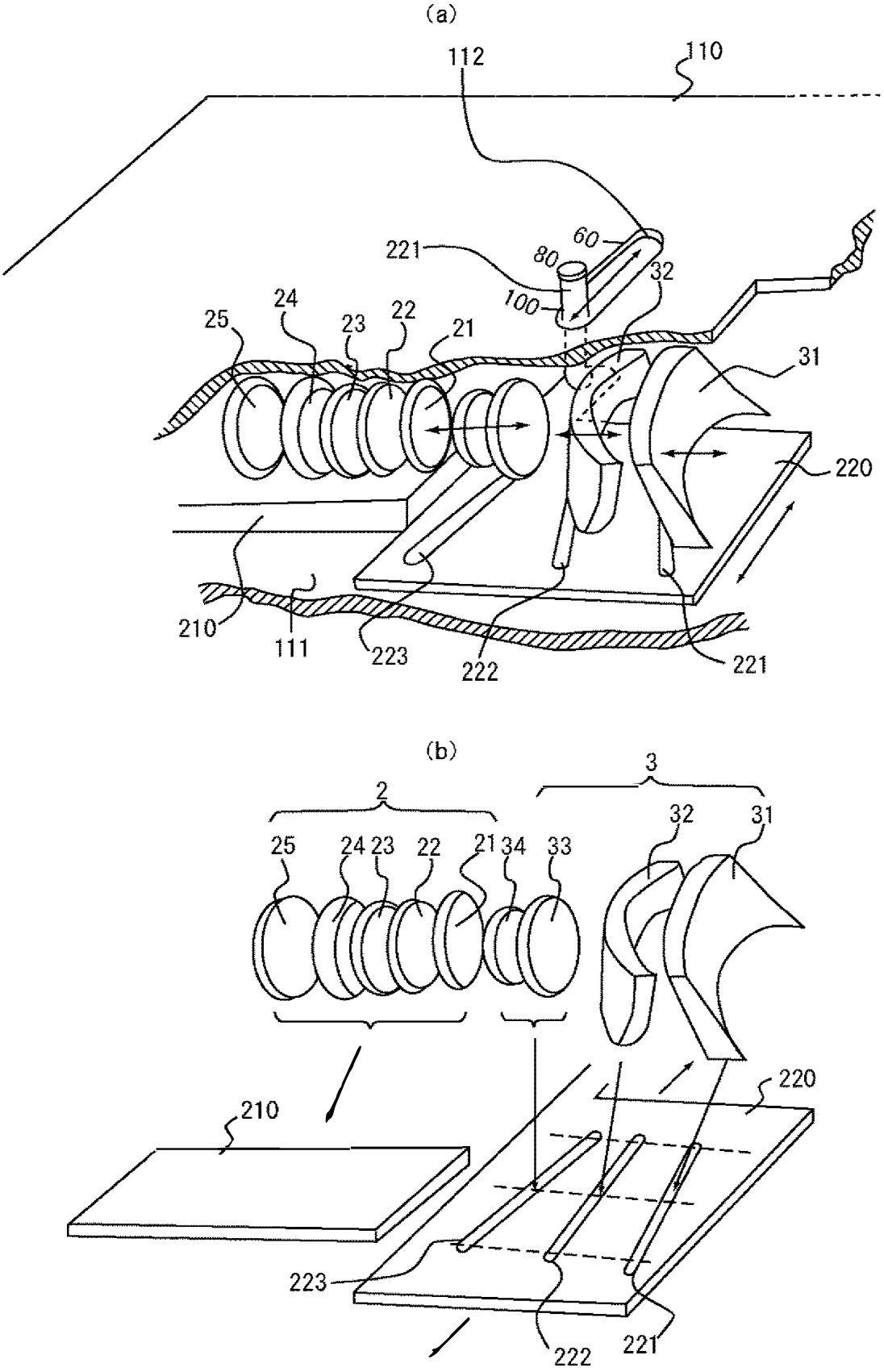
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【図２４】

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【図２５】

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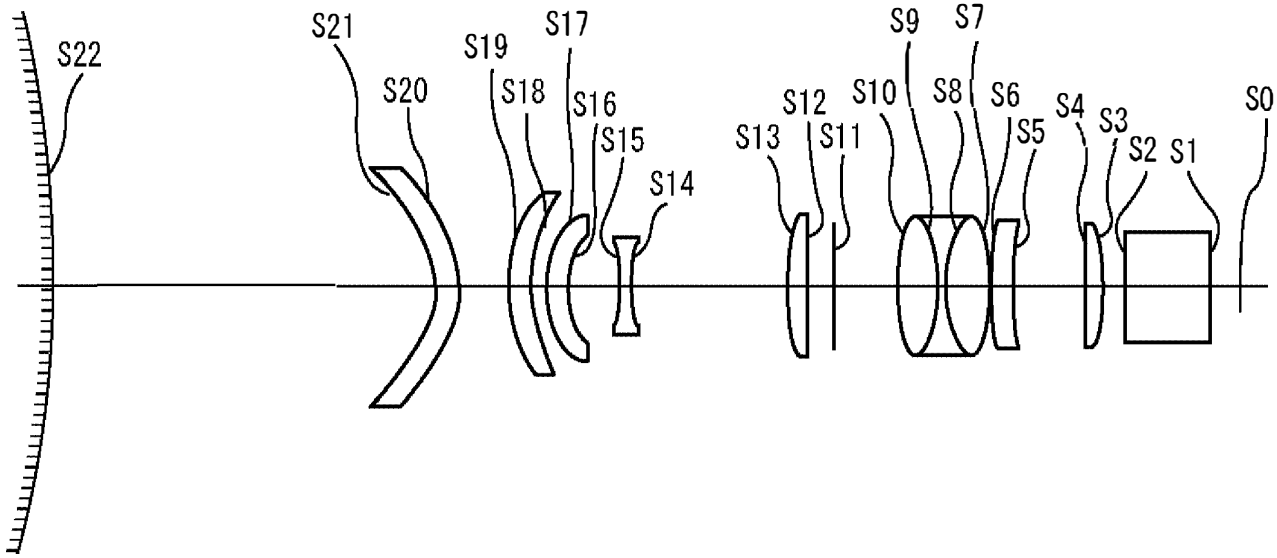

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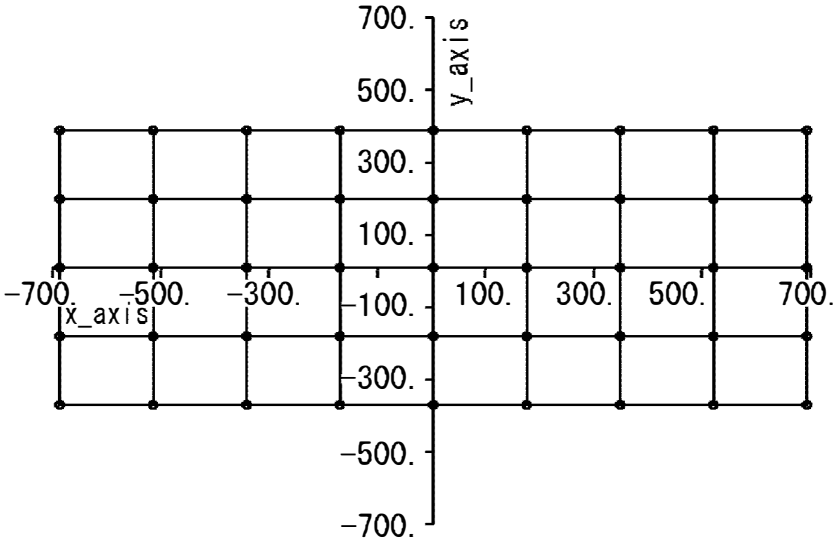
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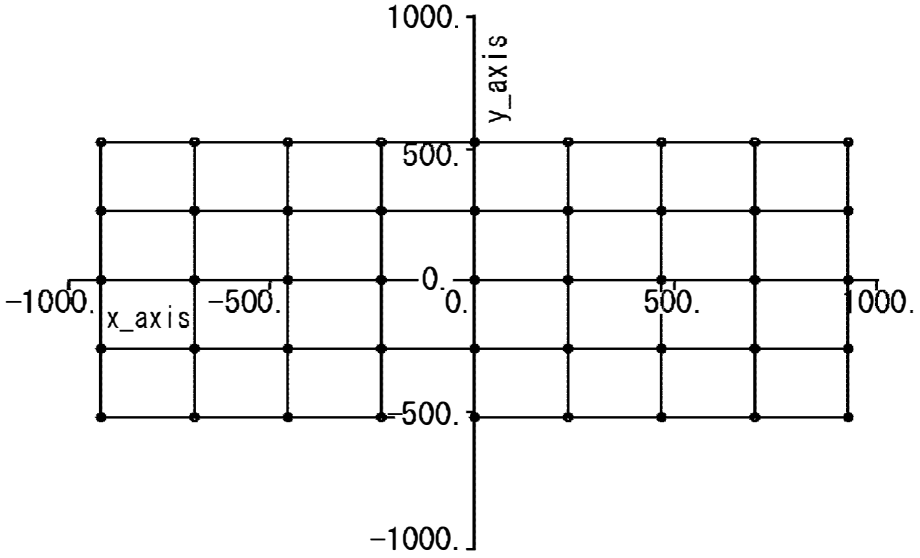
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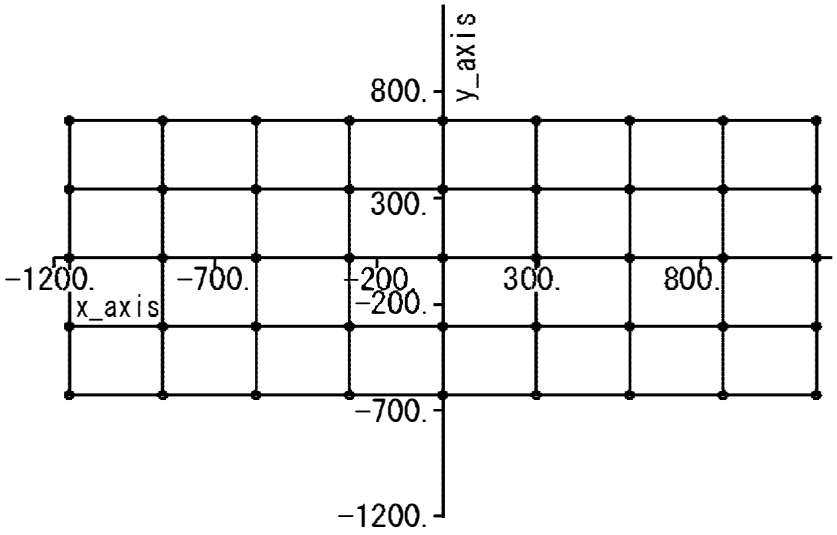
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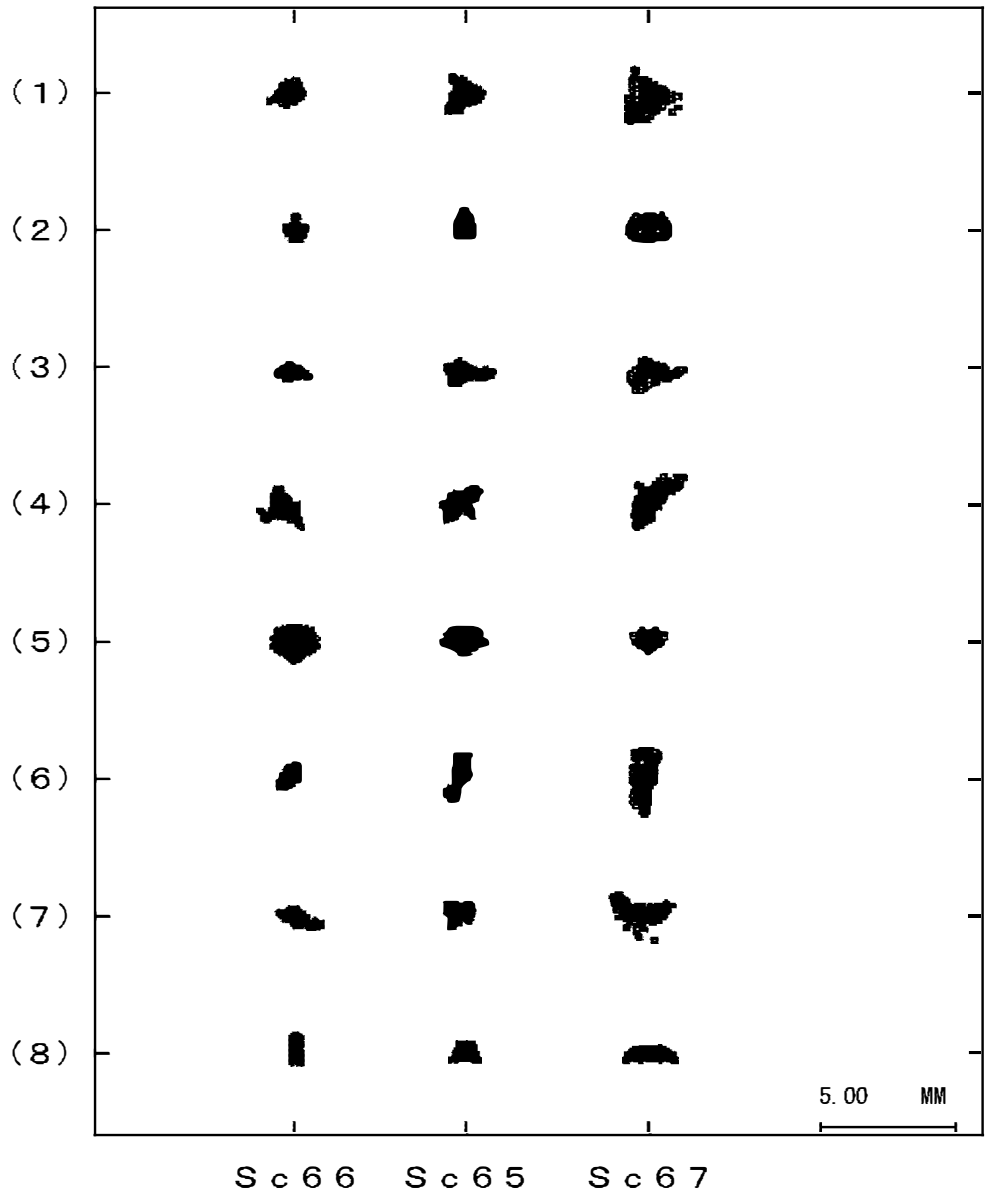

【図２７】

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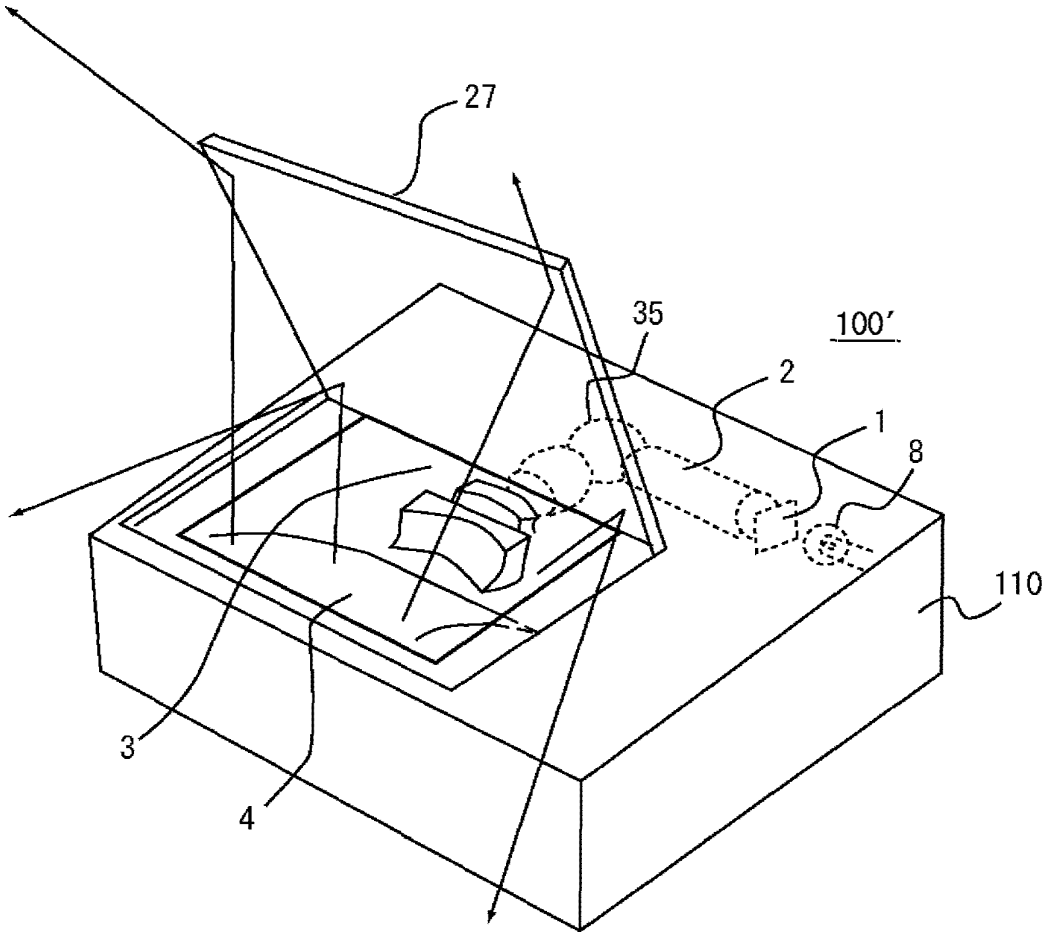

【図２８】

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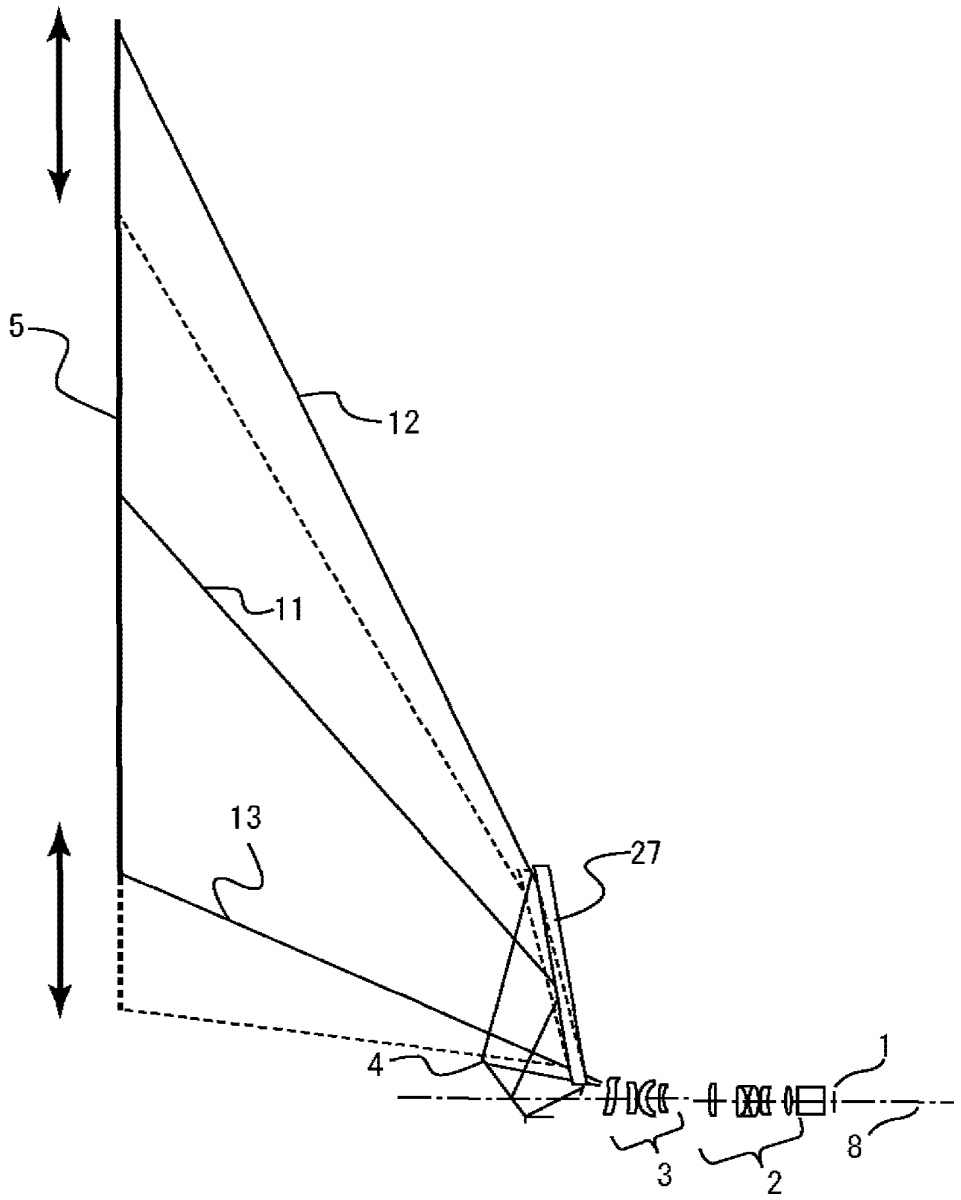

【図２９】

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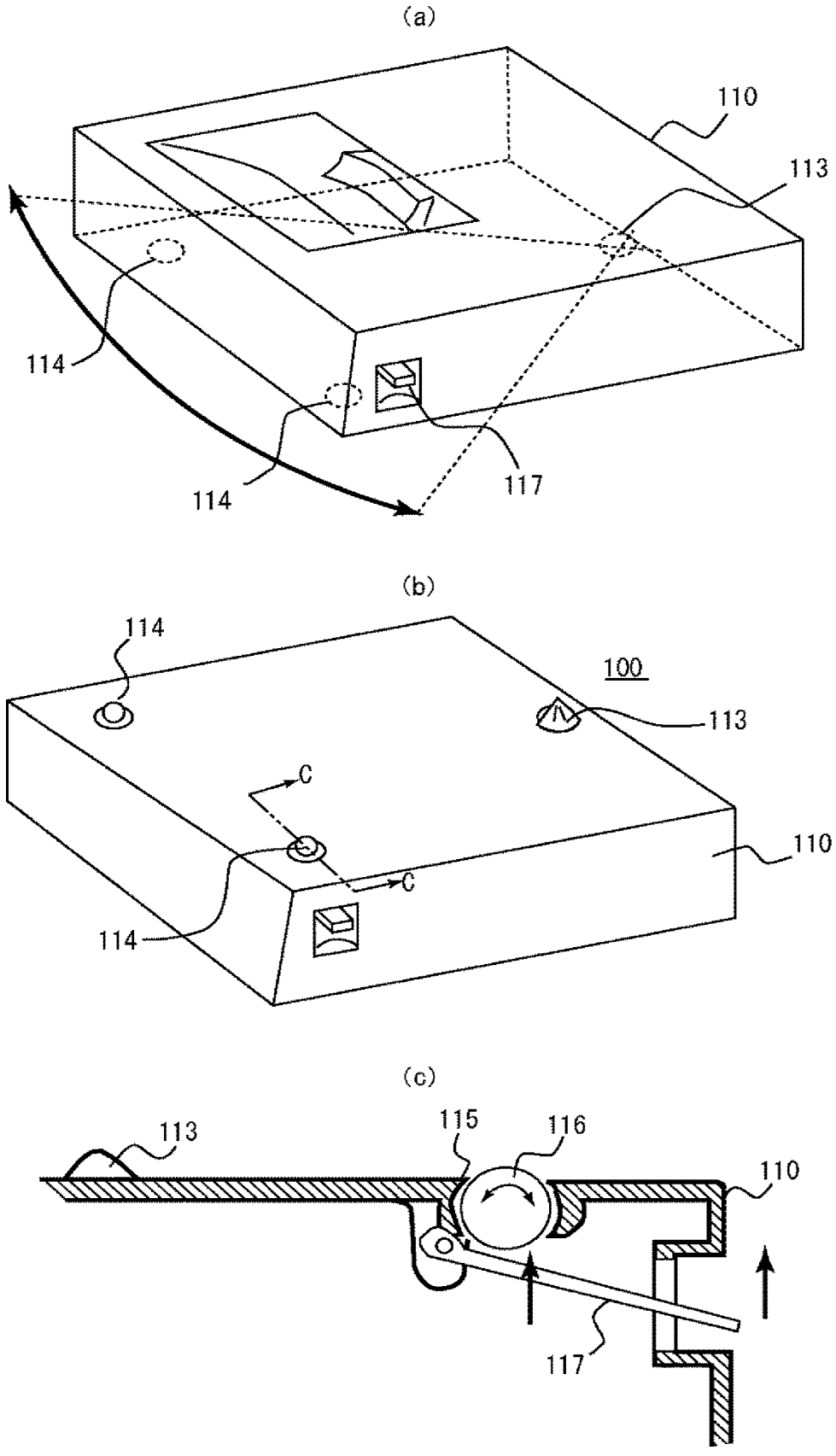
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東京都千代田区丸の内一丁目６番６号

株式会社日立製作所

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

20457 7590 08/05/2010

ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873

EXAMINER	
PYO, KEVIN K	
ART UNIT	PAPER NUMBER
2878	

DATE MAILED: 08/05/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/825,836	06/29/2010	Koji Hirata	520.47611CX2	2374

TITLE OF INVENTION: PROJECTION TYPE IMAGE DISPLAY APPARATUS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	11/05/2010

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20457 7590 08/05/2010

ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/825,836	06/29/2010	Koji Hirata	520.47611CX2	2374

TITLE OF INVENTION: PROJECTION TYPE IMAGE DISPLAY APPARATUS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	11/05/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
PYO, KEVIN K	2878	353-070000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively, 1_____

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2_____ 3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/825,836	06/29/2010	Koji Hirata	520.47611CX2	2374

20457 7590 08/05/2010

ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873

EXAMINER	
PYO, KEVIN K	
ART UNIT	PAPER NUMBER
2878	

DATE MAILED: 08/05/2010

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No.	Applicant(s)	
	12/825,836	HIRATA ET AL.	
	Examiner	Art Unit	
	Kevin Pyo	2878	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the application filed on 6/29/2010.*

2. ☒ The allowed claim(s) is/are *1-6.*

3. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☒ All b) ☐ Some* c) ☐ None of the:
      1. ☒ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 6/29/10
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The application has been amended as follows in view of providing missing information for related applications:

IN THE SPECIFICATION:

(1) On page 1, line 7, after "Serial No.", --12/825,801-- is inserted.

(2) On page 1, line 8, after "Serial No.", --12/825,881-- is inserted.

Allowable Subject Matter

2. Claims 1-6 are allowed.

3. The following is an examiner's statement of reasons for allowance:

The prior art fails to disclose or make obvious a projection type image display apparatus comprising, in addition to the other recited features of the claim, a reflection mirror, which is configured to reflect lights emitted from at least one of first and second lens groups, so as to project upon a screen obliquely, a first mounting base, on which a first lens group is mounted, a second mounting base, on which a second lens group is mounted, and a chassis, which is configured to store the first and second lens group, the reflection mirror and the first and second mounting bases, wherein the first mounting base is fixed at a bottom of the chassis while the second mounting base is movable.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Hisada et al (US 2009/0059185) is cited for disclosing a projection image displaying device.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin Pyo whose telephone number is (571) 272-2445. The examiner can normally be reached on Mon-Fri (with flexible hour), First Mon. off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Georgia Y. Epps can be reached on (571) 272-2328. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would

like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kevin Pyo/
Primary Examiner, Art Unit 2878

Notice of References Cited	Application/Control No. 12/825,836	Applicant(s)/Patent Under Reexamination HIRATA ET AL.	
	Examiner Kevin Pyo	Art Unit 2878	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2009/0059185 A1	03-2009	HISADA et al.	353/98
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
12825836	HIRATA ET AL.
Examiner	**Art Unit**
Kevin Pyo	2878

ORIGINAL		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
353	70	G 0 3 B 21 / 14 (2006.0)	
		G 0 3 B 21 / 28 (2006.01.01)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
353	69	77	101		
359	649	813	823		

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE

(Assistant Examiner) (Date)

Total Claims Allowed: 6

/Kevin Pyo/
Primary Examiner.Art Unit 2878 8/1/2010

(Primary Examiner) (Date)

O.G. Print Claim(s): 1

O.G. Print Figure: 23(a)

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12825836	HIRATA ET AL.
	Examiner	**Art Unit**
	Kevin Pyo	2878

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/01/2010								
	1	=								
	2	=								
	3	=								
	4	=								
	5	=								
	6	=								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12825836	HIRATA ET AL.
	Examiner	**Art Unit**
	Kevin Pyo	2878

SEARCHED			
Class	**Subclass**	**Date**	**Examiner**
353	69; 70; 77; 98; 101	8/1/10	kp
359	448; 649; 726; 813; 823; 846; 850	8/1/10	kp

SEARCH NOTES		
Search Notes	**Date**	**Examiner**
EAST-see search history printout	8/1/10	kp
Inventor name search	8/1/10	kp

INTERFERENCE SEARCH			
Class	**Subclass**	**Date**	**Examiner**
	Interference search history printout-EAST	8/1/10	kp

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BIB DATA SHEET

CONFIRMATION NO. 2374

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/825,836	06/29/2010	353	2878	520.47611CX2

APPLICANTS

Koji Hirata, Yokohama, JAPAN;
Takanori Hisada, Yokohama, JAPAN;
Masahiko Yatsu, Fujisawa, JAPAN;

**** CONTINUING DATA ***************************

This application is a CON of 11/763,465 06/15/2007 PAT 7,766,488

**** FOREIGN APPLICATIONS ***************************

JAPAN 2006-166434 06/15/2006

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

07/08/2010

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☑ Yes ☐ No	☑ Yes ☐ No	/KEVIN K PYO/ Examiner's Signature	☐ Initials	JAPAN	29	6	1

ADDRESS

ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873
UNITED STATES

TITLE

Projection Type Image Display Apparatus

FILING FEE RECEIVED		
1090	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1379	trapezoidal near2 distortion	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:47
L2	14	("20030114430" | "20030227299" | "20060164605" | "20060227432" | "20090115975" | "5648871" | "6220712").PN.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L3	11044	project$3 near3 imag $3 near2 display$3 near3 (apparatus or device)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L4	119864	(front or first) near2 lens	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:48
L5	92745	(rear or second) near2 lens	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:48
L6	7436	L4 with L5 with reflect $4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:48
L7	17537	(mov$6 or adjust$5) near8 L5	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:48
L8	1549	L6 and L7	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48

L9	85	L3 and L8	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L10	7444	mount$5 with L5	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L11	13	L9 and L10	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L12	56	L10 and L3	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L13	2658	L7 and L10	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L14	32	L3 and L13	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L15	207286	chassis	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L16	178	L13 and L15	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L17	2164	L15 with lens	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/07/31 21:48
L18	146	L16 and L17	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48

L19	55	L15 with L4 with L5	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L20	16	L7 and L19	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L21	755	rear near5 project$3 near3 imag$3 near2 display$3 near3 (apparatus or device)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L22	19	L7 and L21	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 21:48
L23	781	hirata near koji	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:03
L24	0	hisada near taknori	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:08
L25	40	hisada near takanori	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:08
L26	150	yatsu near masahiko	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:16
L27	849	23 25 26	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:17
L28	259	27 and 3	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:17

L29	176	5 and 28	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:17
L30	13	7 and 28	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:17
L31	709	353/69.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:27
L32	388	353/70.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:27
L33	300	353/77.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:27
L34	827	353/98.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:27
L35	774	353/101.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:27
L36	127	359/448.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:28
L37	683	359/649.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:28
L38	988	359/726.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:28

L39	666	359/813.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:28
L40	1773	359/823.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:28
L41	561	359/846.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:29
L42	766	359/850.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:29
L47	1187825	"43" and "46"	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2010/07/31 22:31

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L43	945	(project$3 near3 imag$3 near2 display $3 near3 (apparatus or device)).clm.	US-PGPUB; UPAD	OR	OFF	2010/07/31 22:29
L44	11259	((rear or second) near2 lens).clm.	US-PGPUB; UPAD	OR	ON	2010/07/31 22:29
L46	2209	(mov$6 or adjust$5) near8 L44	US-PGPUB; UPAD	OR	ON	2010/07/31 22:31
L48	14	L43 and L46	US-PGPUB; UPAD	OR	ON	2010/07/31 22:32

7/31/2010 11:16:53 PM
H:\EAST\Workspaces\12825836.wsp

PTO/SB/08A (08-03)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	12825836 - GAU: 2878
Filing Date	June 29, 2010
First Named Inventor	Koji HIRATA, et al.
Art Unit	
Examiner Name	pyo
Attorney Docket Number	520.47611CX2

U.S. PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 5,648,871	07-15-1997	Canon Kabushiki Kaisha	
		US- 6,220,712	04-24-2001	Minolta Co., Ltd.	
		US- 2006/0114430	06-01-2006	T. Masubuchi, et al.	
		US- 2006/0164605	07-27-2006	T. Kuwa	
		US- 2006-0227299	10-12-2006	T. Hisada	
		US- 2006/0227432	10-12-2006	H. Yoshikawa, et al.	
		US- 2009/0115975	05-2009	Ogura	
		US-			
		US-			
		US-			

FOREIGN PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
		JP 05-134213	05-28-1993	CANON INC		ABS
		JP 2000-162544	06-16-2000	MINOLTA CO LTD		ABS
		JP 2004-157560	06-03-2004	NEC VIEWTECHNOLOGY LTD		ABS
		JP 2006-138882	06-01-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-154041	06-15-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-292900	10-26-2006	HITACHI LTD		ABS
		JP 2006-292901	10-26-2006	HITACHI LTD		ABS

Examiner Signature	/Kevin Pyo/	Date Considered	07/31/2010

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5 Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /KP/

PTO/SB/08A (08-03)
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U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	12825835 - GAU: 2878
Filing Date	June 29, 2010
First Named Inventor	Koji HIRATA, et al.
Art Unit	
Examiner Name	pyo
Attorney Docket Number	520.47611CX2

RL 9/15/10

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US- 5,648,871	07-15-1997	~~Canon Kabushiki Kaisha~~	Okuyama et al.
		US- 6,220,712	04-24-2001	Minolta Co., Ltd.	Ohzawa
		US- 2006/0114430	06-01-2006	T. Masubuchi, et al.	
		US- 2006/0164605	07-27-2006	T. Kuwa	
		US- 2006-0227299	10-12-2006	T. Hisada	
		US- 2006/0227432	10-12-2006	H. Yoshikawa, et al.	
		US- 2009/0115975	05-2009	Ogura	
		US-			
		US-			
		US-			

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]–Number[4]–Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
		JP 05-134213	05-28-1993	CANON INC		ABS
		JP 2000-162544	06-16-2000	MINOLTA CO LTD		ABS
		JP 2004-157560	06-03-2004	NEC VIEWTECHNOLOGY LTD		ABS
		JP 2006-138882	06-01-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-154041	06-15-2006	KONICA MINOLTA OPTO INC		ABS
		JP 2006-292900	10-26-2006	HITACHI LTD		ABS
		JP 2006-292901	10-26-2006	HITACHI LTD		ABS

Examiner Signature	/Kevin Pyo/	Date Considered	07/31/2010

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5 Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /KP/

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/825,836	06/29/2010	Koji Hirata	520.47611CX2

CONFIRMATION NO. 2374

20457
ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET
SUITE 1800
ARLINGTON, VA 22209-3873

PUBLICATION NOTICE

OC000000044113682

Title:PROJECTION TYPE IMAGE DISPLAY APPARATUS

Publication No.US-2010-0265471-A1
Publication Date:10/21/2010

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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Alexandria, Virginia 22313-1450

Or Fax **(571) 273-2885**

520.47611CX2

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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope Addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/825,836	6/29/2010	Koji HIRATA	520.47611CX2	2374

TITLE OF INVENTION: Projection Type Image Display Apparatus

APPL. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE (S) DUE	DATE DUE
Nonprovisional	NO	$1510	$300	$0	$1810	**11/5/2010**

EXAMINER	ART UNIT	CLASS-SUBCLASS
PYO, KEVIN K	2878	353-070000

1. Change of correspondence address or indication of "Fee Address: (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122 attached.

agents OR, alternatively,

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of Customer Number is required.

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys 1 ANTONELLI, TERRY, STOUT & KRAUS, LLP.

Or agents OR, alternatively,
(2) the name of single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed no name will be printed.

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: **HITACHI, LTD.**

(B) RESIDENCE: (CITY and STATE OR COUNTRY): **TOKYO, JAPAN**

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:
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- ☒ Publication Fee (No small entity discount permitted)
- ☒ Advance Order- # of Copies 4

4b. Payment of Fee (s):
- ☐ A check is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number **01-2135**.

5. Change in Entity Status (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above. NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in Interest as shown by the records of the United States patent and Trademark Office.

Authorized Signature /Melvin Kraus/ Date: **November 4, 2010**

Typed or printed name **Melvin Kraus** Registration No. **22,466**

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and Submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent tot eh Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal

Application Number:	12825836
Filing Date:	29-Jun-2010
Title of Invention:	PROJECTION TYPE IMAGE DISPLAY APPARATUS
First Named Inventor/Applicant Name:	Koji Hirata
Filer:	Melvin Kraus/Jessica Smith
Attorney Docket Number:	520.47611CX2

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1510	1510
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
Printed copy of patent - no color	8001	4	3	12
		Total in USD ($)		**1822**

Electronic Acknowledgement Receipt

EFS ID:	8766096
Application Number:	12825836
International Application Number:	
Confirmation Number:	2374
Title of Invention:	PROJECTION TYPE IMAGE DISPLAY APPARATUS
First Named Inventor/Applicant Name:	Koji Hirata
Customer Number:	20457
Filer:	Melvin Kraus/Jessica Smith
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1	Issue Fee Payment (PTO-85B)	IF47611CX2.pdf	219951 ce7981d60a7bbe921e83567680cb397d5703d3b3c	no	1
Warnings:					
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2	Fee Worksheet (PTO-875)	fee-info.pdf	33826 b625c55082e22302e158969a6a9b3284c68bb31f	no	2
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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

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