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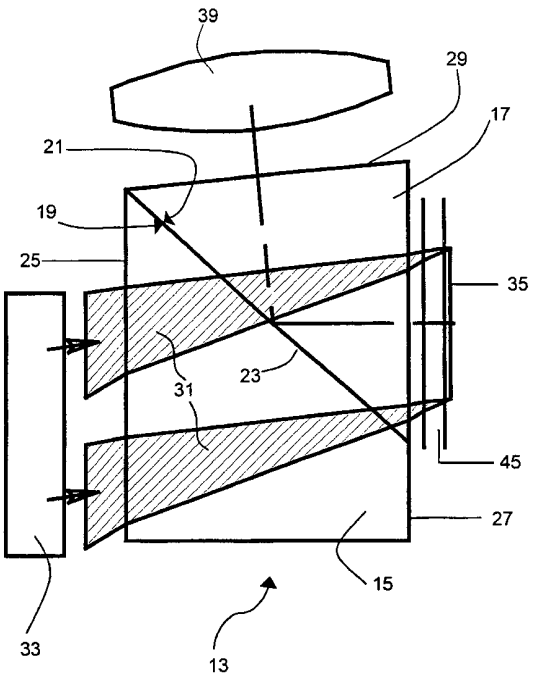
(54) Title: OPTICAL SYSTEMS FOR PROJECTION DISPLAYS



(57) Abstract: A prism (13) for use in a projection system which employs a digital light panel (35) is provided. The prism includes first (19) and second (21) spaced a part surfaces which are oriented such that: (a) light from a light source (33) will pass through the spaced apart surfaces to the digital light panel; (b) light from "on" pixels will undergo total internal reflection at the second surface (21) and be directed into the acceptance angle of a projection lens (39); and (c) light from "off" pixels which reflects from the second surface will be directed away from the lens' acceptance angle.

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OPTICAL SYSTEMS FOR PROJECTION DISPLAYS

FIELD OF THE INVENTION

This invention relates to optical systems for projection displays and, in particular, relates to optical systems of the type disclosed in U.S. Patent No. 5,552,922 (the '922 patent), the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The '922 patent discloses a system for transmitting illuminating light from a light source to a digital light panel (DLP), and then from "on" pixels of the DLP to a projection lens. Although the system of the '922 patent works successfully, two areas in which that system can be improved to reduce its cost and make it easier to manufacture have been identified.

The first area relates to the tilted airspace between surfaces 18 and 20 of the '922 patent. Because light from "on" pixels passes through this airspace, the airspace can introduce astigmatism and coma into the projected image of the DLP unless the width and wedge of the airspace are carefully controlled. The need for tight control of the width and wedge of the airspace makes manufacture of the system more difficult.

The second area involves the fact that in the system of the '922 patent, light from "on" pixels passes through both the optical component defined by surfaces 14, 16, and 18 of the '922 patent and the optical component defined by surfaces 12 and 20 of that patent. This means that both of these optical components must be manufactured from high quality glass and must satisfy tight tolerances for surfaces flatness, surface positioning, straie, birefringence, and the like. Such requirements increase the overall cost of the system and are thus undesirable.

SUMMARY OF THE INVENTION

In view of the foregoing, it is an object of this invention to provide an improved optical system for transmitting illuminating light from a light source to a DLP and then from "on" pixels of the DLP to a projection lens. More particularly, it is an object of the invention to provide a system of the general type disclosed in the '922 patent which is easier to manufacture and has reduced cost.

To achieve these and other objects, the invention provides an optical system comprising a light source, a DLP, a projection lens, and a prism having first and second spaced apart surfaces wherein the first and second spaced apart surfaces, the light source, the DLP, and the projection lens are oriented relative to one another such that light from the light source passes through the first and second spaced apart surfaces to the DLP, light reflected from the "on" or "first position" pixels of the DLP is internally reflected at the second spaced apart surface towards the projection lens at an angle such that the light is within the acceptance angle of the projection lens, and light reflected from "off" or "second position" pixels of the DLP is either internally reflected at the second spaced apart surface towards the projection lens at an angle such that the light is not within the acceptance angle of the projection lens or otherwise passes through the prism so that the light is outside of the acceptance angle (see, for example, the uppermost bundle of light 41 in Figure 3).

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic drawing illustrating the passage of light from a light source to a DLP in accordance with the invention.

Figure 2 is a schematic drawing illustrating the passage of light from "on" pixels of a DLP to a projection lens in accordance with the invention.

Figure 3 is a schematic drawing illustrating light paths for light from "off" pixels of a DLP in accordance with the invention.

The foregoing drawings, which are incorporated in and constitute part of the specification, illustrate the preferred embodiments of the

invention, and together with the description, serve to explain the principles of the invention. It is to be understood, of course, that both the drawings and the description are explanatory only and are not restrictive of the invention.

The reference numbers used in the drawings correspond to the following:

13	prism
15	prism component
17	prism component
19	first spaced apart surface
21	second spaced apart surface
23	diagonal
25	prism entrance surface
27	prism exit/entrance surface
29	prism exit surface
31	illumination light
33	illumination system
35	DLP
37	light reflected from "on" pixels
39	projection lens
41	light reflected from "off" pixels
43	light ray from "off" pixel
45	DLP cover plate

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in the figures, prism 13 consists of two parts or components 15,17 which are separated by a thin air layer at diagonal 23 of the prism. Surface 19 of component 15 and surface 21 of component 17 face each other along this diagonal and respectively constitute the first and second spaced apart surfaces referred to above.

As shown in Figure 1, light 31 from illumination system 33 enters into prism 10 through side 25. The angle of incidence of this light on the

prism diagonal 23 is less than the critical angle so that this light passes through diagonal 23 and illuminates DLP 35.

As shown in Figure 2, pixels in the "on" position reflect the incident illumination light 31 of Figure 1 in a direction perpendicular to the active area of the DLP. This light 37 has an angle of incidence on air-spaced diagonal 23 larger than the critical angle and thus 100% of this light is reflected from this diagonal. In particular, reflected light 37 from the DLP strikes surface 21 of component 17 at angle greater than the critical angle defined by the index of refraction of component 17 compared to the index of refraction of air.

Light 37 exits from prism 13 through side 29, which is the mirror image of side 27. This relationship of sides 27 and 29 means that prism component 17, along the light beam 37 reflected from "on" pixels, is in effect a plano-parallel plate. This, in turn, means that prism component 17, the only component which is in the imaging path, does not create coma or astigmatism.

Projection lens 39 is positioned after side 29 to capture the light from "on" pixels and to create the desired image on a viewing screen (not shown).

As shown in Figure 3, pixels in the "off" position reflect the incident illumination light 31 of Figure 1 in directions such that the light does not effectively enter the entrance pupil of the projection lens 39 (see, for example, rays 43 in Figure 3). That is, light 41 from "off" pixels will not be within the acceptance angle of the projection lens.

In practice, sides 25, 27, and 29 of prism 13 have conventional antireflection coatings to minimize Fresnel reflection. Also, spaced apart surfaces 19,21 have antireflection coatings optimized for an angle of incidence close to the critical angle to reduce the Fresnel losses of illumination light 31.

Instead of being separated by an air layer, surfaces 19 and 21 can be separated by a low index of refraction coating. To maintain a large critical angle at surface 21, component 17 should be made of a high index glass.

Component 15 should be made of a similar glass to avoid introducing chromatic and other aberrations into illumination light 31. The advantages of such a coating include ease of assembly of the prism components and elimination of problems due to dust and/or water contamination of the spaced apart surfaces. Such contamination can destroy the ability of total internal reflection at surface 21 to guide light into the projection lens and can lead to high levels of light loss.

As shown in Figures 1-3, the DLP is normally protected by a cover plate 45. If desired, this cover plate can be cemented to surface 27, thus removing two glass/air interfaces from the system which reduces Fresnel losses.

As discussed above, the foregoing configuration for the projection system achieves the following advantages:

(1) The width and wedge of the airspace along diagonal 23 does not affect the light path from the "on" pixels to the projection lens. Accordingly, astigmatism and coma associated with this tilted airspace are eliminated.

(2) Only one prism component 17 works in the imaging light path. Accordingly, prism component 15 can be manufactured from lower quality glass without tight tolerances for surface flatness and positioning, straie, birefringence, etc. In this way, the overall cost of the device is lowered.

Although preferred embodiments of the invention have been described herein, further embodiments may be perceived by those skilled in the art without departing from the scope of the invention as defined by the following claims.

What is claimed is:

1. In an image projection system comprising:

(a) a light source which provides illuminating light;

(b) a plurality of selectively adjustable reflecting elements which are arranged in a common plane, said elements being adjustable between at least a first position and a second position;

(c) a lens having a principal plane which is parallel to said common plane; and

(d) a prism positioned between said lens and said plurality of reflecting elements;

the improvement wherein the lens has an acceptance angle and the prism comprises first and second spaced apart surfaces that are oriented relative to the light source, the plurality of reflecting elements, and the lens such that:

(i) light from the light source passes through the first and second spaced apart surfaces to the plurality of reflecting elements, and

(ii) light reflected from reflecting elements in the first position is reflected at the second spaced apart surface in directions which are within the lens' acceptance angle.

2. The image projection system of Claim 1 wherein light reflected from reflecting elements in the second position is reflected at the second spaced apart surface in directions which are not within the lens' acceptance angle.

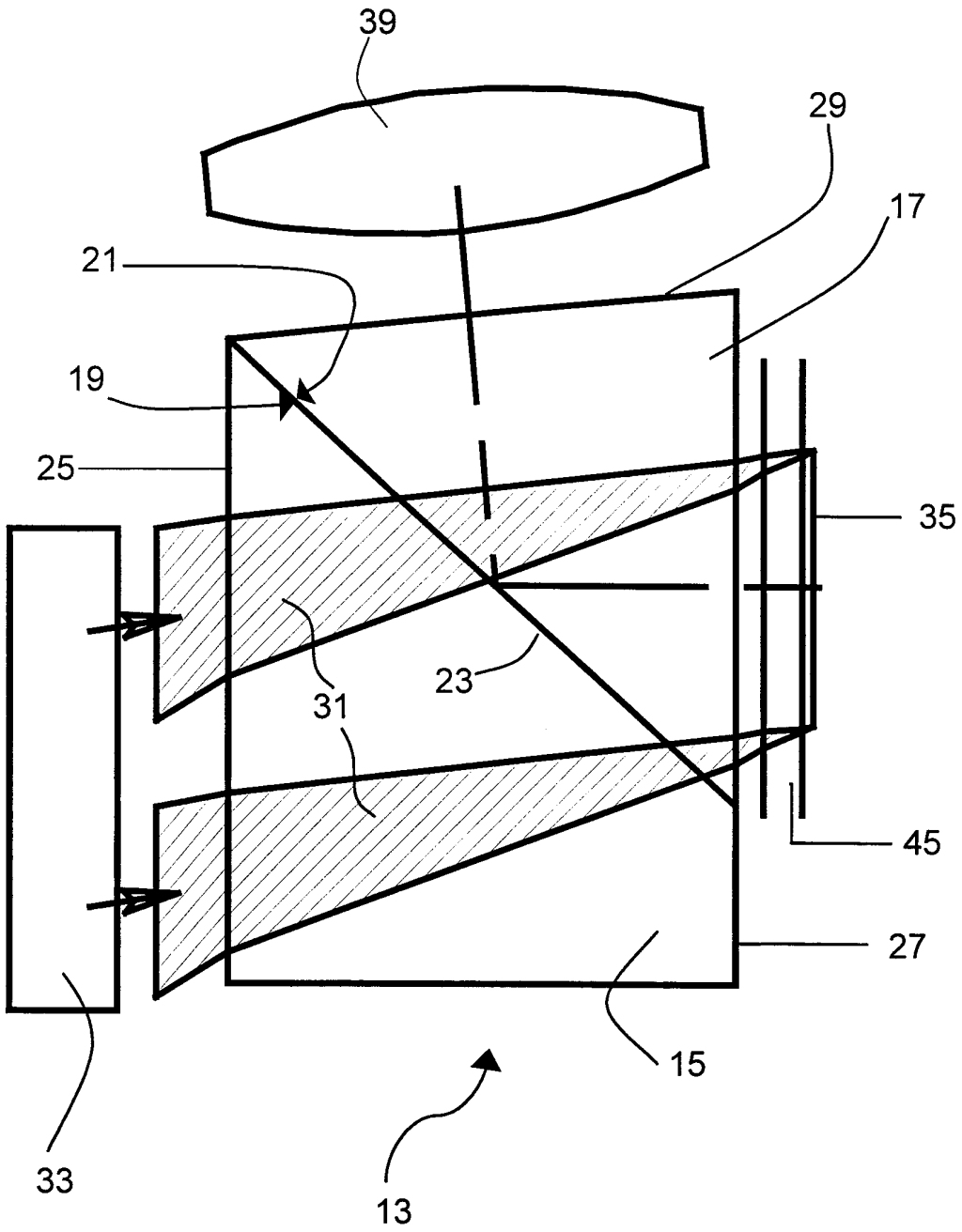

FIG. 1

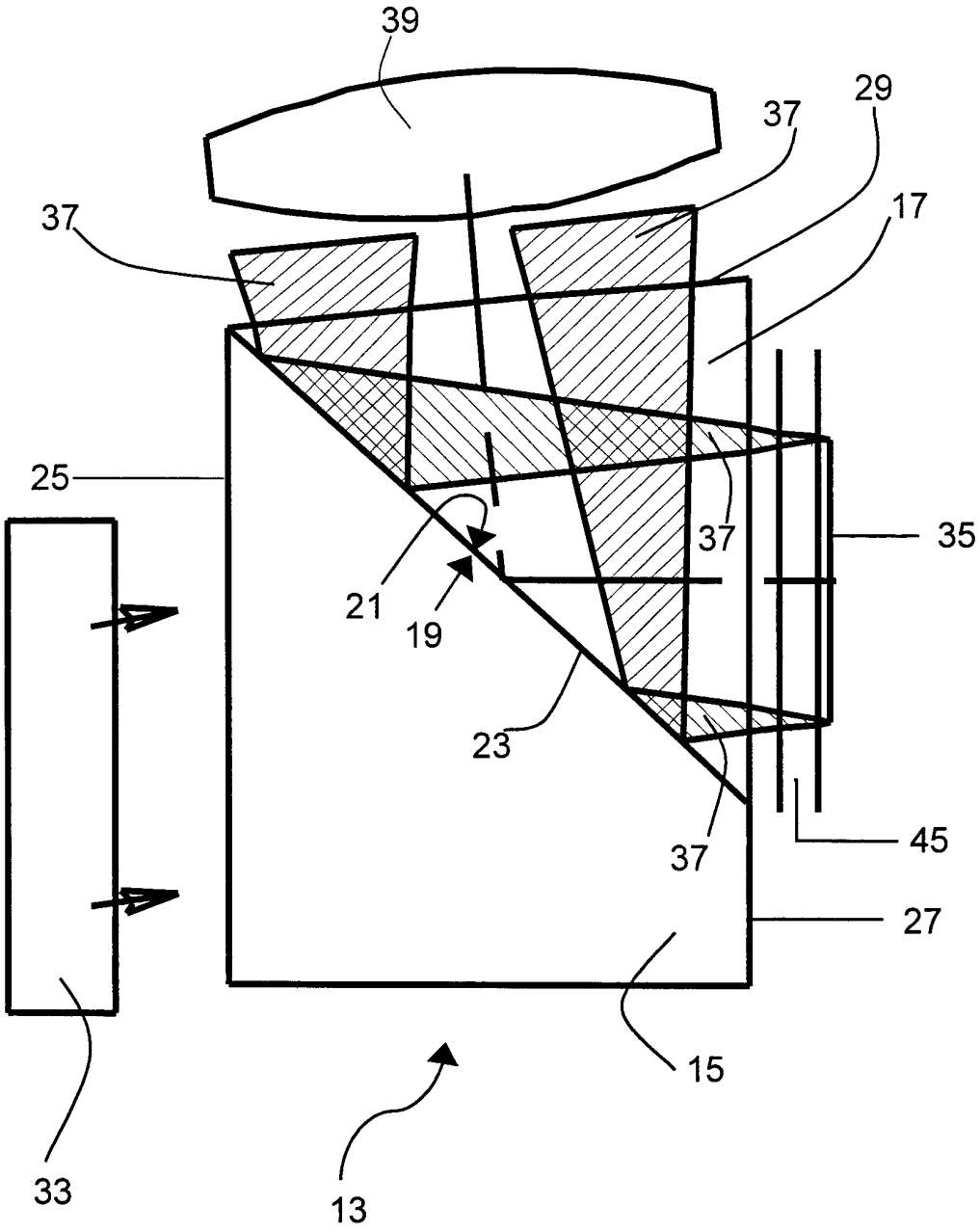

FIG. 2

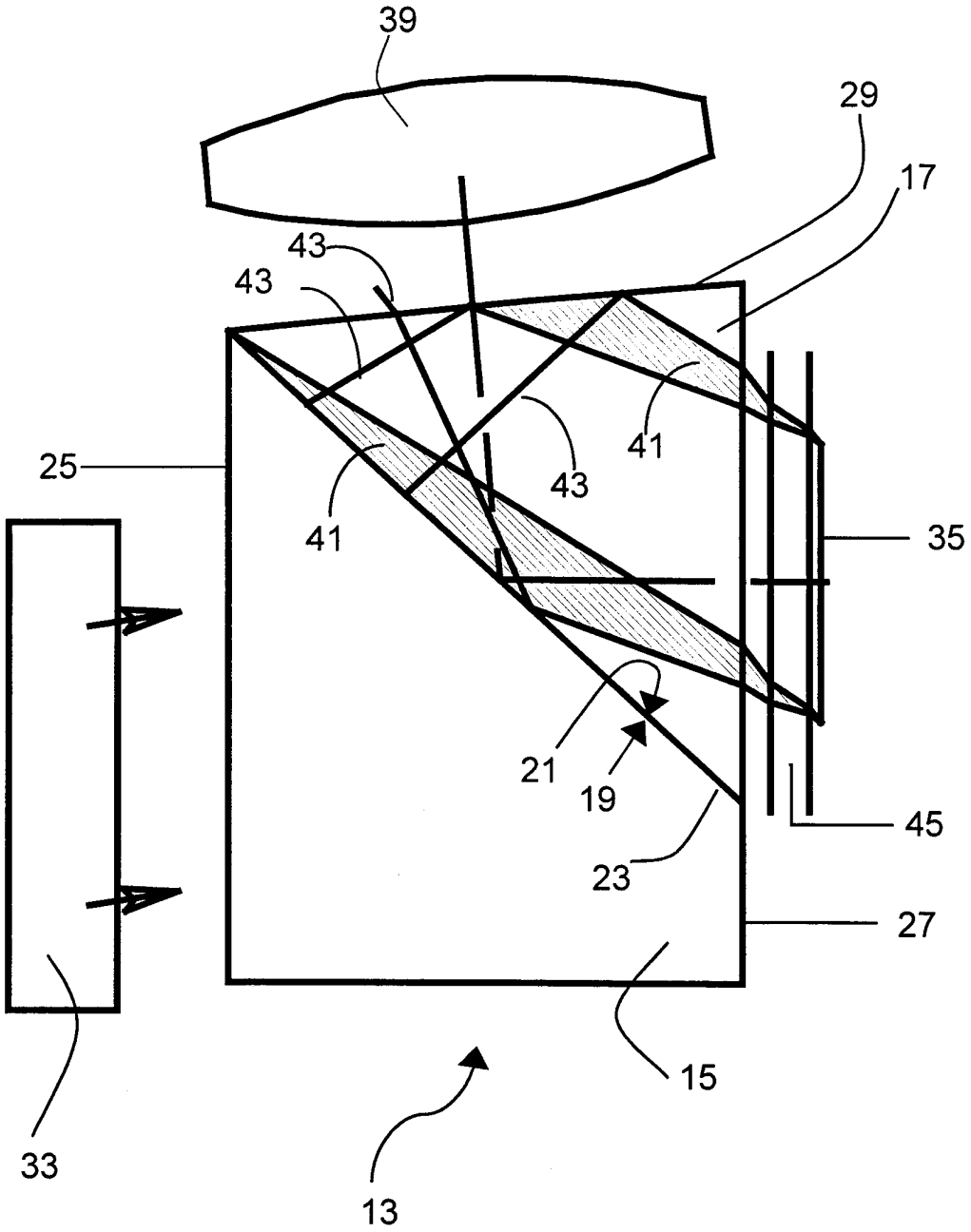

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/07388

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G03B 21/14
US CL :353/81, 33

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 353/20, 31, 33, 81, 98; 348/771, 742, 743; 345/31; 359/831, 833

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

NONE

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

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,442,414 A (JANSSEN et al.) 15 August 1995 (15.08.1995), see entire document.	1-2
Y	US 4,983,032 A (VAN DEN BRANDT) 08 January 1991 (08.01.1991), see entire document.	1-2
Y	US 5,865,520 A (KAVANAGH et al.) 02 February 1999 (02.02.1999), see entire document.	1-2
A	US 5,552,922 A (MAGARILL) 03 September 1996 (03.09.1996), see entire document.	1-2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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