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(71) Applicant(s):
Samsung Electronics Co. Ltd.
(Incorporated in the Republic of Korea)
416 Maetan-dong, Paldal-gu, Suwon-City,
Kyungki-Do, Republic of Korea

(72) Inventor(s):
Jee-uk Jeon

(74) Agent and/or Address for Service:
Venner Shipley & Co
20 Little Britain, LONDON, EC1A 7DH,
United Kingdom

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EP 0646828 A1
JP 2001109062 A
US 5467146 A
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US 6219110 B1

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(54) Abstract Title: **Rear projection display**

(57) A projection display apparatus 300 comprises a light source 310 and a rectangular light beam forming device 330 which acts to supply a rectangular light beam towards a spatial light modulator in the form of a digital micromirror device (DMD) 390. Two mirrors 350,370 are included between the light source and the DMD in order to fold the optical path thereby enabling the overall height of the display apparatus be reduced.

FIG. 3

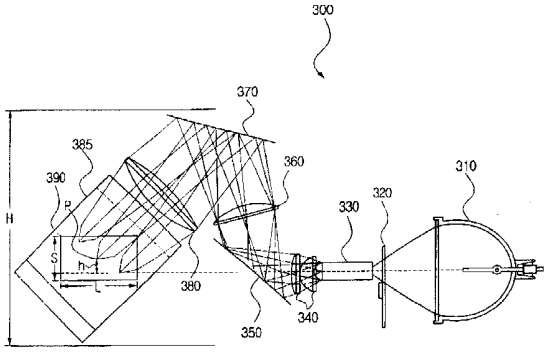

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FIG. 1

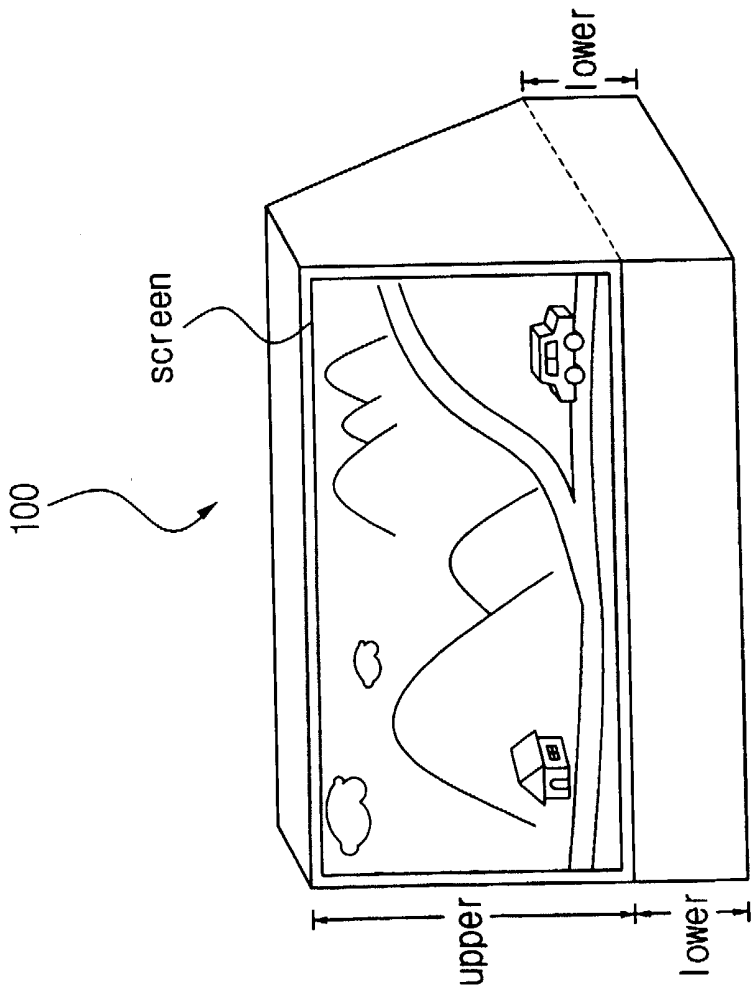

FIG. 2

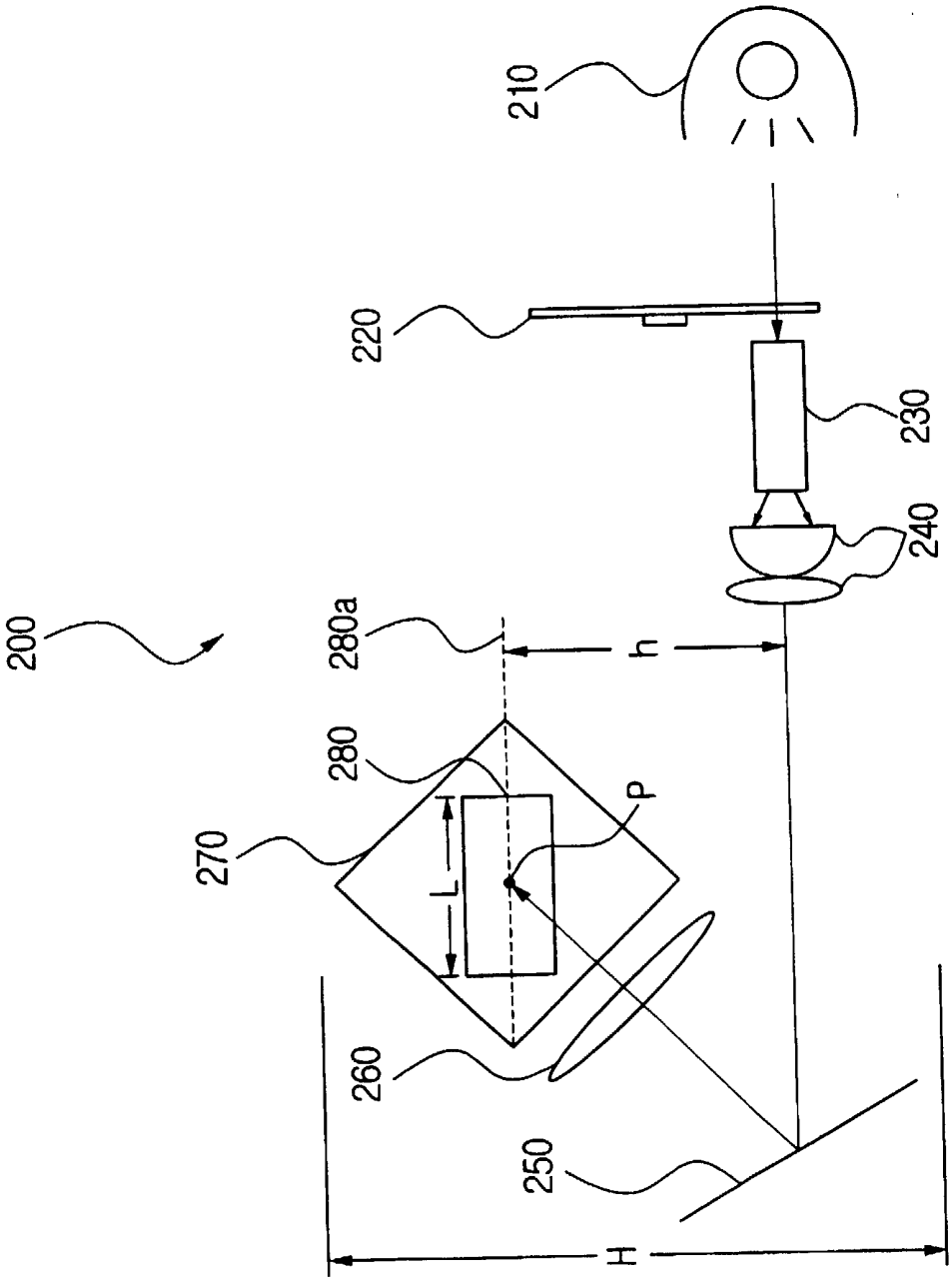

FIG. 3

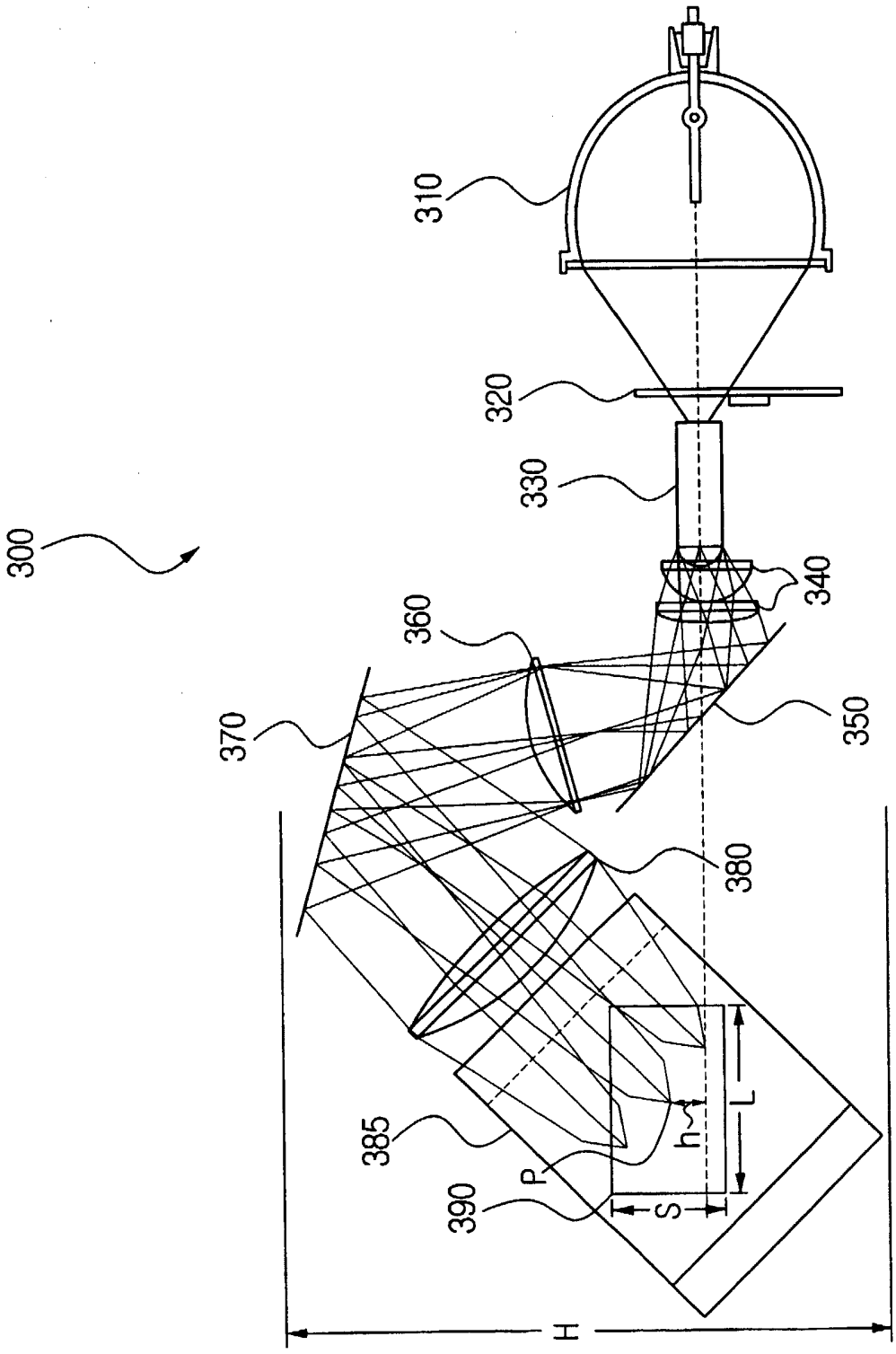

FIG. 4

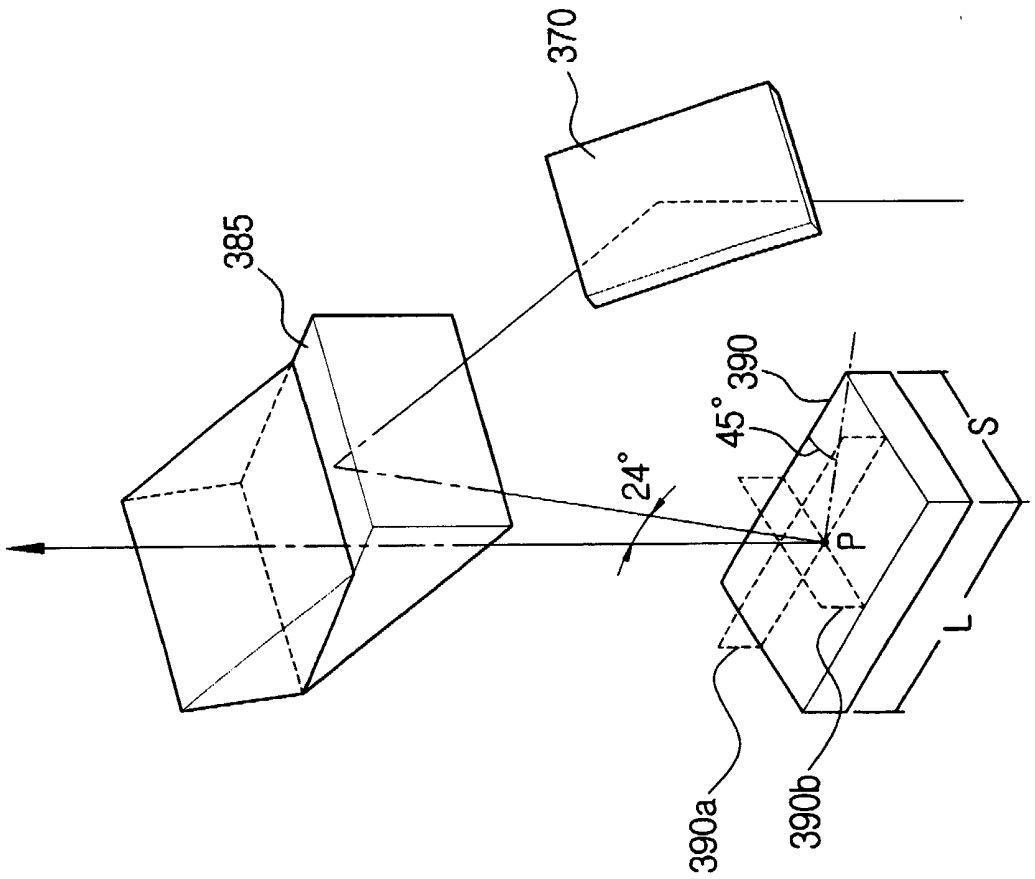

Image Projecting Apparatus

Description

The present invention relates to an image projecting apparatus.

Image projecting apparatus, e.g. a projection television, uses a projection lens to magnify a small image and projects it onto a screen. Such image projecting apparatuses are categorized as either front projection or rear projection types.

Front projection apparatuses project images from in front, i.e. from the viewing side, of the screen and are commonly used in cinemas and presentation rooms. Rear projection apparatuses project images from the rear of the screen and are widely used in projection televisions. Rear projection apparatuses are more widely used than front projection apparatuses because they can produce bright images which are viewable even under high ambient light conditions.

Figure 1 shows a rear projection TV having a conventional image projecting apparatus.

Referring to Figure 1, the rear projection TV 100 has an upper portion and a lower portion. On the upper portion is formed a screen through which a viewer watches images projected onto its rear face. An image projecting apparatus (not shown) is provided inside the lower portion of the rear projection TV 100 for projecting images onto the screen.

Figure 2 shows the function elements of the conventional image projecting apparatus of Figure 1.

Referring to Figure 2, the image projecting apparatus 200 includes a light source 210, a colour filter wheel 220, a rectangular beam generator 230, a first lens group 240, a mirror 250, a second lens group 260, a prism 270 and a digital micromirror device (DMD) 280.

The light source 210 radiates white light using a halogen or xenon light. The white light, which is emitted from the light source 210, is filtered by the red, green and blue regions of the colour filter wheel 220 so that it is monochromatically red, green and blue by turns. The rectangular beam generator 230 shapes the cross-section of the filtered beam from the colour filter wheel 220 into rectangular.

The monochromatic beam is collimated by the first lens group 240 and reflected by the mirror 250. The second lens group 260 is for collimating the monochromatic beam, reflected by the mirror 250, towards the prism 270 and, thus, the monochromatic beam is reflected toward the movable mirror surfaces of the DMD panel 280 upon being incident on the prism 270. The monochromatic beam is then modulated to form an image by the mirrors on the movable mirror surfaces of the DMD panel 280, transmitted through the prism 270 and the projection lens system (not shown), and finally forms a visible image on the screen of Figure 1.

It is assumed that an imaginary surface 280a of infinite size is formed on the movable mirror surfaces in a vertical direction, parallel to the longer side L of the movable mirror surfaces and passing through the centreline (p) of the movable mirror surfaces. Since the vertical distance (h) from the imaginary surface 280a to the optical axis of the light source 210 is long, the height H of the conventional image projecting apparatus 200 needs to larger and the height of the lower portion of the rear projection TV 100 is also increased. As a result, a compact rear projection TV is not achieved.

An image projecting apparatus according to the present invention comprises a light path extending from a light source to a micromirror device for modulating a light beam following the light path, wherein the light path includes first and second mirrors in series.

Preferably, the light source and the mirrors are disposed to one side of the micromirror device.

Preferably, light from the light path has an angle of incidence on the micromirror device which is 1.5~2.5 times greater than the maximum angle at which the mirrors of micromirror device are tiltable from their neutral positions and approaches the micromirror device approximately diagonally.

Preferably, first lens means is included between the light source and the first mirror and second lens means is included between the second mirror and the micromirror device. More preferably, third lens means is included between the first mirror and the second mirror.

Preferably, a rectangular beam former is included between the light source and the first mirror.

An embodiment of the present invention will now be described, by way of example, with reference to Figures 3 and 4 of the accompanying drawings, in which:

Figure 1 shows a rear projection TV having a conventional image projecting apparatus;

Figure 2 shows the functional elements of the conventional rear image projecting apparatus of Figure 1;

Figure 3 shows an image projecting apparatus according to the present invention; and

Figure 4 is a perspective view of the second mirror, the prism and the DMD panel the apparatus shown in Figure 3.

Referring to Figure 3, an image projecting apparatus 300 according to the present invention includes a light source 310, a colour filter wheel 320, a rectangular beam generator 330, a first lens group 340, a first mirror 350, a second lens group 360, a second mirror 370, a third lens group 380, a prism 385, a digital micromirror device (DMD) panel 390 and a projection lens system (not shown).

The light source 310 radiates white light. The light source 310 may be implemented using a laser, a mercury lamp, a metal halide lamp, a halogen lamp and xenon lamp may be used.

The colour filter wheel 320 is divided into red, green and blue regions, and is rotated by a rotating means (not shown). The white light, emitted by the light source 310, is sequentially filtered to be red, green and blue in turn by the red, green and blue regions of the colour filter wheel 320. The red, green and blue regions of the colour filter wheel 320 are rotated at a speed sufficient for a viewer not to perceive separate red, green and blue images.

The rectangular beam generator 330 transforms the filtered beam from the colour filter wheel 320 into a rectangular cross-section beam having a predetermined aspect ratio. To this end, the rectangular beam generator 330 uses a light tunnel or glass rod (not shown). The light tunnel is a hollow hexahedron, whose four inner faces are mirrored. Accordingly, a light beam is incident on the DMD panel 390 with uniform light intensity. The predetermined aspect ratio of the light tunnel is similar, or identical to that of the DMD panel 390. Unlike the light tunnel, the glass rod (not shown) has no space defined therein, and the beam is transmitted by the glass rod (not shown) by total internal reflection.

The first lens group 340 is provided with at least one lens, and has a positive refractive power so that the rectangular beam is wholly incident on the first mirror 350. The first mirror 350 reflects the incident rectangular beam from the first lens group 340.

The second lens group 360 comprises at least one lens for causing the reflected beam from the first mirror 350 to fall incident on the second mirror 370. Use of the second lens group 360 is optional and, accordingly, the second lens group 360 may be omitted.

The second mirror 370 is arranged such that its reflective surface faces the reflective surface of the first mirror 350 in order to reflect the incident monochromatic light from the second lens group 360 to be incident on the movable mirror surface of the DMD panel 390. The sloping degree of the first and the second mirrors 350, 370 may be different or identical.

The third lens group 380 and the prism 385 are located between the second mirror 370 and the DMD panel 390. The third lens group 380 causes the reflected rectangular beam from the second mirror 370 to enter the prism 385. The third lens group 380 is provided with at least one lens and has a positive refractivity.

The prism 385 is a TIR (total internal reflection) prism, and Figure 3 shows the light incident side of the TIR prism 385. The prism 385 is arranged for total internal reflection of the rectangular beam, after it has passed through the third lens group 380, so that it is incident on the movable mirrors of the DMD panel 390.

The movable mirror surface of the DMD panel 390 is rectangular and has a longer side L parallel to the lower side where the image projecting apparatus 300 is provided, and a shorter side S which is perpendicular to the lower side. The predetermined aspect ratio of the DMD panel 390 may be similar to or identical with that of the screen (not shown) of the projection TV.

The movable mirror surface of the DMD panel 390 is arranged parallel to the optical axis (dotted line in Figure 3) of the light source 310. In other words, the DMD panel 390 is arranged such that the normal plane of the DMD panel 390, which is parallel to the longer side L of the movable mirror surface is parallel with the optical axis of the light source 310. The DMD panel 390 is also arranged such that the rectangular beam is incident on the corresponding part of the movable mirror surface. For example, a particular portion of the opening of the rectangular beam generator 330 emitting the light would correspond to a part of the movable mirror surface on which the light is incident.

The beam, which is modulated by the movable mirrors of the DMD panel 390, is passed back through the prism 385 and is then incident on the projection lens system (not shown). The projection lens system enlarges the image from the DMD panel 390 and projects the enlarged image onto the screen. It is preferred that the angle between the normal line of the movable mirror surface and the centre incident ray be 1.5~2.5 times greater than the angle at which the DMD panel 390 is tilted,

which is, for example, 12°. This is because each micromirror (not shown) can be driven through the range +12° to -12°.

For example, when a ray is incident onto a +12° tilted micromirror (not shown) at an angle of 24° with respect to the normal line of the micromirror (not shown), the incident ray is 'on' and is transmitted through the prism 385 and then incident on the projection lens system (not shown). On the other hand, i.e.,when a ray is incident onto a -12° tilted micromirror (not shown) at an angle of 24° with respect to the normal line of the micromirror (not shown), the incident ray is 'off' and is not being incident on the projection lens system (not shown). The above is in consideration of the characteristics of a typical TIR prism and the DMD panel 390 and, because it is well known in the art, detailed description thereof will be omitted.

Referring to Figure 4, the angle between the normal line of the movable mirror surface and the centre incident ray (shown by the chained line) is approximately 24°, i.e., two times greater than the tilting angle, approximately 12°, of the DMD panel 390, and the angle between the orthographic projective line (double-dotted line) of the incident ray which is entering at approximately 24° and the longer side L of the movable mirror surface is approximately 45°.

Describing the above in greater detail, as the light from the light source 310 is incident on the centreline p of the movable mirror surface, the orthographic projective line on the movable mirror surface of the centre incident ray is at an angle of approximately 45° with respect to the longer side L of the movable mirror surface, while the orthographic projective line of the marginal rays of light other than the centre ray is incident at an angle deviated from the angle 45° to some extent, i.e. incident at an angle from about 30° to about 60°. What is more preferred is that the orthographic projective lines of the incident chief rays other than the centre incident ray are also incident at an angle approximately of 45°.

Furthermore, when it is assumed that there is a first imaginary surface 390a of infinite size formed on the movable mirror surface in perpendicular relation and parallel to the longer side L of the movable mirror surface of the DMD panel 390

and passing through the centre (p) of the movable mirror surface, and a second imaginary surface 390b of infinite size formed on the movable mirror surface in a perpendicular relation and parallel to the shorter side S of the movable mirror surface of the DMD panel 390 and passing through the centreline (p) of the movable mirror surface, the first and the second mirror 350, 370 are arranged such that the beam does not cross the second imaginary surface 390b of the movable mirror surface until the light is incident on the movable mirror surface of the DMD panel 390. As a result, the optical path is tilted to one side in the internal structure of the image projecting apparatus 300. The first and the second mirrors 350, 370 are arranged such that the normal plane of the movable mirror surface, which is parallel with the longer side L of the movable mirror surface, is parallel to the optical axis of the light source 310.

Furthermore, the first and the second mirrors 350, 370 are arranged to face each other such that the optical axis is parallel with the first imaginary surface 390a.

By arranging the respective parts of the image projecting apparatus 300 to meet the above-described conditions, the distance (h) from the centre (p) of the imaginary mirror surface of the DMD panel 390 to the optical axis (chained line) of the light source 310 is minimized and, thus, the height H of the image projecting apparatus 300 is reduced.

With the image projecting apparatus according to the present invention, through the use of two reflective opposed mirrors and a lens, the vertical height of the image projecting apparatus can be reduced. In other words, since the optical path is varied by using the two mirrors, and the distance from the centre of the DMD panel to the optical axis is minimized, the vertical height of the image projecting apparatus is also reduced. As the lower portion, where the image projecting apparatus is provided, is reduced in height making a more compact projection TV possible.

Although the preferred embodiment of the present invention has been described, it will be understood by those skilled in the art that the present invention should not

be limited to the described preferred embodiment, but various changes and modifications can be made.

Claims

1. An image projecting apparatus comprising a light path extending from a light source to a micromirror device for modulating a light beam following the light path, wherein the light path includes first and second mirrors in series.

2. An apparatus according to claim 1, wherein the light source and the mirrors are disposed to one side of the micromirror device.

3. An apparatus according to claim 1 or 2, wherein light from the light path has an angle of incidence on the micromirror device which is 1.5~2.5 times greater than the maximum angle at which the mirrors of micromirror device are tiltable from their neutral positions and approaches the micromirror device approximately diagonally.

5. An apparatus according to claim 1, 2 or 3, including first lens means between the light source and the first mirror and second lens means between the second mirror and the micromirror device.

6. An apparatus according to claim 4, including third lens means between the first mirror and the second mirror.

7. An apparatus according to any preceding claim, including a rectangular beam former between the light source and the first mirror.

8. An image projecting apparatus forming an image by projecting a light irradiated from a light source onto a digital micromirror panel, comprising:

the digital micromirror panel configured such that a normal plane of a movable mirror surface of the digital micromirror panel, which is parallel with a longer side of the movable mirror surface, is parallel with an optical axis of the light source;

a first reflective mirror configured to reflect the light from the light source at a predetermined angle; and

a second reflective mirror configured to receive the light reflected from the first reflective mirror and to reflect the light onto the movable mirror surface of the digital micromirror panel.

9. The image projecting apparatus of claim 7, wherein the first and the second reflective mirrors are configured such that an optical path of the light from the light source does not cross the normal plane of the digital micromirror panel until the light is incident on the movable mirror surface.

10. The image projecting apparatus of claim 7, wherein the second reflective mirror is configured such that the light from the first reflective mirror is reflected from the second reflective mirror to be incident on the movable mirror surface of the digital micromirror panel, with an angle between the normal line of the movable surface and the incident light being 1.5~2.5 times greater than the angle at which the digital micromirror is tilted, and also with an angle between the orthographic projective line of the incident light and the longer side of the movable mirror surface being 40°-50°.

11. The image projecting apparatus of claim 10, further comprising a first lens group provided with at least one lens, having a positive refractivity, and disposed on the optical path between the light source and the first reflective mirror; and

a second lens group provided with at least one lens, having a positive refractivity, and disposed on the optical path between the second reflective mirror and the digital micromirror panel.

12. The image projecting apparatus of claim 11, further comprising a third lens group provided with at least one lens, having a positive refractivity, and disposed on the optical path between the first reflective mirror and the second reflective mirror.

13. The image projecting apparatus of claim 8, further comprising a square beam generator provided between the light source and the first reflective mirror, the square beam generator configured to transform the light from the light source into a

square beam of a predetermined aspect ratio and to output the transformed square beam,

wherein the digital micromirror panel is arranged such that the square beam from the square beam generator is incident on a corresponding part of the movable mirror surface.

Application No:	GB 0316635.2	**Examiner:**	Jeremy Cowen
Claims searched:	1,8	**Date of search:**	9 December 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X,Y	X:1,2,8 Y:7	JP 2001109062 A	(Minolta), see abstract & figure 9
X,Y	X:1,2,8 Y:7	WO 01/33865 A1	(Sim2 Multimedia), see line 30, page 2 to line 9, page 3
X,Y	X:1,2,8 Y:7	US 6219110 B1	(IBM Japan & Advanced Peripheral Technologies), see figure 8
X,Y	X:1,2,8 Y:7	US 5467146	(Texas Instruments), see figure 2
Y	7	EP 0646828 A1	(Seiko Epson), see abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

G2J,H4F

Worldwide search of patent documents classified in the following areas of the IPC[7] :

G03B,H04N

The following online and other databases have been used in the preparation of this search report :

WPI,EPODOC,PAJ